# EXHIBIT M

Archived version as of 12/25/2024

The Wayback Machine - https://web.archive.org/web/20241225042744/https://www.rd.usda.gov/inflati…


An official website of the United States government Here's how you know


Rural Development
U.S. DEPARTMENT OF AGRICULTURE

# IRA Pocket Guides

The Inflation Reduction Act included historic investments across the federal government. These pocket guides highlight the many programs that rural communities may be able to take advantage of as they work toward building a stronger workforce, a more resilient economy, and making climate-smart investments. The USDA Rural Development Innovation Center, in partnership with the US Department of Energy, US Department of Treasury, the Environmental Protection Agency, and the Economic Development Agency, created these guides to be a quick-reference tool to aid stakeholders in their search for funding opportunities.

- Selected Federal Support for Clean Energy by Potential Uses | English (/web/20241225042744/https://www.rd.usda.gov/media/file/download/usda-federalsupportforcleanenergypotentialuses508-english.pdf) | Espanol (/web/20241225042744/https://www.rd.usda.gov/media/file/download/usda-seleccion-de-ayudas-federales-la-energia-limpia-por-usos-potenciales-508.pdf)
- Selected Federal Support for Clean Energy by Applicant Types | English (/web/20241225042744/https://www.rd.usda.gov/media/file/download/usda-federalsupportforcleanenergyapplicanttype508-english.pdf) | Espanol (/web/20241225042744/https://www.rd.usda.gov/media/file/download/usda-seleccion-de-ayudas-federales-las-energias-limpias-por-tipos-de-solicitantes-508.pdf)

Live version as of 2/20/2025

An official website of the United States government Here's how you know

USDA Rural Development
U.S. DEPARTMENT OF AGRICULTURE

Oops! File Not Found

## Perhaps you were looking for one of these areas?

### Programs & Services (/programs-services)

All Programs (/programs-services/all-programs)

Loan Turn Times (/page/sfh-guaranteed-lender)

Lender Training (/page/usda-linc-training-resource-library)

### Newsroom (/newsroom)

News Releases (/newsroom/news-releases)

Stakeholder Announcements (/newsroom/stakeholder-announcements)

Funding Opportunities (/newsroom/federal-funding-opportunities)

### Resources (/resources)

Publications (/resources/publications)

Regulations and Guidance (/resources/regulations)

Handbooks (/resources/directives/handbook

## Still need help? Try our general contact information (/browse-state) or email rdwebmaster@usda.gov (mailto:rdwebmaster@usda.gov) for technical assistance.

# EXHIBIT N

Live version as of 2/20/2025

# Climate-Smart Agriculture and Forestry Mitigation Activities and Inflation Reduction Act Funding

## Frequently Asked Questions

The Inflation Reduction Act provides historic investments ($19.5 billion) to support producers in adopting climate-smart mitigation practices that can sequester carbon and reduce key greenhouse gas emissions like nitrous oxide, methane, and carbon dioxide. Inflation Reduction Act funding began in fiscal year 2023 and must be finalized by September 30, 2031.

### 1. What is the significance of Climate-Smart Agriculture and Forestry Mitigation Activities for implementing Inflation Reduction Act funding through the Environmental Quality Incentives Program and the Conservation Stewardship Program?

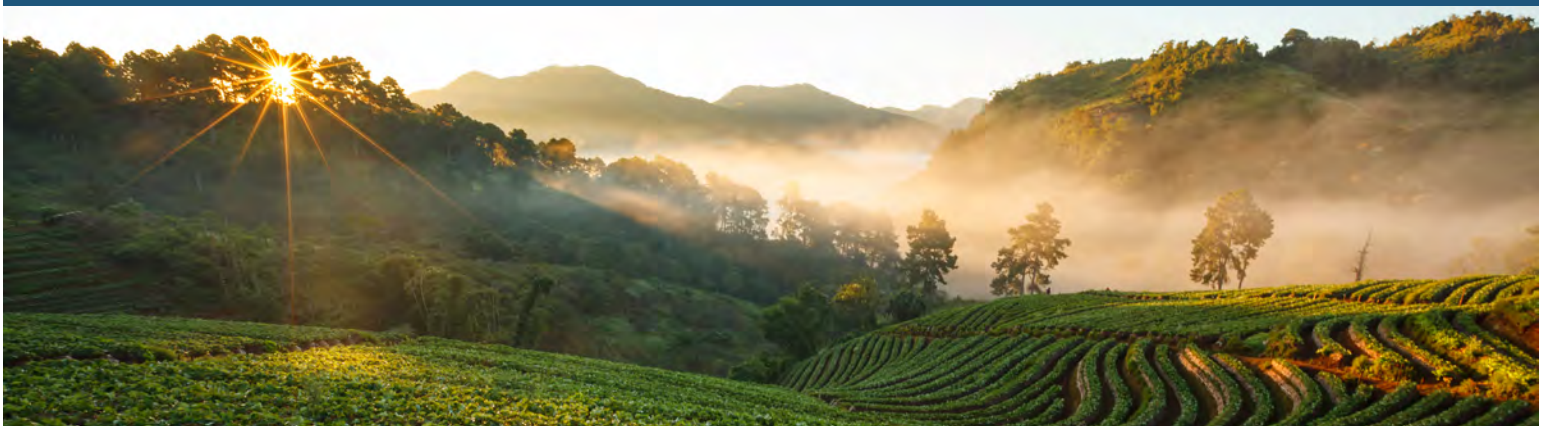
The conservation activities (conservation practice or enhancement) on the **NRCS Climate-Smart Agriculture and Forestry Mitigation Activities List** all provide climate change mitigation benefits (reduction in greenhouse gas emissions or increase in carbon sequestration). These activities are eligible to receive funding through the Inflation Reduction Act because, based on scientific literature, they are expected to directly improve soil carbon; reduce nitrogen losses; or reduce, capture, avoid, or sequester carbon dioxide, methane, or nitrous oxide emissions associated with agricultural production. The Inflation Reduction Act provides $19.5 billion in additional funding to existing conservation programs already popular with producers, like the Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program (CSP), Agricultural Conservation Easement Program (ACEP), Regional Conservation Partnership Program (RCPP) and Conservation Technical Assistance (CTA), to implement climate-smart mitigation practices. Inflation Reduction Act funds may also be used for facilitating practices that support the management or the function of Climate-Smart Agriculture and Forestry Mitigation Activities.

### 2. Does the Climate-Smart Agriculture and Forestry Mitigation Activities List apply to the Regional Conservation Partnership Program (RCPP) projects funded by the Inflation Reduction Act?

According to the Inflation Reduction Act, RCPP is directed to *prioritize* projects with climate change mitigation benefits. The RCPP projects funded by the Inflation Reduction Act are selected because of their potential climate mitigation benefits and should include listed activities that are expected to provide those benefits. While RCPP contracts are not required to exclusively use the Climate-Smart Agriculture and Forestry Mitigation Activities List, use of listed activities is encouraged to support the goals of the Inflation Reduction Act. For RCPP easements, NRCS will prioritize forest, wetland, and grassland easements that protect land and habitats that are or will be in permanent vegetative cover, are located on soils high in organic carbon, or will be managed to contribute to carbon sequestration.

### 3. How does the Natural Resources Conservation Service estimate the impact of Climate-Smart Agriculture and Forestry Mitigation Activities?

USDA's Natural Resources Conservation Service (NRCS) uses methodologies such as those used in **COMET-Planner** to quantitatively estimate the potential mitigation benefits of a practice and determine the potential impact of these Inflation Reduction Act investments.



## 4. What is the process NRCS uses for adding or removing practices on the Climate-Smart Agriculture and Forestry Mitigation Activities List?

Each year, NRCS considers and evaluates the practices on the **Climate-Smart Agriculture and Forestry Mitigation Activities List**. Throughout the year, NRCS receives feedback from partners and staff, which is used to identify practices for consideration to be removed or added. Using this feedback, the NRCS Climate Office works with subject matter experts, including the NRCS National Discipline Leads (such as the National Agronomist, National Environmental Engineer, and National Air Quality Specialist), to review feedback and literature and prioritize practices that would be most suitable for consideration. Evaluation teams, composed of employees across NRCS and an external-to-NRCS USDA participant, evaluate the practice based on the identified criteria and available scientific literature for the practice. Climate-Smart Agriculture and Forestry Mitigation Activities are evaluated against two main criteria: (1) The activity must result in a direct impact on net greenhouse gas emission reduction or removal within a given scope as supported by the scientific literature, and (2) NRCS must have a science-based methodology for quantitatively estimating mitigation benefits using available NRCS activity data. Evaluation team recommendations for removals or additions are then presented to NRCS leadership for final approval for the next fiscal year. The NRCS Climate Office will continue to refine this approach to be sure it is both science-based and incorporates locally led feedback where possible. The list is updated each fiscal year. NRCS is currently working towards announcement of the updates to the list for fiscal year 2025 prior to the start of the fiscal year to inform that year's program signups.

## 5. What is a provisional activity?

Provisional activities and their associated enhancements are added to the **Climate-Smart Agriculture and Forestry Mitigation Activities List** and eligible for Inflation Reduction Act funding under the premise that they may provide mitigation benefits, and a quantification methodology will be evaluated during the fiscal year. Practices may be removed from the mitigation activities list in a subsequent fiscal year if quantification is not possible.

## 6. Why was Upland Wildlife Habitat Management (Code 645) removed from the Climate-Smart Agriculture and Forestry Mitigation Activities List for fiscal year 2024?

Upland Wildlife Habitat Management (Code 645) was historically included as a Climate-Smart Agriculture and Forestry Mitigation Activity due to a nominal mitigation benefit associated with improvements to and establishment of vegetation plantings for improving upland wildlife habitat. Currently, this practice is limited to management activities that are not included in other practices, such as habitat monitoring and management. As such, it would currently not be used to establish vegetation (other than seasonal, typically annual cover). While Upland Wildlife Habitat Management (Code 645) may guide the implementation of certain other practices, it is not the practice through which implementation occurs and to which mitigation benefits could be attributed. Vegetation establishment components previously under Upland Wildlife Habitat Management are currently implemented instead under Wildlife Habitat Planting (Code 420) or Conservation Cover (Code 327), which are currently recognized as Climate-Smart Agriculture and Forestry Mitigation Activities.

## 7. What does it mean if a practice is listed with a specific implementation?

This means the practice is considered a mitigation activity only when implemented in a specified way. These are described in the **Climate-Smart Agriculture and Forestry Mitigation Activities List for FY2024**.

## 8. Under what circumstances will Inflation Reduction Act funds be used to fund irrigation activities through the Environmental Quality Incentives Program and the Conservation Stewardship Program?

Several irrigation practices were added with the expectation that when implemented in a specific way, they can result in energy savings that, in most cases, would lead to emission reductions. To provide the expected emissions reductions, these practices are only applicable when changes are made to an existing system that is powered by a fossil fuel-based energy source. The practices are not to be used for implementation of a new irrigation system and must not result in increased irrigated acres. Planners must consider local energy sources when planning the practice as a Climate-Smart Agriculture and Forestry Mitigation Activity to ensure that the existing system is powered by a fossil fuel-based energy source.

## 9. Under what circumstances will Inflation Reduction Act funds be used to fund livestock manure management activities through the Environmental Quality Incentives Program and the Conservation Stewardship Program?

Manure management is a major source of methane emissions within the agricultural sector and is therefore an important opportunity for significant climate change mitigation. When compared to a typical liquid storage system or uncovered lagoon, the identified practices on the Climate Smart Agriculture and Forestry Mitigation Activities List are expected to provide emissions reductions from methane. Livestock manure management activities can only be funded through Inflation Reduction Act for specific purposes:

- To implement a Composting Facility (Code 317), which can lead to reduced methane emissions from the increased higher temperatures and more aeration during composting.
- To implement a Compost-Bedded Pack system, under the practice Waste Storage Facility (Code 313), which can lead to reduced methane emissions resulting from the added carbonaceous bedding material and regularly tilling to promote composting.
- To install a cover to capture biogas from anaerobic lagoons or liquid storage systems, under the practice Roofs and Covers (Code 367), which can lead to reduced methane emissions as biogas is captured and either flared or used as a natural gas substitute.
- To install an Anaerobic Digester (Code 366), which can reduce emissions by capturing biogas and combusting it for energy generation or flaring it.
- To install a Waste Separation Facility (Code 632), which removes solids from manure streams to potentially reduce methane generated from the storage lagoon.

## 10. What is the difference between climate change mitigation and climate change adaptation and what can the Inflation Reduction Act fund?

Climate change mitigation addresses the root causes of climate change, while adaptation focuses on resilience to the consequences of climate change. Mitigation is making the impacts of climate change less severe by preventing or reducing the emission of greenhouse gases into the atmosphere. Adaptation is the process of adjusting to the current and future effects of climate change. While the Inflation Reduction Act requires funds to be used for climate change mitigation activities, some of those same practices may also support adaptation. Through its conservation programs, NRCS also provides support to producers to help them adapt to the climate change impacts they face, such as increased drought, extreme weather, or seasonal shifts.

## 11. Why aren't all conservation activities eligible to receive Inflation Reduction Act funding through the Environmental Quality Incentives Program and the Conservation Stewardship Program?

While all conservation activities provide important benefits to address natural resource concerns, not all practices provide the climate change mitigation benefits required by the **Inflation Reduction Act**. Under the law, only conservation activities that have climate change mitigation benefits are eligible to receive Inflation Reduction Act funding. Farm Bill funding is available for conservation programs to help producers implement conservation activities that may not meet Inflation Reduction Act requirements.

## 12. What was the public input process for the fiscal year 2024 list and how can the public provide input on what should or should not be considered climate change mitigation activities for fiscal year 2025?

To inform the current fiscal year 2024 list, NRCS published a **Request for Information (RFI) in the Federal Register during fiscal year 2023**. Through this RFI, NRCS requested public input to inform how the agency should implement funds received under the Inflation Reduction Act to fund the deployment of climate-smart mitigation practices on U.S. farms, ranches, and forestlands through its four Farm Bill conservation programs. Public comment received through this RFI was used to inform priorities for both the fiscal year 2024 Climate-Smart Agriculture and Forestry Mitigation Activities List and the implementation of other NRCS Inflation Reduction Act activities.

NRCS collects input throughout the year, however **input for the fiscal year 2025 list should be provided no later than June 7, 2024**. Input can be provided in several ways – locally to the Local Working group (a subcommittee of the State Technical Committee), at the state level to the **State Technical Committee**, and nationally via formal requests for information or by emailing the NRCS Climate Office at **SM.FPAC.NRCS.CLIMATE@usda.gov**. NRCS plans to establish additional opportunities for external input that will be shared broadly, including on the NRCS **Climate-Smart Mitigation Activities Webpage.**

## 13. Can Climate-Smart Agriculture and Forestry Mitigation Activities only be implemented using Inflation Reduction Act funds?

No. All conservation practices and activities are eligible to receive funding through NRCS's conservation programs. The Inflation Reduction Act provides additional funding to these programs to be used only for or prioritizing climate-smart mitigation activities. However, Climate-Smart Agriculture and Forestry Mitigation Activities could also be funded through existing Farm Bill funding through these programs. This results in more climate-smart mitigation practices being implemented. Since NRCS receives far more applications than there is available funding, Inflation Reduction Act funds are helping more customers meet their conservation goals while also helping mitigate climate change.

## 14. Where can I go for more information?

As with any conservation assistance, visit your local **USDA Service Center** to meet one-on-one with an NRCS conservation planner. Information about the Inflation Reduction Act is available on the **NRCS Inflation Reduction Act page** at nrcs.usda.gov/about/priorities/inflation-reduction-act. More details about climate-smart activities – including short videos featuring producers implementing these activities, as well as the list of activities and descriptions – are available on the NRCS **Climate-Smart Mitigation Activities page**.



USDA is an equal opportunity provider, employer, and lender. nrcs.usda.gov

# EXHIBIT O

Archived version as of 01/15/2025

Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Bureau of Land Management
U.S. DEPARTMENT OF THE INTERIOR

FS-1215a | April 2024 (revised)

# **Mature and Old-Growth Forests:** Definition, Identification, and Initial Inventory on Lands Managed by the Forest Service and Bureau of Land Management

## in Fulfillment of Section 2(b) of Executive Order No. 14072



In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at How to File a Program Discrimination Complaint and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

# Contents


1 **Executive Summary**

2 **Contributors**

2 Technical Team

2 Executive Team

2 USDA Forest Service Extended Team

3 **Introduction**

5 **Results**

5 Narrative Frameworks and Working Definitions

5 Old-Growth Forest Narrative Framework

5 Mature Forest Narrative Framework

6 Working Definitions

6 Old-growth and Mature Forest Initial Inventory Estimates

14 Old-Growth and Mature Forest Maps

15 Background

15 Old-Growth and Mature Forest Definition Chronology

16 Old-Growth and Mature Forests Executive Actions and Legislation

17 Tribal, Stakeholder, and Public Perspectives

19 Definition Development

20 Old-Growth Definition Development

21 Mature Forest Definition Development

24 FIGSS Method for Mature Forest Definitions

26 Estimation

27 Geospatial Display

28 **Discussion**

28 Context and Relation to Other Estimates

28 Appropriate Use of Data

30 Assumptions and Limitations

30 Stages of Stand Development

30 FIA Limitations for Old-Growth and Mature Inventory

31 Refinements and Opportunities for Future Research

32 **Next Steps**

33 **Acknowledgements**

33 **Literature Cited**

38 **Appendix 1: Old-Growth Working Definitions**

38 Northern Region (Region 1)

41 Rocky Mountain Region (Region 2)

42 Southwestern Region (Region 3)

44 Intermountain Region (Region 4)

46 Pacific Southwest Region (Region 5)

48 Pacific Northwest Region (Region 6)

50 Southern Region (Region 8)

52 Eastern Region (Region 9)

52 Alaska Region (Region 10)

54 **Appendix 2: Mature Forest Working Definitions**

66 **Appendix 3: Area (acres) of Old-growth and Mature Forest Land by Fireshed**

67 **Appendix 4: FIA Evaluations and Inventory Years for Each State**

69 **Appendix 5: Public Comment and Response Summary**

# Figures


8 **Figures 1a and 1b.**—Distribution of forested land managed by the BLM and Forest Service, respectively, in old-growth, mature, and younger forest classes by congressionally designated land allocations.

12 **Figures 2a and 2b.**—Proportion of forested land in old-growth, mature, and younger forest classes, Forest Service regions and BLM State offices respectively.

13 **Figure 3.**—Area (acres) of combined Forest Service and BLM old-growth, mature, and younger forest by FIA forest type group.

14 **Figure 4.**—Contiguous United States fireshed map of mature and old-growth area (acres) on Forest Service and BLM lands.

23 **Figure 5.**—Four-stage forest development model for several ecosystem archetype examples.

24 **Figure 6.**—Fundamental components of the FIGSS approach.


# Tables


7 **Table 1.**—National total area (acres) of mature and old-growth forest land on Forest Service and BLM lands, shown by Congressionally designated land-use allocations.

10 **Table 2.**—Area (acres) of mature and old-growth forest land by FIA forest type group, shown in alphabetical order.

25 **Table 3.**—Structural indicator variables used in mature forest definitions.

26 **Table 4.**—Geospatial layers used to attribute FIA plots for inventory reporting.

39 **Table 5.**—Northern Region old-growth forest types and minimum criteria thresholds for old-growth status for the Northern Idaho Zone.

40 **Table 6.**—Northern Region old-growth forest types and minimum criteria thresholds for old-growth status for the Western Montana Zone.

40 **Table 7.**—Northern Region old-growth forest types and minimum criteria thresholds for old-growth status for the Eastern Montana Zone.

41 **Table 8.**—Rocky Mountain Region forest types with old-growth definitions, their corresponding FIA forest type groups, and mimumum thresholds.

42 **Table 9.**—Southwestern Region ecological response units and their old-growth minimum criteria.

43 **Table 10.**—Ecological response units (ERUs) and the corresponding habitat type codes on Southwestern Region FIA plots.

44 **Table 11.**—Intermountain Region old-growth types and minimum criteria.

46 **Table 12.**—Pacific Southwest Region old-growth types, FIA forest type codes, and minimum criteria.

48 **Table 13.**—Pacific Northwest Region, Northwest Forest Plan area old-growth forest types and minimum threshold for old-growth status.

49 **Table 14.**—Pacific Northwest Region old-growth criteria outside the Northwest Forest Plan area.

50 **Table 15.**—Southerm Region old-growth community types and minimum criteria.

51 **Table 16.**—FIA forest type codes cross-walked to Southern Region old-growth community types (each FIA observation was classified as old growth if it met criteria for any matched old-growth community type).

52 **Table 17.**—Eastern Region old-growth community types, corresponding FIA forest types, and large tree diameter and density and stand age minima.

53 **Table 18.**—Alaska Region old-growth forest types and minimum threshold for old-growth status.

54 **Table 19.**—Working definitions for mature forest as applied to FIA data for the national old-growth and mature forest inventory (definitions were applied to each FIA plot record based on the Forest Service region and mature vegetation class).

67 **Table 20.**—FIA evaluations and inventory years for each State from FIA data used in the national inventory.

# Executive Summary

Lands managed by the U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management (BLM) contain more than 178 million acres of forest and provide a variety of ecological, social, cultural, Tribal, and economic values. Among these values are those provided by older forests, sometimes referred to as old-growth and mature forests. The terms 'old-growth' forest and 'mature' forest have not been consistently defined. Correspondingly, the national extent of old-growth and mature forests on lands managed by the Forest Service and BLM has not been previously inventoried by these agencies.

This report was developed in response to Executive Order (E.O.) 14072, which required the Forest Service and BLM to define and inventory old-growth and mature forest on lands managed by the agencies. This report is national in scale and presents initial estimates of old-growth and mature forests across all Forest Service and BLM lands. This report contains the first national inventory of old-growth and mature forests focused specifically on Forest Service and BLM lands and demonstrates that both old-growth and mature forests are generally widely distributed geographically and across land-use allocations.

The definitions of old-growth and mature forests are presented in two forms. *Narrative frameworks* are descriptive, general definitions of old-growth and mature forests that can be used consistently across geographic scales and forest types. *Working definitions* provide detailed quantitative criteria, using measureable structural characteristics that were applied to specific regions and forest types in this national-scale inventory.

Based on the working definitions used in this initial inventory, Forest Service and BLM lands collectively contain 33.1 +/- 0.4 million acres[1] of old-growth and 80.8 +/- 0.5 million acres of mature forest. Old-growth forest represents 19 percent and mature forest another 45 percent of all forested land managed by the two agencies. This initial national-scale inventory was conducted by applying the old-growth and mature working definitions to Forest Inventory and Analysis (FIA) field plot data.

Like all of the Nation's forests, old-growth and mature forests are threatened by climate change and associated stressors. The initial inventory and definitions for old-growth and mature forests are part of an overarching climate-informed strategy to enhance carbon sequestration and address climate-related impacts to forests, including insects, disease, wildfire risk, and drought. Initial inventory results will be used to analyze threats to these forests, which will allow consideration of appropriate climate-informed forest management, which is also required by E.O. 14072.

[1] Sampling error at 68 percent confidence level.

# Contributors

## Technical Team

Scott Barndt, U.S. Department of Agriculture, Forest Service

Andrew Gray,* U.S. Department of Agriculture, Forest Service

Greg Hayward, U.S. Department of Agriculture, Forest Service

Christopher Hiemstra, U.S. Department of Agriculture, Forest Service

Aaron Kamoske, U.S. Department of Agriculture, Forest Service

Shanna Kleinsmith, U.S. Department of Agriculture, Forest Service

Joseph Krueger, U.S. Department of Agriculture, Forest Service

Marin Palmer,** U.S. Department of Agriculture, Forest Service

Kristen Pelz, U.S. Department of Agriculture, Forest Service

Wade Salverson,* U.S. Department of the Interior, Bureau of Land Management

Thomas Schuler, U.S. Department of Agriculture, Forest Service

Chris Schumacher, U.S. Department of the Interior, Bureau of Land Management

Kari Tilton, U.S. Department of Agriculture, Forest Service

Christopher Woodall, U.S. Department of Agriculture, Forest Service

## Executive Team

Jamie Barbour, Project Leader, U.S. Department of Agriculture, Forest Service

Chris Swanston, U.S. Department of Agriculture, Forest Service

David Lytle, U.S. Department of Agriculture, Forest Service

Linda Heath, U.S. Department of Agriculture, Forest Service

Peter Nelson, Overstory Strategies

Susanne Tracy, U.S. Department of Agriculture, Forest Service

## USDA Forest Service Extended Team

Joanne Baggs, Jock Blackard, Ramona Butz, Brie Darr, Raymond Davis, Andrew Graves, Kathryn Heard, Chelsea Leitz, Ariel Leonard, Megan Lowell, James Mcfarland, Natalie Morgan, Amy Nathanson, Stephanie Rebain, Priya Shahani, Benjamin Soderquist, Paul Strong, Jack Triepke, James Youtz, and Damien Zona.

* Team members that contributed on both the Technical Team and Executive Team.
** Team leader.

# Introduction

**E.O. 14072 (also known as "Strengthening the Nation's Forests, Communities, and Local Economies") instructed the Department of the Interior, Bureau of Land Management (BLM) and U.S. Department of Agriculture (USDA), Forest Service to define and inventory old-growth and mature forest for lands managed by the agencies. The old-growth and mature definition, identification criteria, and resulting initial inventory reported here meet this direction and identify these forests in a consistent way at a national scale.**

E.O. 14072 includes a series of actions intended to foster resilience in the Nation's forests during an era of rapidly changing climate. It highlights the critical role forests play in slowing the pace of climate change, conserving biodiversity, supporting local communities through recreation and sustainable forest products, and enabling subsistence and cultural uses of forest resources. The Executive order calls particular attention to the benefits provided by old-growth and mature forests on Federal lands, including their substantial contributions to carbon storage. While old-growth and mature forests are important as nature-based climate solutions, these forests are simultaneously at risk from climate-related stressors and disturbances. Effective stewardship of old-growth and mature forests requires climate-informed land management to reduce risks to these systems and sustain their critical ecosystem services.

Federal public lands support a substantial amount of forest. Lands managed by the BLM and the Forest Service include more than 178 million acres that meet the Forest Inventory and Analysis (FIA)[2] forest land definition: forest lands that currently (or recently) have at least 10 percent canopy cover and are at least 1 acre in size (Burrill et al. 2021). Old-growth and mature forests look dramatically different from coast-to-coast, State by State, and locally. For instance, old-growth sequoias in California can be thousands of years old and upwards of 250 feet tall with a 30-foot or greater trunk diameter, while an old-growth stand of dwarf pitch pine in New Jersey may include trees that are hundreds of years old, roughly 14 feet tall and only several inches in diameter. These differences underscore the complexity and need to define old-growth and mature forest.

Tribes, stakeholders, and the public hold many different values for old-growth and mature forests. There are also key ecological processes and characteristics associated with different forests. Creating a framework that accounts for these diverse values and perspectives is challenging (Pesklevits 2011, Wirth et al. 2009). Additionally, the ecological literature contains definitions of mature forest for only a few forest types, and a universal definition of either old-growth or mature forests is difficult to create (Wirth et al. 2009). Tree age, size, and carbon storage capacity differ dramatically across old-growth and mature forest types depending on species, local ecosystems, site conditions, and more. Despite these challenges, a common understanding of which forests are old-growth or mature, and the extent

[2] The Forest Inventory and Analysis Program of the USDA Forest Service provides the information needed to assess America's forests (https://www.fia.fs.usda.gov/).

of these forests on lands managed by the BLM and Forest Service, is the foundation for assessing the status, condition, and restoration needs of these ecosystems to mitigate the effects of climate change on them.

Section 2(b) of E.O. 14072 specifically addresses old-growth and mature forest definitions and inventory:[3]

> **The Secretary of the Interior, with respect to public lands managed by the Bureau of Land Management, and the Secretary of Agriculture, with respect to National Forest System lands, shall, within 1 year of the date of this order, define, identify, and complete an inventory of old-growth and mature forests on Federal lands, accounting for regional and ecological variations, as appropriate, and shall make such inventory publicly available.**

The old-growth and mature definitions, identification criteria, and resulting initial inventory reported here meet this requirement and identify, at a national scale, the geographic extent and distribution of these forests. The initial inventory will then be used to assess threats to these forests, which will allow consideration of appropriate climate-informed forest management, as required by subsequent sections of the Executive order.

E.O. 14072 discusses "mature and old-growth" forests, with mature coming before old-growth. However, this document discusses old-growth forests before mature forests, because people have long recognized unique old-growth values, and more definitions and local-scale inventories existed for old-growth forests prior to the Executive order. Mature forests have not previously been ecologically defined in a consistent way at a national scale, and in this effort, they are explicitly linked to corresponding old-growth definitions.



**Forest stand managed for public recreation on the Flathead National Forest, Montana. USDA Forest Service photo by Elisa Stamm.**

[3] Throughout this report 'inventory' refers to an accounting of the extent (area) of mature and old-growth forest based on a structured estimation system.

# Results

## Narrative Frameworks and Working Definitions

### Old-Growth Forest Narrative Framework

Old-growth forests are dynamic systems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics, which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function (USDA Forest Service 1989).

In addition to their ecological attributes, old-growth forests are distinguished by their ecosystem services and social, cultural, and economic values. Old-growth forests have place-based meanings tied to cultural identity and heritage; local economies and ways of life; traditional and subsistence uses; aesthetic, spiritual, and recreational experiences; and Tribal and Indigenous histories, cultures, and practices. Dialogue with stakeholders and Tribal Nations and integration of local and Indigenous Knowledge[4] with evolving scientific understanding are critical in identifying and stewarding old-growth forests.

### Mature Forest Narrative Framework

Mature forests are delineated ecologically as the stage of forest development immediately before old growth. Mature forests exhibit structural characteristics that are lacking in earlier stages of forest development and may contain some but not all the structural attributes in old-growth forests. The mature stage of stand development generally begins when a forest stand moves beyond self-

**Despite the complex and multifaceted nature of old-growth and mature forests, the Forest Service and BLM are tasked with creating clear narratives and working definitions. We expect to further refine old-growth and mature forest definitions as we gain experience applying the initial criteria.**

**Narrative frameworks establish common definitions for old-growth and mature forests that can be used across forest types. They provide a consistent national framework that has stability and longevity, even as working definitions in specific forest types are refined over time.**

**Working definitions apply quantitative measurement criteria to structural characteristics and fit under the umbrella of the narrative frameworks, reflecting the diversity of forest development in unique forest types. Old-growth and mature working definitions for over 200 regional vegetation types can be viewed in appendix 1 and appendix 2.**

[4] Indigenous Knowledge is a body of observations, oral and written knowledge, innovations, practices, and beliefs developed by Tribes and Indigenous Peoples through interaction and experience with the environment.

thinning, starts to diversify in height and structure, and/or the understory begins to reinitiate. Structural characteristics that mark the transition from an immature to mature forest are unique to each forest type. Characteristics may include but are not limited to abundance of large trees, large tree stem diameter, stem diameter diversity, horizontal canopy openings or patchiness, aboveground biomass accumulation, stand height, presence of standing and/or downed boles, vertical canopy layers, or a combination of these attributes.

Mature forests vary widely in character with age, geographic location, climate, site productivity, and characteristic disturbance regime. The social, cultural, and economic values ascribed to these forests also vary widely. Dialogue with stakeholders and Tribal Nations and integration of local and Indigenous Knowledge with evolving scientific understanding are critical in effectively managing mature forests.

### Working Definitions

The working definitions include quantitative measurement criteria reflecting structural characteristics that fit within the umbrella of both narrative frameworks. Just as old-growth forest definitions have evolved during the past three decades, the working definitions presented in this report will be refined as new science, Indigenous Knowledge, continued stakeholder engagement, and social processes provide new data and information. Working definitions have been applied to FIA data at the national scale for the purpose of this initial national-level inventory. Further refinement may be necessary to apply working definitions at local scales due to diverse ecology, forest types, site characteristics, and varied management contexts. The complete initial old-growth and mature forest working definitions for more than 200 unique forest vegetation types within each Forest Service region (hereafter, regional vegetation types) are in appendix 1 and appendix 2, respectively.

## Old-growth and Mature Forest Initial Inventory Estimates

Old-growth and mature forests cover the majority of forest lands managed by the Forest Service and BLM. Between 30 and 40 percent of Forest Service and BLM forested areas are younger forests[5] that are neither mature nor old growth. Both old-growth and mature forests are distributed across all land-use allocations,[6] with similar proportions in congressionally designated areas (such as National Recreation Areas, National Conservation Areas, and Wilderness) as in other land-use allocations (table 1) (figures 1a and 1b). The patterns in old-growth distributions in the eastern United States, western United States, and Alaska are consistent with the history of management and disturbance in those areas: intensive forest harvest in the east, large areas of intact primary forest in Alaska, and similar patterns across most Forest Service regions in the western

[5] "Younger forest" is used here to designate forests that did not meet the criteria for old growth or mature. Some FIA plots classified as younger forest may have old trees or an older stand age in the FIA database.

[6] A defined area of land to which specific management direction is applied.

United States (figures 2a and 2b). The eastern United States has the largest proportion of mature forests, because many of these forests were harvested before their declaration as national forests. In some cases, eastern forests do not reflect historic species composition, due to their disturbance history (such as non-native pine plantations and loss of species such as American chestnut).

The highest proportion of old-growth forest on BLM lands is found in Utah and Nevada, where pinyon-juniper is the prevalent forest type, followed by Alaska with its large areas of intact primary forest (figure 3b). The proportions of mature forest and younger forest are more variable across BLM State offices than across Forest Service regions, with the highest proportional land area of younger forests occurring on BLM's California and Montana State offices.

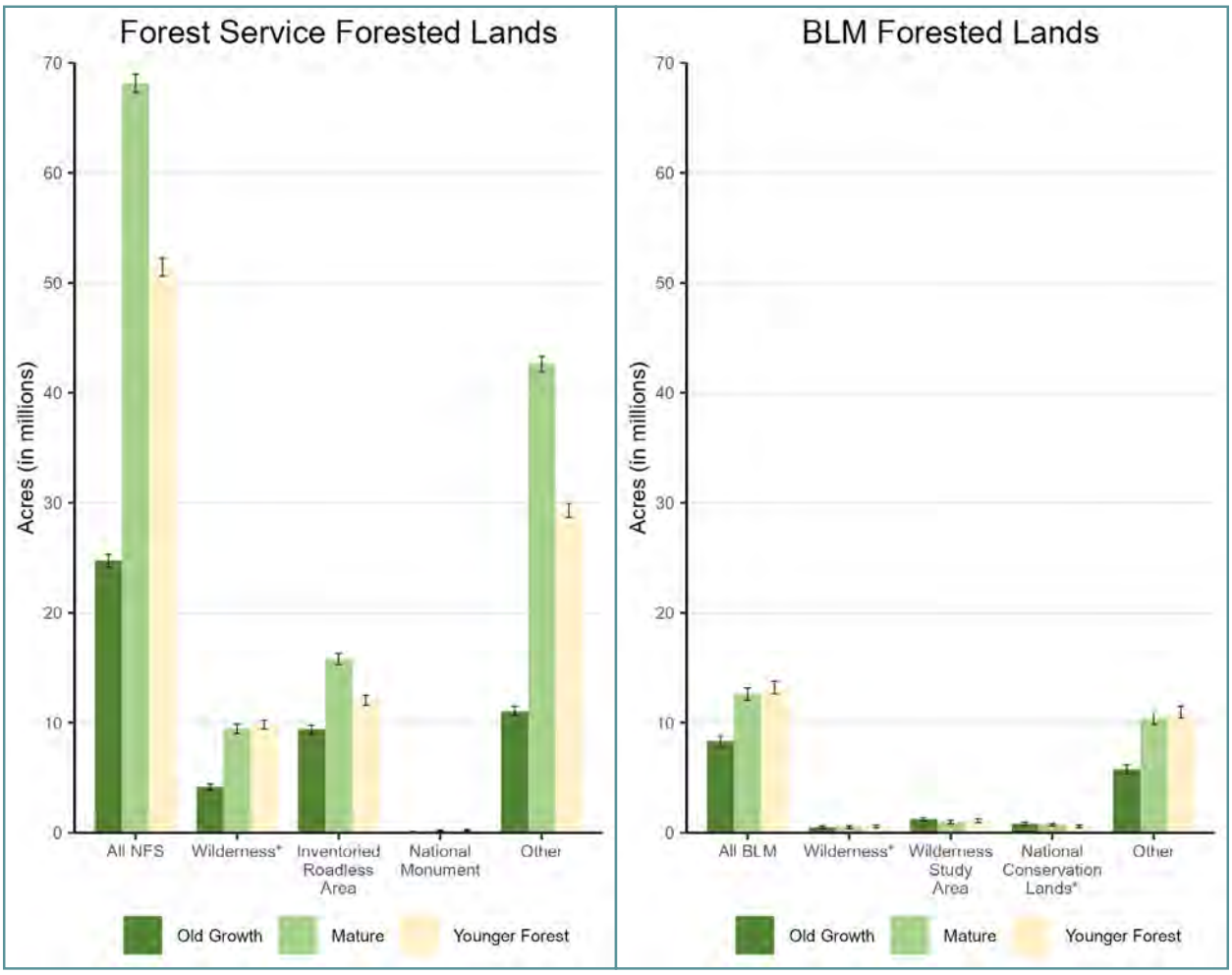
**Table 1.**—National total area (acres) of younger, mature, and old-growth forest land[a] on Forest Service and BLM lands, shown by congressionally designated land-use allocations. "Other" category includes all remaining land-use allocations.

| Agency & Land Use Allocation | Forest (not mature or old growth) | | Mature | | Old Growth | | Total Forest Land[a] |
|---|---|---|---|---|---|---|---|
| | *acres* | *SE%[b]* | *acres* | *SE%[b]* | *acres* | *SE%[b]* | *acres* |
| **Forest Service** | **51,452,872** | **1** | **68,136,957** | **1** | **24,738,364** | **1** | **144,328,194** |
| Wilderness[c] | 9,827,808 | 2 | 9,424,208 | 2 | 4,161,985 | 3 | 23,414,001 |
| Inventoried Roadless Area | 12,007,981 | 2 | 15,697,393 | 2 | 9,380,903 | 2 | 37,086,277 |
| National Monument | 250,113 | 15 | 219,478 | 15 | 88,470 | 26 | 558,061 |
| Other | 29,366,970 | 1 | 42,795,878 | 1 | 11,107,006 | 2 | 83,269,854 |
| **BLM** | **13,218,861** | **2** | **12,619,046** | **2** | **8,331,991** | **3** | **34,169,897** |
| Wilderness | 571,462 | 10 | 507,940 | 11 | 499,884 | 11 | 1,579,287 |
| Wilderness Study Area | 1,107,078 | 7 | 981,046 | 8 | 1,237,693 | 7 | 3,325,816 |
| National Conservation Lands[c] | 563,948 | 10 | 736,268 | 9 | 841,276 | 8 | 2,141,492 |
| Other | 10,976,373 | 2 | 10,393,792 | 3 | 5,753,137 | 4 | 27,123,302 |
| **Total BLM & Forest Service** | **64,671,733** | **1** | **80,756,003** | **1** | **33,070,355** | **1** | **178,498,091** |

[a] Forest land includes areas meeting the FIA forest land definition, https://www.fia.fs.usda.gov/. Sample area excludes 3.4 million acres of forested land managed by the Forest Service and 27.5 million acres of potentially forested land managed by the BLM in Alaska; permanent field plot monumentation is prohibited in Alaska. Forest Service wilderness areas and Interior Alaska have not yet been inventoried by FIA but are in progress for inclusion in future inventories.

[b] SE% is percent sampling error. Estimate plus and minus one sampling error gives a 68% confidence interval.

[c] Forest Service Wilderness includes both Wilderness and Wilderness Study Areas. National Conservation Lands include National Monument, National Conservation Area, and other similar designations, collectively referred to as NM/NCAs.




**Figures 1a and 1b**.—Area distribution (acres) of old-growth, mature, and younger forest on forested land managed by the (a) Forest Service and (b) BLM by congressionally designated land allocations. "Other" category includes all remaining land-use allocations. The first set of bars in each graph represent total forested area for that agency. (Error bars represent 95% confidence intervals, 1.96*SE.)

Although the iconic image of old-growth forest tends to be of moist forests that grow in highly productive coastal areas, extensive areas of old-growth forest occur in pinyon-juniper and other lower productivity forest types (table 2 and figure 3). Nationwide estimates for old-growth and mature forests by FIA forest type group show the most extensive area of both old-growth and mature forests occur in pinyon-juniper forests, followed by fir/spruce/mountain hemlock and Douglas-fir. Pinyon-juniper forest occurs on more than 32 million acres of lands managed by the Forest Service and BLM, with over 9 million and 14 million acres of old-growth and mature forest, respectively. Pinyon-juniper forests cover diverse biophysical settings across the western United States, with 14 distinct old-growth working definitions for this forest type group (appendix 1).



**Old-growth stand on Bitterroot National Forest, Montana that has had management treatment and is still considered old growth by our definitions. USDA Forest Service photo by Shelagh Fox.**

**Table 2.**—Area (acres) of mature and old-growth forest landa by FIA forest type group, shown in alphabetical order. Combined total acres are shown for Forest Service and BLM forested lands.

| FIA Forest Type Group | Younger Forest | | Mature | | Old Growth | | Total Forest Land[a] |
|---|---|---|---|---|---|---|---|
| | *acres* | *SE%[b]* | *acres* | *SE%[b]* | *acres* | *SE%[b]* | *acres* |
| Alder / maple group | 262,323 | 10 | 84,959 | 19 | 49,438 | 29 | 396,720 |
| Aspen / birch group | 3,106,257 | 5 | 3,690,641 | 4 | 1,598,035 | 7 | 8,394,933 |
| California mixed conifer group | 1,159,728 | 7 | 3,051,462 | 4 | 946,922 | 8 | 5,158,112 |
| Douglas-fir group | 8,681,304 | 2 | 9,525,691 | 2 | 3,756,584 | 3 | 21,963,579 |
| Elm / ash / cottonwood group | 266,249 | 12 | 380,120 | 9 | 59,526 | 29 | 705,896 |
| Exotic softwoods group | 2,766 | 78 | 461 | 99 | 0 | 0 | 3,227 |
| Fir / spruce / mountain hemlock group | 8,199,660 | 2 | 13,188,429 | 2 | 7,043,162 | 3 | 28,431,252 |
| Hemlock / Sitka spruce group | 1,138,554 | 6 | 705,597 | 8 | 4,167,232 | 3 | 6,011,383 |
| Loblolly / shortleaf pine group | 1,380,313 | 5 | 2,051,801 | 3 | 42,041 | 30 | 3,474,155 |
| Lodgepole pine group | 3,532,809 | 3 | 6,528,733 | 3 | 1,239,519 | 7 | 11,301,062 |
| Longleaf / slash pine group | 532,953 | 7 | 529,552 | 7 | 138,918 | 15 | 1,201,424 |
| Maple / beech / birch group | 355,143 | 8 | 2,982,911 | 2 | 44,370 | 28 | 3,382,424 |
| Oak / gum / cypress group | 132,162 | 14 | 406,275 | 8 | 10,959 | 47 | 549,396 |
| Oak / hickory group | 1,373,326 | 5 | 6,433,229 | 2 | 919,369 | 6 | 8,725,925 |
| Oak / pine group | 551,365 | 8 | 1,333,214 | 5 | 94,621 | 18 | 1,979,201 |

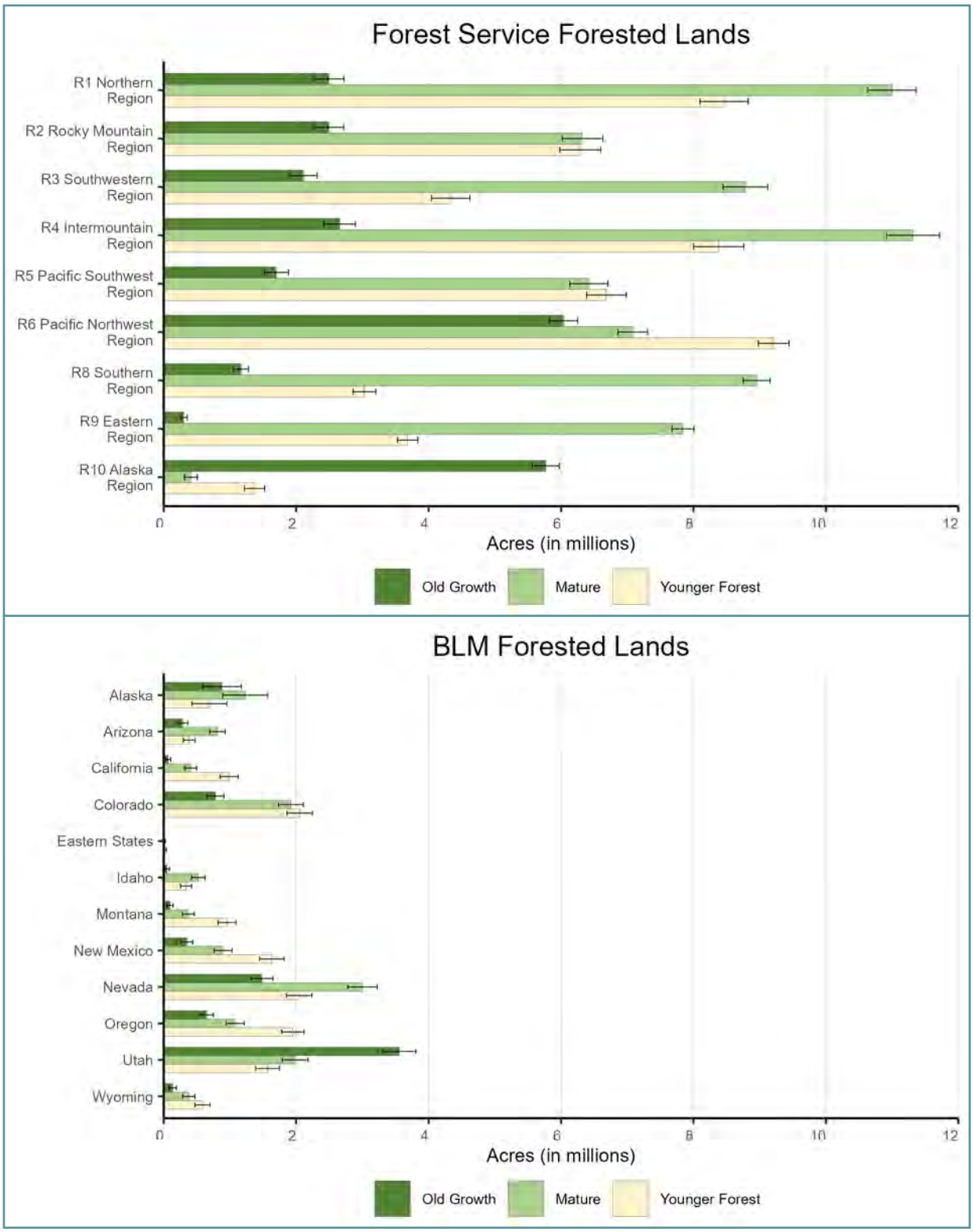
**Table 2.**—Area (acres) of mature and old-growth forest landa by FIA forest type group, continued.

| FIA Forest Type Group | Younger Forest | | Mature | | Old Growth | | Total Forest Land[a] |
|---|---|---|---|---|---|---|---|
| | *acres* | *SE%[b]* | *acres* | *SE%[b]* | *acres* | *SE%[b]* | *acres* |
| Other eastern softwoods group | 46,519 | 28 | 15,630 | 56 | | | 62,149 |
| Other hardwoods group | 483,568 | 10 | 200,451 | 15 | 38,161 | 33 | 722,180 |
| Other western softwoods group | 2,680,810 | 4 | 1,858,822 | 5 | 530,763 | 10 | 5,070,396 |
| Pinyon / juniper group | 7,979,375 | 3 | 14,996,292 | 2 | 9,166,961 | 2 | 32,142,628 |
| Ponderosa pine group | 4,500,420 | 3 | 6,582,797 | 2 | 1,388,303 | 5 | 12,471,520 |
| Redwood group | 0 | 0 | 11,819 | 65 | 9,876 | 75 | 21,695 |
| Spruce / fir group | 1,124,881 | 9 | 2,021,025 | 9 | 760,367 | 17 | 3,906,273 |
| Tanoak / laurel group | 573,486 | 8 | 210,620 | 15 | 138,450 | 18 | 922,556 |
| Tropical hardwoods group | 12,131 | 61 | 0 | 0 | 5,628 | 105 | 17,759 |
| Western larch group | 808,191 | 8 | 196,925 | 13 | 164,160 | 16 | 1,169,276 |
| Western oak group | 2,341,248 | 4 | 846,168 | 8 | 17,197 | 56 | 3,204,613 |
| Western white pine group | 69,982 | 28 | 81,530 | 25 | 20,403 | 48 | 171,915 |
| White / red / jack pine group | 545,573 | 7 | 782,772 | 6 | 71,003 | 18 | 1,399,347 |
| Woodland hardwoods group | 4,158,150 | 4 | 2,058,075 | 5 | 648,386 | 9 | 6,864,611 |
| Nonstocked[c] | 8,672,486 | 2 | 0 | 0 | 0 | 0 | 8,672,486 |
| **Total** | **64,671,733** | **1** | **80,756,003** | **1** | **33,070,355** | **1** | **178,498,091** |

[a] Forest land includes areas meeting the FIA forest land definition, https://www.fia.fs.usda.gov/. Sample area excludes 3.4 million acres of forested Forest Service land and 27.5 million acres of potentially forested BLM land in Alaska; permanent field plot monumentation is prohibited in Alaska. Forest Service wilderness areas and interior Alaska have not yet been inventoried by FIA but are in progress for inclusion in future inventories.

[b] SE% is percent sampling error. Estimate plus and minus one sampling error gives a 68 percent confidence interval.

[c] Nonstocked forest land is land that currently has less than 10 percent stocking but formerly met the definition of forest land. Forest conditions meeting this definition have few, if any, trees sampled.




**Figures 2a and 2b**.—Area (acres) of forested land classified as old-growth, mature, or younger forest by (a) Forest Service Region and (b) BLM State office. (Error bars represent 95% confidence intervals, 1.96*SE.)

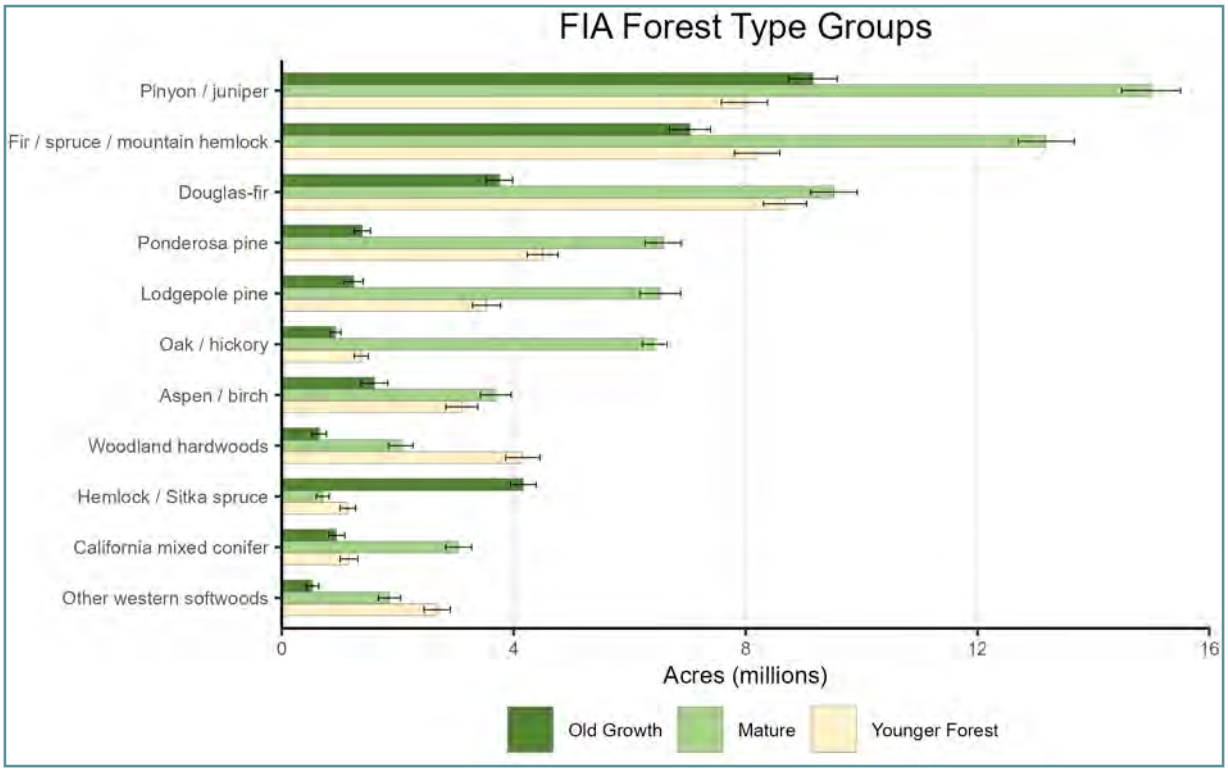



**Figure 3.**—Combined Forest Service and BLM area (in acres) of old-growth, mature, and younger forest by FIA forest type group. Only forest type groups with an area estimate of at least five million acres are shown.



**Old-growth ponderosa pine forest stand on the Fremont-Winema National Forest, Oregon. USDA Forest Service photo.**

# Old-Growth and Mature Forest Maps

Maps for the contiguous United States and Alaska (figure 4) show the estimates of old-growth and mature forest on Forest Service or BLM land (appendix 3) by fireshed polygon. Firesheds are units of roughly 250,000 acres used to evaluate wildfire management and risks to local communities; for this effort and the maps displayed, firesheds have no wildfire context but are simply used as map units.

Firesheds were chosen because the roughly 250,000-acre size of each fireshed is the appropriate scale for statistical inference using FIA plots, fireshed mapping is consistent with other critical Forest Service programs, and it lays the groundwork for repeatable national monitoring of old-growth and mature forests. Nationally, there were 2,447 firesheds with Forest Service or BLM lands that had at least some old-growth or mature forest. Mature estimates within firesheds ranged from 0 to 237,996 acres, old-growth ranged from 0 to 225,302 acres. On average, firesheds contained 32,722 and 13,334 acres of old-growth and mature forest, respectively.

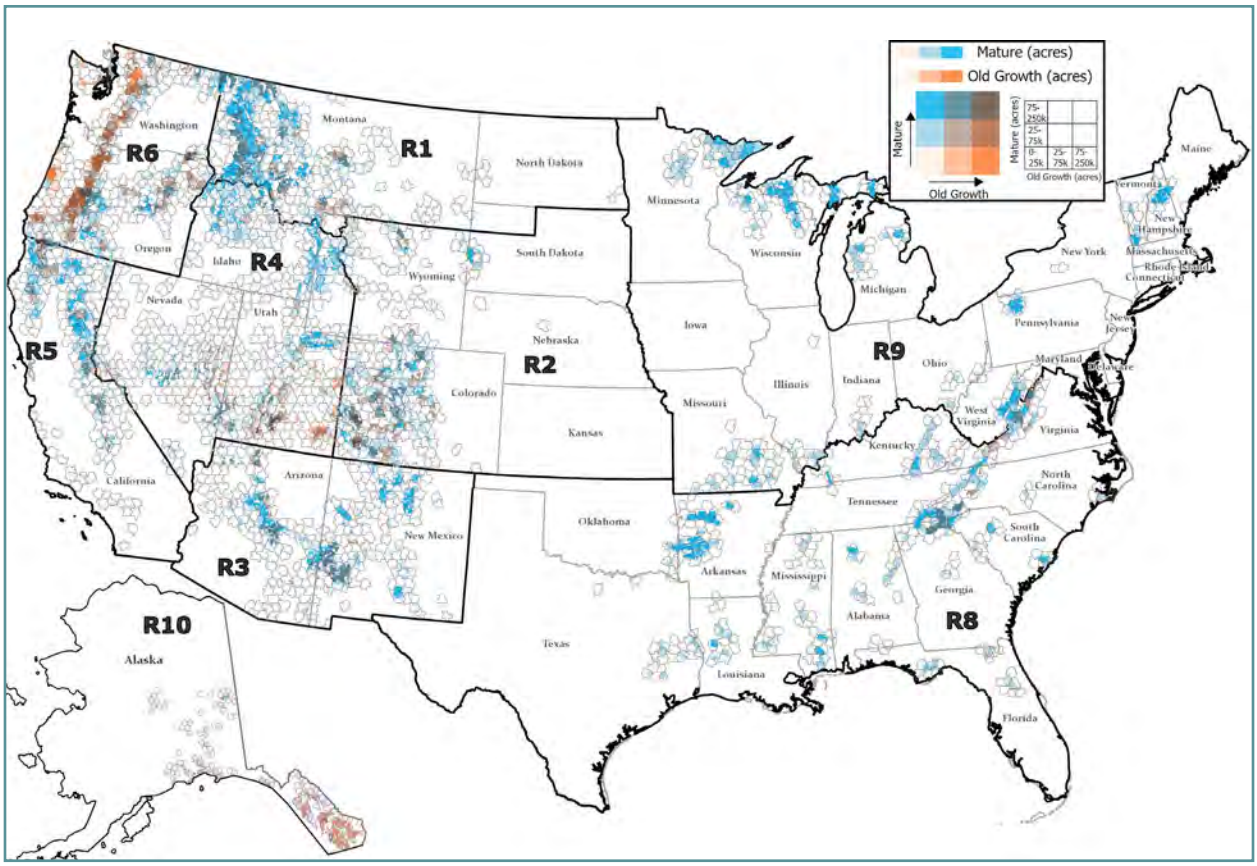



**Figure 4**.—Bivariate map of mature and old-growth acres by fireshed for Forest Service and BLM forested land area, coterminous and coastal Alaska. Only Forest Service and BLM land ownerships are shaded within a fireshed (see appendix 3 for acres of old-growth and mature forest land by fireshed in tabular form).

# Background

## Old-Growth and Mature Forest Definition Chronology

Early attempts at defining old-growth forests date back to the 1940s, when the term old growth was used to differentiate slower growing, older forests from faster growing, younger forests. The idea was largely based on the diameter at breast height of the largest live trees. Discussions around what constitutes old growth expanded in the 1970s with a growing environmental movement (Wirth et al. 2009). By the late 1980s, the conversation around old-growth forest characteristics had developed sufficiently for adoption of a generic, forest-structure based definition to guide Forest Service regions: "Old-growth forests are ecosystems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from younger stages in a variety of characteristics that may include tree size, accumulations of large dead woody material, number of canopy layers, species composition and ecosystem function" (USDA Forest Service 1989). The BLM also developed a similar broad description at that time but did not further refine definitions for local conditions in most States. Under the umbrella of this definition, the Forest Service developed more localized working definitions for old-growth forest, as did the BLM in western Oregon. These definitions have undergone review and revision in each of the Forest Service's nine regions, some more than others, during the past three decades—and are expected to continue to do so. These definitions are considered dynamic, not static, and are subject to refinement as new information is incorporated.

Current agency old-growth forest definitions are based on the unique biophysical characteristics within regions of the United States corresponding with agency management units. The definitions recognize that tree species, climate, soil productivity, and disturbance history all influence the development of old-growth forests. Therefore, regional definitions account for the vast variation in old-growth forest character that occurs across North America, and these definitions are specific to vegetation types because even within a specific geographic area, no one definition represents the diversity of old-growth ecosystems.

It is important to note that in many Forest Service regions, old-growth forest definitions have been used and improved upon for more than 30 years during development of land management plans. Each national forest and BLM district has a management plan governing its activities. Old-growth forest definitions have been used in developing plan components in many Forest Service and BLM management plans.

Today, the discussion of older forests has expanded to include the stage of forest development preceding old growth, called mature forest. Concerns associated with a range of environmental threats led to a broader view of forest management that includes all stages of development (Swanson et al. 2012, White House 2022). Although national definitions and initial inventory for mature forests are included in this report, further scientific development and refinement to better capture the local diversity of geographic

location, climate, site productivity, and characteristic disturbance regimes is expected to improve mature definitions. As such, like old-growth definitions, mature forest definitions are considered working definitions.

Although the term "mature forest" as outlined in E.O. 14072 is a relatively new concept for the Forest Service and BLM, many management plans incorporate it conceptually when assessing forest successional, seral, or structural classes and natural range of variation. For example, the term late successional, used interchangeably with mature, is discussed and monitored in the Northwest Forest Plan (Davis et al. 2022).

Applicable land management plan direction remains the current management direction for old-growth and mature forest. This definition and initial inventory effort does not change existing management direction.

## Old-Growth and Mature Forests Executive Actions and Legislation

Other congressional and Executive actions preceded E.O. 14072 that signaled a desire for agencies to manage for resilient older forests. Notably, the 2021 Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law (BIL) led the way in placing significant emphasis on establishing resilient landscapes, including large trees and old-growth stands, considering future climate conditions. The Act invested $5.5 billion across 5 years to tackle the Forest Service's most pressing issues, including the increased risk of wildland fire, ecosystem restoration, and the conservation of old-growth forests. Section 40803, Wildfire Risk Reduction, directed Federal agencies to "maximize the retention of large trees, as appropriate for the forest type, to the extent that the trees promote fire-resilient stands" and prioritize projects based on several items, including projects "that fully maintain or contribute toward the restoration of the structure and composition of old growth stands consistent with the characteristics of that forest type, taking into account the contribution of the old growth stand to landscape fire adaption and watershed health."

E.O. 14072, section 2(b), signed on April 22, 2022, directed the Forest Service and BLM to develop mature and old-growth definitions and inventory on Federal lands by April 22, 2023. More broadly, the Executive order aims to accelerate reforestation, develop recommendations for community-led economic development opportunities, and develop policies to institutionalize these actions. It further promotes the continued health and resilience of our Nation's forests, including old-growth and mature forests, by retaining and enhancing carbon storage, conserving biodiversity, mitigating wildfire risks, enhancing climate resilience, enabling subsistence and cultural uses, providing outdoor recreational opportunities, and promoting sustainable local economic development.

Once the definitions and inventory are established, section 2(c) then calls on the Forest Service and BLM to:

- Coordinate conservation and wildfire risk reduction activities, including consideration of climate-informed stewardship of mature and old-growth forests, with other Executive

departments and agencies, States, Tribal Nations, and any private landowners who volunteer to participate;

- Analyze the threats to mature and old-growth forests on Federal lands, including from wildfires and climate change; and
- Develop policies, with robust opportunity for public comment, to institutionalize climate-informed management and conservation strategies that address threats to mature and old-growth forests on Federal lands.

On June 23, 2022, USDA Secretary Tom Vilsack released the Secretary's Memorandum on Climate Resilience and Carbon Stewardship of America's National Forests and Grasslands (Secretary's Memorandum 1077-004). Emphasizing E.O. 14072, the Secretary's memo directs the Forest Service to undertake specific and time-bound actions so that data-informed policies, strategies, and actions are in place to provide for increased carbon stewardship and climate resilience on our national forests and grasslands.

## Tribal, Stakeholder, and Public Perspectives

### *Tribal, Stakeholder, and Public Engagement*

Recognizing the many values people hold related to old-growth and mature forests, the Forest Service and BLM created several opportunities to gather input from Tribes, the public, stakeholders, and agency employees. The Forest Service Office of Tribal Relations held a Tribal forum in the summer of 2022, during which Forest Service and BLM representatives shared information about the joint effort to define, identify, and inventory old-growth and mature forests on Federal land; discussed potential Tribal implications; and requested input on the definition and inventory process. The Forest Service opened a Tribal consultation on December 23, 2022, to provide Tribal leaders with opportunities to inform subsequent phases of this effort, including the development of policy related to old-growth and mature forests. To gather public and stakeholder input, the U.S. Departments of Agriculture and Interior jointly published a request for information (RFI) in a July 15, 2022, Federal Register notice about the old-growth and mature forest definition and inventory process (87 FR 42493). In addition, both Departments held several virtual information sessions in the summer of 2022 that were targeted for stakeholders from industry, government, science, and conservation groups, as well as forest users, the general public, and agency employees. Additional engagement sessions were held in early 2023 to provide a progress update and request further feedback on the definition and inventory process.

In total, roughly 2,000 people attended the virtual engagement sessions. The RFI public comment period resulted in more than 4,000 comment letters, with 927 letters providing unique perspectives. In addition to public input, Forest Service and BLM employees submitted 118 unique letters. The project team coded all comments and identified the following 13 themes:

- Opposition to a single definition or framework to serve the needs for any future policy work;

- Suggestion to incorporate ecological integrity into the definition framework;
- Suggestion of 80-years-old as a reasonable criterion for defining mature forests;
- Opposition to a definition that facilitates or promotes resource exploitation;
- Concern about the management implications of a definition and associated inventory;
- Suggestion to use existing definitions found in forest plans and resource management plans;
- Suggestion to use measurable criteria at appropriate scales;
- Concern about the ability and accuracy associated with inventorying mature and old-growth forests;
- Concern with definition and inventory consistency with existing Federal statutes and mandates;
- Concern with using tree age as a definition for mature and old-growth forests;
- Concern regarding specific criteria for mature and old-growth forests;
- Concern that Tribal perspectives, Indigenous Knowledge, and social aspects (such as spirituality, sense of place, and recreation) are included in any definition; and
- Concern that definitions and inventory not affect private lands.

The Tribal, stakeholder, and public input received through the request for information, engagement sessions, and Tribal forum informed decisions made by the project team and significantly shaped the definition and inventory of old-growth and mature forests in this effort.

### *Social, Economic, and Cultural Aspects of Older Forests*

Input received through Tribal participation, public comment, and stakeholder engagement drew substantial attention to the diversity and depth of human relationships with older forests. These sentiments are reflected in the narrative frameworks developed to describe old-growth and mature forests in terms that will be durable —as localized working definitions of these ecosystems evolve. The working definitions used in the current national-level inventory, which rely on measurable ecological characteristics, reflect just one of many ways to characterize old-growth and mature forests on Federal lands. Opportunities to integrate social, cultural, and economic values; a variety of ecosystem services; local and Indigenous Knowledge; and place-based meanings into the ways land managers define, identify, and steward old-growth and mature forests will continue. The expanded understanding of the roles and contributions of old-growth and mature forests is fundamental in our ability to manage both for climate resilience.

Multiple conceptual frameworks were developed to understand and communicate how human values and meanings might be applied to the management of older forests. For example, the concept of ecosystem services highlights the many ways that human life and well-being are tied to natural systems, from climate regulation and nutrient cycling to food provision and spiritual connection. Additional frameworks distinguish between the

"use values" and "nonuse values" people hold for forests. While the concept of use values captures the importance of the forest resources humans utilize, such as timber, nonuse values capture the value people attach to the mere existence of forests or the ability of future generations to experience them. Concepts such as place attachment and place identity may also be particularly relevant in our understanding of how people relate to and value old-growth forests. These concepts refer to the emotional bonds people form with certain places and the symbolic meanings of those places for individuals and communities. Another important way of understanding and effectively managing old-growth forests is through Indigenous Knowledge, which Tribes and Indigenous communities have practiced for millennia (Hoagland 2017). The narrative frameworks included in this report prompt land managers to revisit their understanding of mature and old-growth forests as processes are refined for integrating these social, cultural, and economic perspectives into the policy and practice of forest management.

## Definition Development

An old-growth and mature definition development team met in Washington, D.C. in October 2022 to evaluate mature and old-growth forest definition options based on a combination of existing definitions and comments received. Nine major old-growth forest and seven mature definition approaches were evaluated; those shown in bold were recommended for further evaluation and potential collaborator coproduction, with the expectation that elements of the other approaches would be incorporated where possible.

Old-growth Forest Definition Approaches:

1. Current Forest Service region-by-region structural definitions;
2. Forest development/forest dynamics;
3. Remotely sensed forest structural diversity;
4. National criteria and inventory for mature forest, local definition, and inventory of old-growth forest;
5. Desired condition framework for restoration based on disturbance dynamics;
6. Ecological and spiritual value framework—determine proxy ecological characteristics to reflect social and cultural values;
7. Wildlife habitat;
8. Carbon storage focus; and
9. 2012 Forest Service Planning Rule.

Mature Forest Definition Approaches:

1. Structural complexity;
2. Functional growth dynamics;
3. Multicohort;
4. Dominant species lifespan histogram;
5. Stage of maturity;
6. Reproduction; and
7. Proportion of old-growth criteria met.

The approaches brought forward were those most responsive to comment, but also potentially achievable within the timelines prescribed by E.O. 14072.

A 15-member definition and inventory technical team (hereafter, team) was formed in fall of 2022 under a charter that

focused work on definition and inventory efforts. The team consisted of scientists representing the USDA Forest Service's National Forest System and Research and Development deputy areas, including the FIA program, as well as scientists from the U.S. Department of the Interior's Bureau of Land Management (BLM) and U.S. Geological Survey (USGS). The team's focus was to develop definitions and conduct an initial inventory with a high level of ecological rigor, while also considering the timeline required by the Executive order. The following principles guided development of old-growth and mature forest definitions and initial inventory on Federal land:

- Scientifically sound
- Objective and simple
- Metrics compatible across a spectrum of stand conditions
- Compatible with FIA plot data for all stand conditions
- Applicable across spatial scales and Federal jurisdictions
- Consideration of public input gathered through engagement sessions and formal RFIs
- Operational to meet the deadline

A structural characteristics approach was chosen for the old-growth and mature forest inventory; it refers to measurable structural characteristics such as tree size and the presence or distribution of snags. The structural approach was chosen because it is consistent with Forest Service old-growth definitions developed across three decades, it is well documented in scientific literature, it rests on the foundation of forest-development science, and it is readily interpretable by resource managers across scales. Elements of many approaches are indirectly included in the structural approach or are highly correlated with old forest structures. For example, the narrative framework identifies Tribal and social values in addition to ecological components as important for identifying old growth. The structural approach also applies unique criteria to define old-growth and mature forests within regional vegetation types that capture different disturbance regimes and productivity levels.

## Old-Growth Definition Development

As previously described, the agencies decided in fall 2022 to apply existing structural old-growth definitions as currently maintained by each Forest Service region (Beardsley and Warbington 1996; Boughton 1992a, 1992b; Davis et al. 2022; Gaines 1997; Green 1992; Hamilton 1993; Mehl 1992; Tyrell 1998; USDA Forest Service 1993, 2019). While each region's definitions were developed in the early 1990s in response to then Forest Service Chief Dale Robertson's 1989 letter, many have been refined during the past three decades. Forest Service regions vary in their use and refinement of old-growth definitions. Many definitions have been incorporated into Forest Service land management plans and therefore benefit from public review. Public comments from many external and internal sources recommended using existing definitions. Retaining existing definitions for old growth allows for consistency with existing land management plans and uses structural characteristics that have been vetted for use by resource managers

at multiple scales using standard field protocols, such as common stand exam.

Detailed methods for how regional old-growth definitions were applied to the FIA data for the initial national old-growth inventory are being outlined in Pelz et al. 2023. The team worked with Forest Service regional staff to determine how to apply regional definition criteria to FIA field plot data for this initial national-scale inventory. All of the regional old-growth definitions use structural characteristics and include an attribute that captures abundance of large trees (minimum live trees per acre of a minimum size and/or minimum basal area of live trees). Many of the regional definitions also set a minimum stand age or tree age, and some definitions include standing snags or downed wood. Each region recognizes important ecological variation by defining unique old-growth criteria for vegetation types. Tables listing the old-growth definitions applied to FIA data by region can be found in appendix 1.

The Old Forest Estimation[7] effort that began before E.O. 14072 included only lands managed by the Forest Service. Forest Service regional definitions for old growth were then applied to lands managed by the BLM for the initial inventory directed by the Executive order because most BLM units do not have specific old-growth definitions. Definitions were applied to each FIA plot on lands managed by the BLM based on the geographic footprint of the Forest Service region that each BLM field plot falls within. For example, the BLM California State office contains FIA plots falling within the Forest Service's Southwestern, Intermountain, and Pacific Southwest regions.

## Mature Forest Definition Development

The concept of ecologically mature forest has been extensively discussed in terms of ecological processes but not objectively defined in terms of explicit forest attributes in the scientific literature. While some examples for mature forest definitions exist (Davis et al. 2022, Franklin et al. 2002, Pabst et al 2005), they are mainly limited to the Pacific Northwest. Silvicultural practice often refers to economic maturity using the culmination of mean annual increment (CMAI), defined as the age at which merchantable tree volume reaches a peak or plateau in most even-aged stands. Many land management plans for individual national forests contain tables that refer to stand age of CMAI for specific forest types and site productivity classes; these may be used to calculate maximum sustained yield as required by the 1976 National Forest Management Act. While CMAI has practical application for production forestry, it is not easily applied to forest types that are not managed for

[7] In March 2022, Associate Deputy Chief Barnie Gyant initiated the Old Forest Estimation (OFE) effort as a coproduction project between National Forest System and Research and Development deputy areas to quantify the extent (with confidence intervals) of old forest on Forest Service lands using Forest Inventory and Analysis field plot data. The effort responded to the Infrastructure Investment and Jobs Act and a related Congressional inquiry (February 17, 2022, letter to USDA Secretary Vilsack). While this effort was initiated prior to the release of Executive Order 14072 and the Secretary's Memorandum 1077-004, its results provided a foundation for both.

The OFE effort focused on a non-spatial estimate of old forest as defined by old-growth definitions in current Land Management Plans and associated documents, including General Technical Reports developed in response to Chief Robertson's 1989 letter instructing regions and Research and Development to develop ecologically appropriate criteria to identify old-growth forest. OFE did not attempt to estimate the extent of mature forest.

timber production or to uneven aged management for conservation and restoration goals. Therefore, the team interpreted the Executive order direction to inventory mature forest ecologically rather than economically.

While ecological maturity is not well defined for the many forest types across the United States, several well-known models of forest stand development frame this concept. Franklin et al. (2002) describe seven stages of stand development for Douglas-fir forests, including a maturation stage and three distinct phases within old growth. Oliver and Larson (1996) and Bormann and Likens (1979) present well-cited models that describe four stages of forest stand development after severe disturbance: stand initiation, stem exclusion, understory reinitiation, and old growth. This four stage model was generally developed for productive forest types subject to infrequent yet high-severity fire. However, without more nuanced models for site-limited and frequent disturbance forest types that could be applied nationwide, the team chose to apply the four stage model to identify the mature forest stage (figure 5).

**In applying this model for the purpose of these definitions and initial inventory, the term mature forest is defined as the entire stage of stand development from understory reinitiation to onset of old growth.**

Given the urgency to develop detailed mature forest definitions and conduct an initial inventory, the team completed a rapid inquiry and relied on several basic assumptions when creating initial definitions. These mature definitions are considered working definitions, and further refinement is expected to improve them, as old-growth definitions have evolved during the past three decades.

Pesklevits et al. (2011) and Gray et al. (2023) describe many of the difficulties and inherent contradictions that scientists face when attempting to define and inventory old-growth and mature forests. The team encountered similar challenges when developing definitions to provide a robust and repeatable initial national-scale inventory while also capturing enough variation in forest type, disturbance regime, and productivity level to be relevant at regional scales. Using the principles outlined above, the team explored several ways that structural characteristics could be used to define mature forests. Key concepts the team considered included how different forest productivity levels and disturbance regimes could be accounted for, and which structural characteristics were most indicative of the onset of ecological maturity in different forest types. For example, understory reinitiation might be indicated by canopy gaps, diameter diversity, height diversity, or an inflection point in height growth. The team also considered whether the structural indicators used in old-growth definitions would indicate the mature stage.

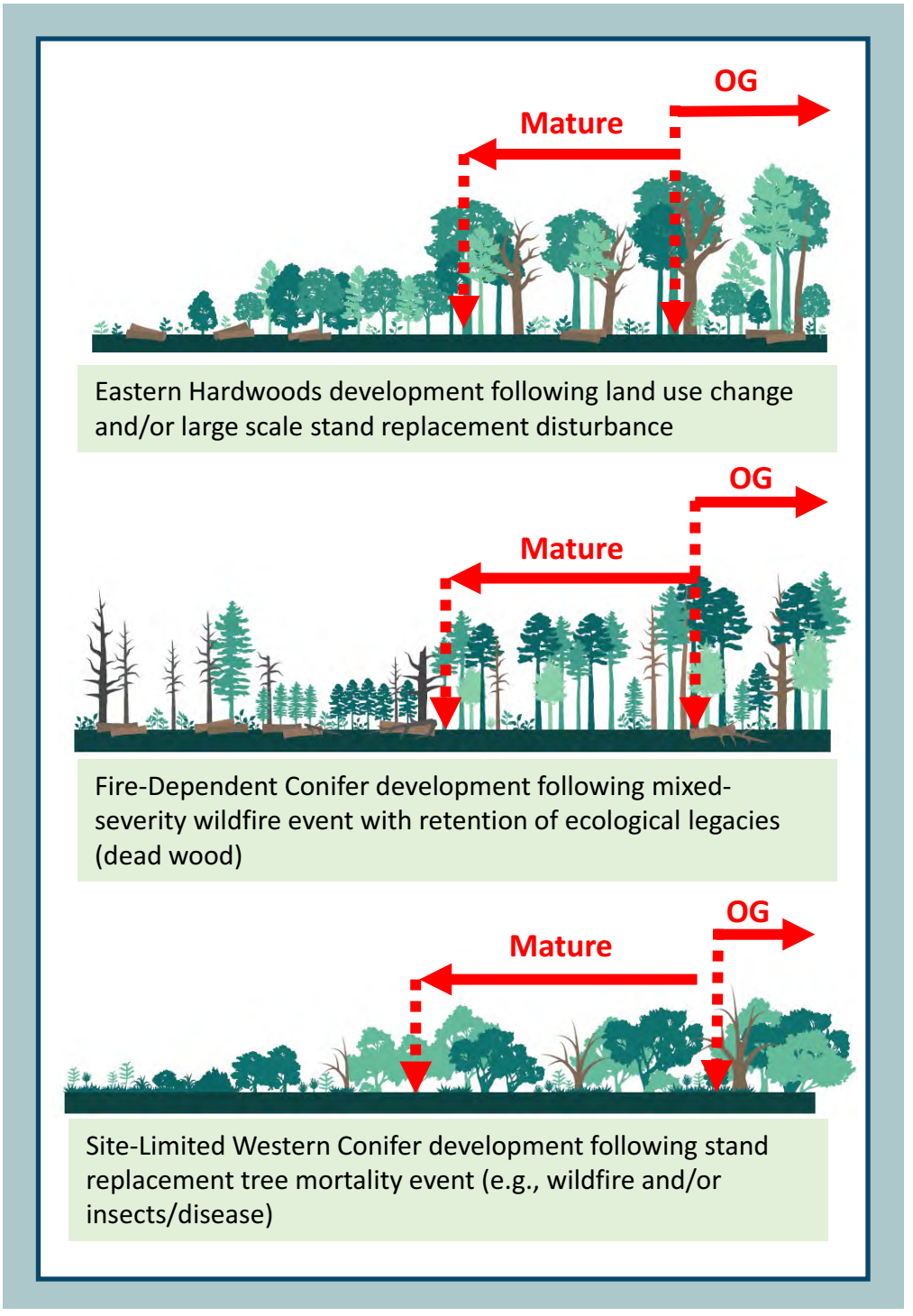



**Figure 5.**—Four-stage forest development model for several ecosystem archetype examples. Adapted from Woodall et al (2023).

## FIGSS Method for Mature Forest Definitions

The Forest Inventory Growth Stage System (FIGSS) (Woodall et al. 2023) uses the FIA condition records from individual FIA plots (hereafter, FIA records) classified as old growth based on Forest Service regional old-growth definitions to inform inverse modeling of the prior mature growth stage's structural thresholds. FIGSS identifies unique structural indicators (figure 6) for 80 regional vegetation types based on their correlation with stand age. Of more than 200 regional vegetation types used in old-growth definitions, types with fewer than 10 old-growth FIA records were grouped to allow modeling of structural indicators. This affected 2.9 percent of the 49,158 FIA records used in the analysis. For each regional vegetation type, all FIA records classified as old growth are used to estimate the 25th percentile of each indicator. This estimate was then "walked down" to approximate the onset of maturity (such as structural conditions) via the use of carbon accumulation curves (Barnett et al. 2023) and maximum physiological ages as part of a composite index as the lower threshold of old-growth forest characteristics.

Carbon accumulation curves (Barnett et al. 2023) and maximum physiological ages (MAXMORT; Loehle 1988; Supplementary Table S3) were used to estimate the proportion of time from maturity to mortality for each vegetation type. This proportion was used as the walkdown factor from the lower threshold of old growth to the onset of mature characteristics for each structural indicator (e.g., inverse modeling paradigm). Each structural indicator also received a correlation weighted composite index to determine its relative weight in classification as mature. Resulting working definitions for mature forest are shown in appendix 2.

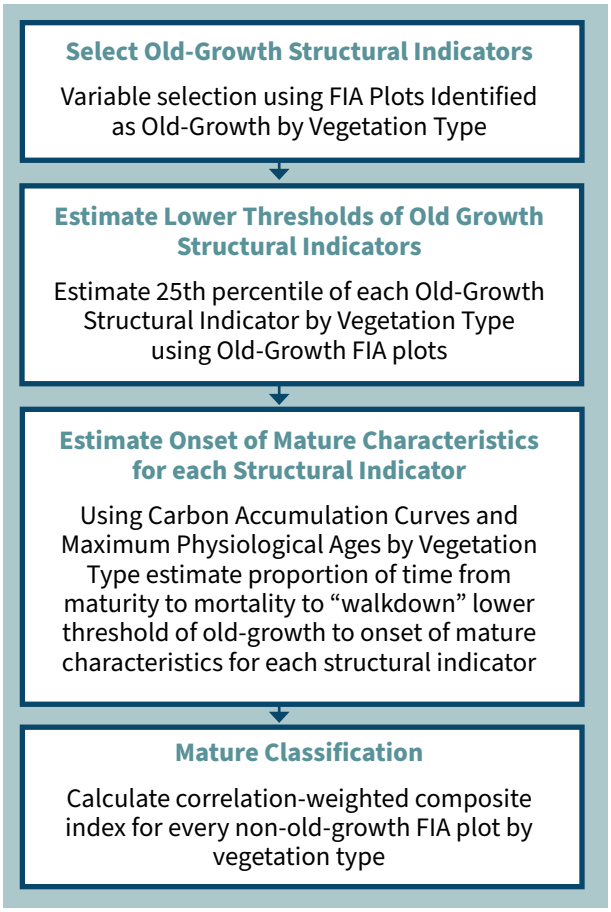



**Figure 6**.—Fundamental components of the FIGSS approach (Woodall et al. 2023) include selecting old-growth structural indicators that are used to identify the lower thresholds of old-growth attributes, then using a walkdown factor to identify the onset of mature forest conditions. The definitions are then applied to non-old-growth plots to classify mature forest.

**Table 3.**—Structural indicator variables used in mature forest definitions. Structural indicators were selected from 36 potential FIA attributes based on their ecological relevance to forest stand development, scalability from old-growth to mature developmental stages for identifying classification thresholds, minimal multicollinearity between indicators, and ability to measure indicators in the field at various scales.

| Variable | Description | Ecological Significance | Calculation from Field Data |
|---|---|---|---|
| tpadom | Density of dominant or codominant live trees ≥1-inch DBH | Abundance of large trees in the upper layers of the canopy serve to indicate the stage of stand development | Sum of live trees per acre, where diameter ≥1 inches and crown class code (CCLCD) is 1,2, or 3. |
| badom | Total basal area of dominant or codominant live trees ≥1-inch DBH (ft2/ac) | Indicates the site occupancy of the dominant, large trees in a stand | Sum of basal area for live dominant trees (crown class code 1,2, or 3) from the FIA tree table.<br>BA= tpa_unadj*3.141593*(dia/24)*2 |
| QMDdom | Quadratic mean diameter of all dominant and codominant trees (in) | The average size of trees that dominate the canopy is highly correlated with stand development as dominant trees in the stand continue to add diameter growth as they age | QMD_DOM = √((BA_DOM / (TPA_DOM* 0.005454))) |
| ddiscore | Diameter diversity index. DDI is a measure of the structural diversity of a forest stand, based on tree densities in different DBH classes. | The variation in tree size in a stand is an indicator of cohorts developing over time and differentiation of tree sizes in the canopy | Calculate the 4 TPA classes:<br>Class_0 = 2–9.8 inches DBH<br>Class_1 = 9.9–19.7 inches DBH<br>Class_2 = 19.8–39.4 inches DBH<br>Class_3 = 39.5+ inches DBH<br>Calculate index values from TPA classes, then calculate DDI from index values.<br>https://lemma.forestry.oregonstate.edu/data/structure-maps |
| HTquart | Mean height of tallest 25% of trees (TPA-weighted) (ft) | Height development in a stand indicates stage of stand development | Calculated from HT for all live trees from the FIA tree table, weighted by tpa_unadj. |
| HTsd | Standard deviation of height of all trees (TPA-weighted) (ft) | The variation in tree height in a stand is an indicator of extended periods of stand development and differentiation of tree sizes in the canopy | Calculated from HT for all live trees from the FIA tree table, weighted by tpa_unadj. |
| snagbatot | Total basal area of standing dead trees (ft2/ac) | Dead wood resources can indicate stand development processes such as self-thinning and/or disturbance related tree mortality | Sum of basal area for all standing dead trees from the FIA tree table.<br>BA= tpa_unadj*3.141593*(dia/24)*2 |

BA = basal area; DBH = diameter at breast height; HT = height; QMD = quadratic mean diameter; TPA = trees per acre

The mature forest working definitions developed using FIGSS (appendix 2) were applied to all non-old-growth FIA records to classify each as mature forest or not. When an FIA record's composite index was greater than 0.5, it was classified as mature. All analyses were conducted in R (R Core Team 2022) using base-R. Detailed information about the FIGSS approach, assumptions, and limitations are described in Woodall et al. (2023).

## Estimation

The initial inventory relies on the FIA field plot network, which is the primary source for information about the extent, condition, status, and trends of forest resources across the United States (Oswalt et al. 2019). The FIA program applies a nationally consistent sampling protocol using a systematic design covering all ownerships across the United States with a national sample intensity of approximately one plot per 6,000 acres (Bechtold and Patterson 2005). All data used in the initial inventory are available in the public FIA database (https://apps.fs.usda.gov/fia/datamart/datamart.html), with the exception of several geospatial layers (table 4). Estimates used data from the most recent FIA cycle for each State as of December 2022 (see appendix 3; Burrill et al. 2021).

It is important to note that any inventory represents a snapshot in time and presents the existing condition at the date of the field data collection. Initial inventory results provide information

**Table 4.**—Geospatial layers used to attribute FIA plots for inventory reporting. FIA spatial data services staff completed spatial overlay to overlay exact plot locations while maintaining plot location confidentiality.

| Attribute | Geospatial Data Source |
|---|---|
| Fireshed | https://www.fs.usda.gov/research/rmrs/projects/firesheds Firesheds in Alaska were included based on a draft layer developed by the Rocky Mountain Research Station team and used with permission. |
| BLM Administrative Unit | https://gbp-blm-egis.hub.arcgis.com/datasets/blm-national-administrative-unit-boundary-polygons-and-office-points-national-geospatial-data-asset-ngda-1 |
| BLM Wilderness | https://gbp-blm-egis.hub.arcgis.com/maps/blm-natl-nlcs-wilderness-areas-polygons |
| BLM Wilderness Study Area | https://gbp-blm-egis.hub.arcgis.com/maps/blm-natl-nlcs-wilderness-study-areas-polygons |
| BLM National Conservation Areas | https://gbp-blm-egis.hub.arcgis.com/maps/blm-natl-nlcs-national-monuments-national-conservation-areas-polygons |
| USDA Forest Service Wilderness | USDA Forest Service FSGeodata Clearinghouse - Download National Datasets National Wilderness Areas |
| USDA Forest Service National Monument and Wilderness Study Areas | USDA Forest Service FSGeodata Clearinghouse - Download National Datasets National Forest Lands with Nationally Designated Management or Use Limitations |
| USDA Forest Service Inventoried Roadless Area | USDA Forest Service FSGeodata Clearinghouse - Download National Datasets Roadless Areas: 2001 Roadless Rule |

about the status of old-growth and mature forests; they do not present any information about their sustainability, climate-informed management, or desired conditions for any given forest type or location.

Each Forest Service and BLM FIA record was assigned a singular classification of old-growth, mature, or younger forest. All FIA records with nonstocked FIA forest type were assigned to the younger forest class as those conditions do not meet the definitions of old growth or mature presented in this document. All reported forest area estimates were computed using the standard FIA estimation procedure (Bechtold and Patterson 2005). Note that sampling error should be considered alongside estimates. Some vegetation types or firesheds that contain small amounts of forested lands managed by the Forest Service or BLM have large sampling errors.

## Geospatial Display

Maps for the contiguous United States and Alaska (figure 4) were created by joining the estimates of old-growth and mature forest on Forest Service or BLM land within each fireshed (appendix 3) to fireshed maps using ESRI's ArcGIS Pro (V3.1). Estimates for each fireshed represent only the forested Forest Service or BLM lands within a fireshed; no FIA data outside these two ownerships was classified. Natural breaks classification (Jenks[8]) was used to create three different classes of old-growth and mature forest into low, intermediate, and high classes for portrayal in bivariate chloropleth maps and old-growth and mature breaklines were averaged for ease of display. The same scale was used for both old-growth and mature forest: >0–25,000; 25,000–75,000; and 75,000–250,000 acres were the defined class ranges. Old-growth classes are represented by white, medium blue, and dark blue. Mature classes are represented by white, orange, and brown. The matrix created by these colors allows users to see firesheds where old-growth, mature, and both old-growth and mature forest is dominant for all areas of the map. Firesheds shown on the map are those that overlap Forest Service or BLM lands. Within a fireshed, mature and old-growth estimates are only shown for Forest Service or BLM lands.

Other ancillary data included in maps are 7.5 arc-seconds topography (7.5 GMTED2010[9]), large North American water bodies (natural earth lakes and reservoirs[10]), 2021 U.S. Census 1:5,000,000 (national) state boundaries,[11] and Forest Service regional boundaries (https://data.fs.usda.gov/geodata/edw/datasets.php). Alaska forest cover data was provided by the 2016 National Land Cover Database, NLCD (Jin et al. 2019).

[8] See Univariate classification schemes in Geospatial Analysis - A Comprehensive Guide, 6th Edition; 2007–2018; de Smith, Goodchild, Longley.

[9] Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) Digital Object Identifier (DOI) number: /10.5066/F7J38R2N

[10] https://www.naturalearthdata.com/downloads/10m-physical-vectors/10m-lakes/

[11] https://www.census.gov/geographies/mapping-files/time-series/geo/cartographic-boundary.html

# Discussion

## Context and Relation to Other Estimates

This report contains the first national inventory of old-growth and mature forests focused specifically on lands managed by the Forest Service and BLM. It demonstrates that old-growth and mature forests are generally widely distributed geographically and across land use allocations, with old-growth covering 19 percent and mature forest covering 45 percent of forested lands managed by the Forest Service and BLM. The structural approach presented here is consistent with the way the Forest Service regions have been defining and communicating old-growth forest for the past 30 years, and it is easily applied across spatial scales, which is desirable in coordinating actions within land management agencies.

The Federal initial inventory results differ substantially from those reported by two studies published while definitions were being developed (DellaSala et al. 2022, Barnett et al. 2023). Part of this difference is scale. The other publications estimate old-growth and mature forest across all ownerships in the 48 contiguous States, including lands managed by the Forest Service and BLM. In contrast, the Federal estimate of old-growth and mature forest includes inventoried portions of Alaska, which contains large amounts of BLM and Forest Service land. Those differences aside, the Federal estimate is larger than DellaSala et al. (2022) and Barnett et al. (2023) when compared at equivalent scale (lands in the contiguous United States managed by the BLM and Forest Service) and combining both old-growth and mature forest: more than 104 million acres as compared to 53 million acres and 59 million acres, respectively. This outcome is not surprising given the differing goals and methodologies of the three inventories. It is worth noting that the ratios of mature to old growth estimated by Barnett et al. (2023) and this report (Woodall et al. 2023) are virtually the same (ratio = 2.4).

Disparities among various estimates also arise based on the datasets used and classification of forest types. The Federal approach applies existing definitions based on structural characteristics for old-growth forest types to FIA data. Barnett et al. (2023) also used FIA data but classified old-growth and mature forest based on the pattern of biomass accumulation. DellaSala et al. (2022) developed their classification based on remotely sensed data, emphasizing tall, high-biomass, and closed-canopy forests. The Federal approach stratifies forest into 200 regional vegetation types; the finer resolution of forest types results in an inventory accommodating greater variation in the expression of old-growth and mature forest characteristics, especially in low productivity types.

## Appropriate Use of Data

The initial inventory report is national in scale and presents estimates of old-growth and mature forests across all lands managed by the Forest Service and BLM. In preparing this report, published scientific literature was reviewed and scientists were consulted to understand the current work in this area and to get technical assistance in providing what was needed to respond to E.O. 14072. Applicable Forest Service and BLM land

management plan direction constitutes current management direction for old-growth and mature forests on individual management units. The definition and initial inventory effort does not change existing Forest Service and BLM management direction. It is expected that a continual adaptive management process integrating new science, Indigenous Knowledge, continued stakehold engagement, and social processes will refine old-growth and mature forest working definitions through time. Although there is interest in a high-resolution spatial representation of old-growth and mature forest, this was not achievable with a rapid, national-scale inventory based solely on FIA field plot data. The national FIA sample was designed to provide national- and regional-scale estimates that can be used to inform resource management questions (Oswalt et al. 2019). Application of FIA estimates for small areas, with few sample plots, can result in substantial uncertainty as indicated by large sampling error. Some of the FIA forest type groups (redwood, exotic softwoods, and tropical hardwoods) presented in this report contain only small amounts of forested Federal land and should be used with caution due to high levels of uncertainty.

The importance of spatial scaling in ecology and land management is well recognized (Schneider 2001, Turner et al. 1993, and Wiens 1989). Therefore, application of national inventory results at fine spatial extents is not appropriate.

The remeasurement cycle for FIA plots is 10 years in the western United States and 5–7 years in the eastern United States. These estimates are based on the most recent available field measurements; appendix 4 provides the date ranges for each State. Growth of trees, as well as disturbances such as fires, harvest, and insects, may have affected the trees on an FIA plot after measurement and the subsequent changes are not reflected in these estimates. For example, wildfire impacts in California since 2020 are not captured in these estimates. It is

**Applying working definitions to field reconnaissance of individual stands:**

**Foundational descriptions of old-growth forest in general technical reports may discuss supplementary indicators not included in appendix 1. Some Forest Service regions have operationalized additional indicators to describe old-growth quality of individual stands (such as Green et al. 1992, errata 2011).**

**Direct application of the working definitions in appendix 1 and appendix 2 should be preceded by evaluation of the indicators and thresholds which were selected to apply to FIA data at national scale. Appropriateness of structural indicators and thresholds for mature forest had not been tested for regional vegetation types at local levels.**

**We expect to periodically evaluate field application of definitions as new science, local conversations, and social processes provide insights to refine old-growth and mature forest working definitions.**

important to consider that any sample of current forest condition reflects existing vegetation rather than historical or potential vegetation structure and composition.

# Assumptions and Limitations

Any inventory of old-growth forest is based on a definition of old growth that represents human values; old growth is a social, cultural, and ecological concept (such as Wirth et al. 2009). While old-growth and mature forests are difficult to classify, there is value in defining and identifying older forests that have unique qualities and management needs. Some limitations of the data and methods are outlined here to provide a framework for improvement in future inventories.

### Stages of Stand Development

The four-stage stand development model (stand initiation, stem exclusion, understory reinitiation, and old growth) assumes mature forest upper and lower thresholds are based on the typical progression of forests on productive sites (for example, sites not limited by soil moisture, nutrients, or depth) after a severe disturbance. However, not all stands follow four development stages in smooth progression. Stands affected by frequent low- to moderate-severity disturbance (such as frequent fires or insect and disease outbreaks) may contain individual trees or clumps of trees that cycle between intermediate stages for centuries (standing dead trees and/or old living trees of low abundance). While these stands generally follow the four stages of development, progressing from seedling to old growth, the period spent in each stage varies and setbacks to earlier stages may occur due to site limitations (moisture, substrate, or climate) or intermediate disturbances, making the stand origin or endpoint difficult to determine (such as, Franklin et al. 2007, Palik et al. 2020).

### FIA Limitations for Old-Growth and Mature Inventory

FIA is a national- and regional-level strategic inventory that provides unbiased estimates of forest attributes across large areas by sampling forests systematically (approximately one plot per 6,000 acres). While the FIA design effectively samples variation in forest composition and structure regionally, rare vegetation types are captured less precisely. Classification error decreases with increasing plot size and increasing density of the attribute being estimated (Azuma and Monleon 2011). Classification errors of old-growth or mature forest for this national-scale inventory have not been tested. Furthermore, our use of FIA stand age is imperfect. Stand age is straightforward for young, even-aged forests, but for older stands with multiple cohorts or uneven-aged stands, stand age may not correspond to the time since the last major disturbance (Stevens et al. 2016). Old-growth and mature forests are known to contain trees of varying ages.

# Refinements and Opportunities for Future Research

Old-growth and mature forests defined here are grounded in a narrative framework based on measurable structural characteristics, with the

acknowledgement that old-growth and mature forests also have cultural, Indigenous, functional, historic, carbon capture and storage, economic, wildlife, and social values. Understanding how older forests are valued and viewed by different stakeholders is an essential part of developing conservation strategies that are both equitable and durable. Because these values and the ecological elements differ, further engagement with Tribes, stakeholders, and local communities is needed to continue to improve the inventory.

Forest Service regional old-growth forest working definitions may be updated. Mature forest working definitions are also expected to be refined. Woodall et al. (2023) identifies refinements for the FIGSS mature model, including enhanced sampling strategies for rare conditions, review of structural indicators, and analysis of thresholds used to identify old-growth and mature forests. FIGSS, which is currently based on structural attributes, has potential to assess old-growth and mature forest systems using alternative approaches such as carbon, Indigenous Knowledge, wildlife habitat, or risk profiles.

The addition of remotely sensed data and modeling is expected to improve the spatial resolution of old-growth and mature forest inventory and provide a faster data update cycle that will be useful in long-term monitoring. The FIA BIGMAP project is one example of a model that uses FIA plot data combined with other information, including satellite imagery, ecological ordination, spatial modeling, and computing to calculate finely scaled maps of forest attributes (Bell et al. 2022). Emerging datasets and techniques, such as lidar (Jarron et al. 2020, Dubayah et al. 2020), synthetic aperture radar (SAR) (Adeli et al. 2021), and fusion of lidar and SAR (e.g., Silva et al. 2021), could enhance the spatial resolution of current estimates. Work to incorporate remotely sensed data is ongoing, but further quality assurance is required before incorporating it into an inventory. As processes are refined it is likely that a hybrid approach using field plots combined with remotely sensed data will improve the spatial resolution and temporal relevance of old-growth and mature estimates.

# Next Steps

This initial inventory represents the current condition of forests managed by the Forest Service and BLM at the time of the most recent FIA measurement; it does not provide any information on resilience or climate response of these forests. Some old-growth and mature forests may be ecologically resilient while others may be at risk of catastrophic loss. The team plans to apply working definitions for old-growth and mature forest to prior FIA data, which will inform how these forests have changed throughout the past 10–20 years. In addition, the team will explore how old-growth and mature forests are distributed in additional land use allocations that are currently grouped into the "other" category (figure 1, table 1).

Forests are dynamic systems that will change through time. Both congressional (BIL) and Executive directives mandate that the Forest Service and BLM identify sustainable 21st century forest conditions. E.O. 14072, section 2(c) and USDA Secretarial Memo 1077-004 provide the following next steps:

- Identify threats to old-growth and mature forests on lands managed by the Forest Service and BLM from wildfires, insects and disease, drought, invasive species, and other 21st century stressors.
- Develop strategies to recruit, sustain, and restore old-growth and mature forests that are at risk from acute and chronic disturbances, often amplified by climate change.
- Advance policy-level guidance to address climate-informed management of old-growth and mature forests on Federal lands.
- Further develop guidance on how old-growth and mature forests can be managed to conserve biodiversity, provide recreational opportunities, promote and sustain local economic development, and enable subsistence and cultural uses.
- Provide new guidelines for carbon stewardship while also addressing the multiple objectives stated above.

Strategies to recruit, sustain, and restore old-growth and mature forests that are at risk, as called for in E.O. 14072 section 2(c), must support conditions that facilitate the sustainability of older forests. The fire exclusion era allowed some forests to develop fuels and stocking levels that put them at risk for catastrophic loss from high-intensity wildfire, severe insect epidemics, and unnatural shifts in forest species composition. Wildfire risk reduction strategies in identified firesheds can be compatible with restoring and conserving these at-risk forests.

Finally, it should be recognized that many of the old-growth forests of today developed under different climate and disturbance regimes. E.O. 14072 calls for the Forest Service and BLM to recruit, sustain, and restore old-growth and mature forests, albeit more adapted to 21st century conditions. That will require climate-informed management and potentially novel treatments, embracing different perspectives and redoubling efforts to work with partners and stakeholders. Inherent in this approach are both adaptive management and scenario planning methods of continual learning by collecting and analyzing well-designed monitoring data, including from remote sensing, considering alternative future conditions, and sharing those results with managers, policy makers, and stakeholders.

# Acknowledgements

This project was carried out in a collaborative manner with feedback received and incorporated along the way from interested parties representing very diverse interests. The following people helped make this inventory possible and provided valuable insights that improved the definitions and inventory: Greg Aplet, Joanne Baggs, Jessica Barnes, Kevin Barnett, Erin Berryman, Jamis Bruening, Leonardo Calle, Adrian Das, Kerry Dooley, Ralph Dubayah, Tracey Frescino, Earlene Jackson, Kenli Kim, Ellis Margolis, Pete Nelson, Christopher Oswalt, Neil Pederson, Ben Poulter, Scott Pugh, Katie Renwick, Jason Rodrigue, Phil van Mantgem, Ty Wilson, and Joseph Zeiler. Kathleen Riggs provided invaluable facilitation to the teams. In addition, many others not listed provided important contributions to this work.

# Literature Cited

Adeli, S.; Salehi, B.; Mahdianpari, M.; Quackenbush, L.J.; Chapman, B. 2021. Moving toward L-band NASA-ISRO SAR mission (NISAR) dense time series: Multipolarization object-based classification of wetlands using two machine learning algorithms. Earth and Space Science. 8(11). https://doi.org/10.1029/2021EA001742.

Azuma, D.; Monleon, V.J. 2011. Differences in forest area classification based on tree tally from variable- and fixed-radius plots. Canadian Journal of Forest Research. 41: 211–214.

Barnett, K.; Aplet, G.H.; Belote, R.T. 2023. Classifying, inventorying, and mapping mature and old-growth forests in the United States. Frontiers in Forests and Global Change. 5: 100372.

Beardsley, D. and Warbington, R. 1996. Old growth in northwestern California national forests. Research Paper PNW-RP-491. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 47 p. https://doi.org/10.2737/PNW-RP-491.

Bechtold, W.A.; Patterson, P.L., eds. 2005. The enhanced Forest Inventory and Analysis program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p. https://doi.org/10.2737/SRS-GTR-80.

Bell, D.M.; Wilson, B.T.; Werstak Jr, C.E.; Oswalt, C.M.; Perry, C.H. 2022. Examining k-nearest neighbor small area estimation across scales using national forest inventory data. Frontiers in Forests and Global Change. 25. https://doi.org/10.3389/ffgc.2022.763422.

Bormann, F.H. and Likens, G.E. 1994. Pattern and process in a forested ecosystem. New York: Springer-Verlag. 272 p. https://doi.org/10.1007/978-1-4612-6232-9.

Boughton, J.; Copenhagen, M.; Faris, T.; Flynn, R.; Fry, L.; Huberth, P.; Lidholm, G.; Loiselle, R.; Martin, J.; Samson, F.; Shea, L.; Williamson, D. 1992a. Definitions for old-growth forest types in southcentral Alaska. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. Old-growth definition task group technical report. 52 p.

Boughton, J.; Copenhagen, M.; Faris, T.; Flynn, R.; Fry, L.; Huberth, P.; Lidholm, G.; Loiselle, R.; Martin, J.; Samson, F.; Shea, L.; Williamson, D. 1992b. Definitions for old-growth forest types in southeast Alaska. R10-TP-28. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. Old-growth definition task group technical report. 67 p.

Burrill, E.A.; DiTommaso, A.M.; Turner, J.A.; Pugh, S.A.; Menlove, J.; Christiansen, G.; Perry, C.J.; Conkling, B.L. 2021. The Forest Inventory and Analysis Database: database description user guide for phase 2. Version 9.0.1. U.S. Department of Agriculture, Forest Service. 1026 p. http://www.fia.fs.usda.gov/library/database-documentation/. (13 April 2023)

Davis, R.J.; Bell, D.M.; Gregory, M.J.; Yang, Z.; Gray, A.N.; Healey, S.P.; Stratton, A.E. 2022. Northwest forest plan—the first 25 years (1994–2018): status and trends of late-successional and old-growth forests. Gen. Tech. Rep. PNW-GTR-1004. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. https://doi.org/10.2737/PNW-GTR-1004.

DellaSala, D.A.; Mackey, B.G.; Norman, P.; Campbell, C.; Comer, P.J.; Kormos, C.; Keith, H.; Rogers, B. 2022. Mature and old-growth forests contribute to large-scale conservation targets in the conterminous USA. Frontiers in Forests and Global Change. 5: 979528. https://doi.org/10.3389/ffgc.2022.979528.

Dubayah, R.; Blair, JB, Goetz, S.; Fatoyinbo, L.; Hansen, M.; Healey, S.; Hofton, M.; Hurtt, G.; Kellner, J.; Luthcke, S.; Armston, J.; Tang, H.; Duncanson, L.; Hancock, S.; Jantz, P.; Marselis, S.; Patterson, P.L.; Qi, W.; Silva, C. 2020. The global ecosystem dynamics investigation: high-resolution laser ranging of the Earth's forests and topography. Science of Remote Sensing: 1: 100002. https://doi.org/10.1016/j.srs.2020.100002.

Federal Register. 2022. Request for informationon federal old-growth and mature forests. 87 FR 42493. https://www.federalregister.gov/documents/2022/07/15/2022-15185/request-for-information-rfi-on-federal-old-growth-and-mature-forests.

Franklin, J.F.; Spies, T.A.; Van Pelt, R.; Carey, A.B.; Thornburgh, D.A.; Berg, D.R.; Lindenmayer, D.B.; Harmon, M.E.; Keeton, W.S; Shaw, D.C.; Bible, K.; Chen, J. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management. 155: 399–423. https://doi.org/10.1016/s0378-1127(01)00575-8.

Franklin, J.; Hemstrom, M.; Van Pelt, R.; Buchanan, J.; Hull, S.; Crawford, R.; Curry, S.; Obermeyer, W. 2007. Extent and distribution of old forest conditions on DNR-managed state trust lands in eastern Washington. Washington Department of Natural Resources. 44 p.

Gaines, G.; Arndt, P.; Croy,S.; Devall, M.; Greenberg, C.; Hooks, S.; Martin, B.; Neal, S.; Pierson, G.; Wilson, D. 1997. Guidance for conserving and restoring old-growth forest communities on national forests in the southern region. For. Rep. R8-FR-62. [Location unknown]: U.S. Department of Agriculture, Forest Service.

Gray, A.N.; Pelz, K.; Hayward, G.; Schuler, T.; Salverson, W.; Palmer, M.M.; Schumacher, C.; Woodall, C.; Margolis, E. 2023. Perspectives: The wicked problem of defining and inventorying mature and old-growth forests, Forest Ecology and

Management, Volume 546. 121350. ISSN 0378-1127, https://doi.org/10.1016/j.foreco.2023.121350.

Green, P.; Joy, J.; Sirucek, D.; Hann, W.; Zack, A.; Naumann. B. 1992, errata 2011. Old-growth forest types of the northern region. R-1 SES 4/92. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region. 63 p.

Hamilton, R.G. 1993. Characteristics of old-growth forests in the Intermountain Region. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 86 p

Hoagland, S. J. (2017). Integrating traditional ecological knowledge with western science for optimal natural resource management. IK: Other Ways of Knowing, 1-15.

Infrastructure Investment and Jobs Act, Public Law No: 117–58. 2021. https://www.congress.gov/bill/117th-congress/house-bill/3684/text

Jin, S.; Homer, C.; Yang, L.; Danielson, P.; Dewitz, J.; Li, C.; Zhu, Z.; Xian, G.; Howard, D. Overall Methodology Design for the United States National Land Cover Database 2016 Products. Remote Sens. 2019, 11, 2971. https://doi.org/10.3390/rs11242971

Loehle, C. 1988. Tree life history strategies: the role of defenses. Canadian Journal of Forest Research. 18: 209–222.

Mehl, M.S. 1992. Old-Growth descriptions for the major forest cover types in the Rocky Mountain region. In: Kaufman, M.R.; Moir, W.H.; Bassett, R.L., eds. Old-growth forests in the southwest and Rocky Mountain regions - proceedings of a workshop. Gen. Tech. Rep. RM-213. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 106–120. https://doi.org/10.2737/RM-GTR-213.

Jarron, L.R.; Coops, N.C.; MacKenzie, W.H.; Tompalski, P.; Dykstra, P. 2020. Detection of sub-canopy forest structure using airborne LiDAR. Remote Sensing of Environment. 244: 111770. https://doi.org/10.1016/j.rse.2020.111770.

Oliver, C.D. and Larson, B.C. 1996. Forest stand dynamics, updated edition. Yale School of the Environment. 540 p. https://elischolar.library.yale.edu/fes_pubs/1/.

Oswalt, S.N., W.B. Smith, P.D. Miles, S.A. Pugh. 2019. Forest resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA Assessment. Gen. Tech. Rep. WO-97. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office, 223 p.

Palik, B.J.; D'Amato, A.W.; Franklin, J.F.; Johnson, K.N. 2020. Ecological silviculture: foundations and applications. Longrove, IL: Waveland Press. 343 p.

Pesklevits, A.; Duinker, P.N.; Bush, P.G. 2011. Old-growth forests: anatomy of a wicked problem. Forests. 2: 343–356. https://doi.org/10.3390/f2010343.

Pelz, K.A.; Hayward, G.; Gray, A.N.; Berryman, E.M.; Woodall, C.W.; Nathanson, A.; Morgan, N.A. 2023. Quantifying old-growth forest of United States Forest Service public lands. Forest Ecology and Management. 549: 121437.

Popp, J.B.; Jackson, P.D.; Bassett, R.L. 1992. Old-growth concepts from habitat type data in the Southwest. In: Kaufman, M.R.; Moir, W.H.; Bassett, R.L., eds. Old-growth forests in the southwest and Rocky Mountain regions - proceedings of a workshop. Gen. Tech. Rep. RM-

213. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 100–105. https://doi.org/10.2737/RM-GTR-213.

R Core Team. 2020. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

Schneider, D.C. 2001. The rise of the concept of scale in ecology. BioScience. 51(7): 545–553. https://doi.org/10.1641/0006-3568(2001)051[0545:TROTCO]2.0.CO;2.

Secretary's Memorandum 1077-004. 2022. Climate Resilience and carbon stewardship of America's national forests and grasslands. https://www.usda.gov/directives/sm-1077-004.

Silva, C.A.; Duncanson, L.; Hancock, S.; Neuenschwander, A.; Thomas, N.; Hofton, M.; Fatoyinbo, L.; Simard, M.; Marshak, C.Z.; Armston, J.; Lutchke, S.; Dubayah, R. 2021. Fusing simulated GEDI, ICESat-2 and NISAR data for regional aboveground biomass mapping. Remote Sensing of Environment. 253: 112234. https://doi.org/10.1016/j.rse.2020.112234

Stevens, J.T.; Safford, H.D.; North, M.P.; Fried, J.S.; Gray, A.N.; Brown, P.M.; Dolanc, C.R.; Dobrowski, S.Z.; Falk, D.A.; Farris, C.A.; Franklin, J.F.; Fulé, P.Z.; Hagmann, R.K.; Knapp, E.E.; Miller, J.D.; Smith, D.F.; Swetnam, T.W.; Taylor, A.H. 2016. Average stand age from forest inventory plots does not describe historical fire regimes in ponderosa pine and mixed-conifer forests of western North America. Plos One. 11: e0147688. https://doi.org/10.1371/journal.pone.0147688.

Swanson, M.E.; Studevant, N.M.; Campbell, J. L.; Donto, D.C. 2019. Biological associates of early-seral pre-forest in the Pacific Northwest. Forest Ecology and Management 324: 160–171.

Turner, M.G.; Romme, W.H.; Gardner, R.H.; O'Neil, R.V.; Kratz, T.K. 1993. A revised concept of landscape equilibrium: disturbance and stability on scaled landscapes. Landscape Ecology. 8(3): 213–227. https://doi.org/10.1007/BF00125352.

Tyrrell, L.E.; Nowacki, G.J.; Crow, T.R.; Buckley, D.S.; Nauertz, E.A.; Niese, J.N.; Rollinger, J.L.; Zasada, J.C. 1998. Information about old growth for selected forest type groups in the eastern United States. St Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. GTR NC 197. 507 p.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1989. Chief Dale Robertson letter to regional foresters, station directors, and WO staff regarding national forest old-growth values and the generic definition and description of old-growth forests. Dated October 11, 1989.

USDA Forest Service. 1993. Region 6 interim old growth definition. 124 p. https://ecoshare.info/uploads/publications/FirsWesternHemlockSeries.pdf. (14 April 2023)

USDA, Forest Service. 2019. Desired conditions for use in forest plan revision in the Southwestern Region. Albuquerque, NM. U.S. Department of Agriculture, Forest Service, Southwestern Regional Office. 59 p. https://usdagcc.sharepoint.com/sites/fs-r03-fp/SitePages/ROandWOGuidance.aspx. (14 April 2023)

USDA Forest Service. 2022. Forest

Inventory and Analysis Datamart. Washington, DC: U.S. Department of Agriculture, Forest Service. https://apps.fs.usda.gov/fia/datamart/datamart.html. (14 April 2023)

White House. 2022. Executive order 14072 on strengthening the Nation's forests, communities, and local economies. Washington, DC: White House. https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/

Wiens, J.A. 1989. Spatial scaling in ecology. Functional Ecology. 3: 385–397.

Wirth, C.; Messier, C.; Bergeron, Y.; Frank, D.; Kahl, A. 2009. Old-growth forest definitions: a pragmatic view. In: Wirth, C.; Gleixner, G.; Heimann, M., eds. Old-growth forests: function, fate and value. 11–33. https://doi.org/10.1007/978-3-540-92706-8.

Woodall, C.W.; Kamoske, A.; Hayward, G.; Schuler, T.; Hiemstra, C.; Palmer, M.; Gray, A.N. 2023. Classifying mature federal forests in the United States: The Forest Inventory Growth Stage System. Forest Ecology and Management. 546(4): 121361-. https://doi.org/10.1016/j.foreco.2023.121361

# Appendix 1: Old-Growth Working Definitions

Existing old-growth definitions for each Forest Service region were applied to FIA data for the national-scale inventory using the criteria listed below. These criteria constitute working definitions as used in this report.

## Northern Region (Region 1)

Northern Region minimum criteria for old growth from "Old-Growth Forest Types of the Northern Region" (Green et al. 1992, errata 2011) were applied to FIA data for the national inventory. For a given old-growth forest type and habitat type group, in each of three geographic areas, there must be a minimum number of live trees per acre meeting age and diameter at breast height (DBH) thresholds, and a minimum basal area (square feet per acre of live trees greater than or equal to 5-inches DBH) in order to be considered old growth (tables 5–7). Further details on Northern Region old-growth definitions, including how forest types and habitat type groups are determined, are available in Green et al. (1992, errata 2011). Old growth associated characteristics, such as variation in diameters, decay measures (dead/broken tops or bole decay), canopy layers, and standing and downed dead wood, which are additional attributes not required as minimum criteria, were not included in the national inventory. The presence and quality of these associated characteristics depends on forest type, biophysical setting, and disturbance regime(s).



**Old-growth stand on Bitterroot National Forest, Montana that has had management treatment and is still considered old growth by our definitions. USDA Forest Service photo by Shelagh Fox.**

**Table 5.**—Northern Region old-growth forest types and minimum criteria thresholds for old-growth status for the Northern Idaho Zone.

| Old-growth forest type | Habitat type group | Large tree age (years) | Large tree density (trees $ac^{-1}$) and DBH (in) | Basal area ($ft^2$ $ac^{-1}$) |
|---|---|---|---|---|
| 1 - Ponderosa pine (PP), Douglas-fir (DF), Western larch (L) | A, B | 150 | 8 ≥ 21” | 40 |
| 2- Lodgepole pine (LP) | B, C, D, E, G, H, I, J, K | 120 | 10 ≥ 13” | 60 |
| 3 - Pacific yew (Y) | C, C1, G1 | 150 | 3 ≥ 21” | 80 |
| 4A - DF, Grand fir (GF), L, Engelmann spruce/subalpine fir (SAF), Western white pine (WP), PP | C, C1, D, E | 150 | 10 ≥ 21” | 80 |
| 4B - DF, GF, L, Western hemlock (WH), WP, PP | F, G, G1, H, I | 150 | 10 ≥ 21” | 120/80[a] |
| 5 – SAF, Mountain hemlock/alpine larch/subalpine fir (MAF) | F, G, G1, H, I | 150 | 10 ≥ 17” | 80 |
| 6 – Whitebark pine (WBP) | I, J, K | 150 | 5 ≥ 13” | 60/40[b] |
| 7 – Western redcedar (C) | F, G, G1 | 150 | 10 ≥ 25”[c] | 120 |
| 8 – DF, L, SAF, MAF, WP | J | 150 | 10 ≥ 17” | 60 |
| 9 – SAF, MAF | K | 150 | 5 ≥ 13” | 40 |

[a] In old growth type 4B, 120 $ft^2$ ac-1 basal area applies to habitat type groups F, G, and G1; 80 applies to habitat type groups H and I.
[b] In old growth type 6, 60 $ft^2$ of basal area applies to habitat type groups I and J, and 40 $ft^2$ applies to habitat type group K.
[c] In old growth type 7, the 25” minimum DBH only applies to cedar trees; old trees of other species are evaluated with a minimum DBH appropriate for that species on these habitat types (21” for DF, GF, L, WH, WP, PP; and 17” for SAF, MAF).

**Table 6.**—Northern Region old-growth forest types and minimum criteria thresholds for old-growth status for the Western Montana Zone.

| Old-growth forest type | Habitat type group | Large tree age (years) | Large tree density (trees $ac^{-1}$) and DBH (in) | Basal area ($ft^2$ $ac^{-1}$) |
|---|---|---|---|---|
| 1 - Ponderosa pine (PP), Douglas-fir (DF), Western larch (L), Grand fir (GF), Lodgepole pine (LP) | A, B | 170 | 8 ≥ 21” | 60 |
| 2 - DF, L, PP, Engelmann spruce/subalpine fir (SAF), GF | C | 170 | 8 ≥ 21” | 80 |
| 3 - LP | C, D, E, F, G, H | 140 | 10 ≥ 13” | 60/70/80[a] |
| 4 -SAF, DF, GF, Western redcedar (C), L, Mountain hemlock/subalpine fir (MAF), PP, Western white pine (WP), Western hemlock (WH), combinations of alpine larch/whitebark pine/limber pine (WSL) | D, E, F | 180 | 10 ≥ 21” | 80 |
| 5 - SAF, DF, GF, L, MAF, PP, WP, WSL | G, H | 180 | 10 ≥ 17” | 70/80[b] |
| 6 - SAF, WSL, DF, L | I | 180 | 10 ≥ 13” | 60 |
| 7 - LP | I | 140 | 30 ≥ 9” | 70 |
| 8 - SAF, WSL | J | 180 | 20 ≥ 13” | 80 |

[a] In old growth type 3, 60 ft2 applies to habitat type group E for LP; 70 ft2 of basal area applies to habitat type group C for LP and habitat type group H for ES, AF, WBP; 80 ft2 of basal area applies to all others.
[b] In old growth type 5, 70 ft2 applies to habitat type group H for SAF; 80 ft2 of basal area applies to all others.

**Table 7.**—Northern Region old-growth forest types and minimum criteria thresholds for old-growth status for the Eastern Montana Zone.

| Old-growth forest type | Habitat type group | Large tree age (years) | Large tree density (trees $ac^{-1}$) and DBH (in) | Basal area ($ft^2$ $ac^{-1}$) |
|---|---|---|---|---|
| 1 – Douglas-fir (DF) | A | 200 | 4 ≥ 17” | 60 |
| 2 – DF | B, C, D, E, F, H | 200 | 5 ≥ 19” | 60 |
| 3 – DF | G | 180 | 10 ≥ 17” | 80 |
| 4 – Ponderosa pine (PP) | A, B, C, K | 180 | 4 ≥ 17” | 40 |
| 5 – Limber Pine (PF) | A, B | 120 | 6 ≥ 9” | 50 |
| 6 – Lodgepole pine (LP) | A, B, C, D, E, F, G, H, I | 150 | 12 ≥ 10” | 50 |
| 7 – Engelmann spruce/subalpine fir (SAF) | C | 160 | 12 ≥ 17” | 80 |
| 8 – SAF | D, E | 160 | 7 ≥ 17” | 80 |
| 9 – SAF | F, G, H, I | 160 | 10 ≥ 13” | 60 |
| 10 – SAF | J | 135 | 8 ≥ 13” | 40 |
| 11 – Whitebark pine (WBP) | D, E, F, G, H, I | 150 | 11 ≥ 13” | 60 |
| 12 – WBP | J | 135 | 7 ≥ 13” | 40 |

# Rocky Mountain Region (Region 2)

The Rocky Mountain Region provided current definitions for old growth based on Mehl (1992). These definitions, with limited modification based on current individual land management plans, were used as the foundation for the region's old-growth criteria. Stands had to have a certain number of trees per acre over a threshold size and estimated age, a certain number of trees with cull or broken or dead tops, and a certain number of dead trees more than 10 inches diameter to qualify as old growth (table 8). In Nebraska and South Dakota, the minimum tree age was applied instead as a minimum stand age because tree ages are not available in these States.

**Table 8.**—Rocky Mountain Region forest types with old-growth definitions, their corresponding FIA forest type groups, and mimumum thresholds.

| Forest type | FIA forest type groups | Large tree age (years) | Large tree diameter (inches) | Large trees per acre | Trees with cull or broken/dead top, per acre | Dead trees per acre |
|---|---|---|---|---|---|---|
| Ponderosa pine | 220 | 200 | 16 | 10 | 1 | 2 |
| Mixed conifer | 200 | 200 | 16 | 10 | 1 | 2 |
| Spruce/fir | 120, 260 | 200 | 16 | 10 | 1 | 2 |
| Aspen | 900 | 100 | 14 | 10 | 1 | 0 |
| Lodgepole pine | 280 | 150 | 10 | 10 | 1 | 2 |
| Pinyon-juniper | 180 | 200 | 12 | 30 | 1 | 1 |
| White pine | 360 | 200 | 12 | 10 | 0 | 0 |
| Gambel oak | 970 | 80 | 4 | 30 | 0 | 0 |
| Cottonwood | 700 | 100 | 14 | 20 | 0 | 0 |

# Southwestern Region (Region 3)

The Southwestern Region developed old-growth definitions based on analysis done to support plan revision (USDA Forest Service 2019, Weisz and Vandendriesche 2013) (table 9) examining forests with trees averaging > 20” and over 150 years old. This region classifies vegetation with “ecological response units” (ERUs) and uses FIA habitat types to assign stands to an ERU (table 10). Most forest types (ERUs) are defined as old growth if they had a Zeide’s stand density index (SDI) (Zeide 1983) value that was above a certain percentage when compared to the maximum SDI. Quadratic Mean Diameter (QMD) is measured by diameter at breast height (4.5’) for forest tree species and diameter at root collar for woodland tree species.

**Table 9.**—Southwestern Region ecological response units and their old-growth minimum criteria.

| Ecological response unit | Minimum % SDI from trees ≥18" diameter | Minimum QMD of trees ≥10” diameter |
|---|---|---|
| Spruce-Fir Forest | n/a | 18 |
| Mixed Conifer w/ Aspen | n/a | 18 |
| Bristlecone Pine | n/a | 18 |
| Mixed Conifer -- Frequent Fire | 56 | n/a |
| Ponderosa Pine Forest | 57 | n/a |
| Ponderosa Pine -- Evergreen Oak | 56 | n/a |
| PJ Evergreen Shrub | n/a | 18 |
| PJ Woodland (persistent) | n/a | 18 |
| PJ Sagebrush | n/a | 18 |
| PJ Deciduous Shrub | n/a | 18 |
| PJ Grass | 29 | n/a |
| Juniper Grass | 36 | n/a |
| Madrean Pinyon-Oak | 20 | n/a |
| Madrean Encinal Woodland | 20 | n/a |
| Gambel Oak Shrubland | n/a | 18 |
| Semi-Desert Grassland | 36 | n/a |
| Ponderosa Pine/Willow | 57 | n/a |
| Arizona Walnut | n/a | 18 |
| Rio Grande Cottonwood/Shrub | n/a | 18 |
| Narrowleaf Cottonwood - Spruce, Narrowleaf Cottonwood/Shrub | n/a | 18 |
| Upper Montane Conifer/Willow | n/a | 18 |

**Table 10.**—Ecological response units (ERUs) and the corresponding habitat type codes on Southwestern Region FIA plots.

| Ecological response unit | Habitat type codes |
|---|---|
| Spruce-Fir Forest | 415, 435, 604, 1100, 3060, 3080, 3090, 3110, 3111, 3112, 3200, 3201, 3202, 3203, 3231, 3240, 3300, 3301, 3310, 3320, 3350, 3370, 3999, 4060, 4061, 4062, 4151, 4152, 4300, 4310, 4320, 4330, 4340, 4350, 4351, 4360, 4999, 26005, 240300 |
| Mixed Conifer w/ Aspen | 1010, 1011, 1012, 1020, 1030, 1070, 1080, 1081, 1110, 1111, 1120, 1150, 1160, 1231, 1999, 6010, 6060, 6070, 6071, 6080, 6130, 12320, 12333 |
| Bristlecone Pine | 238040, 238310 |
| Mixed Conifer -- Frequent Fire | 1021, 1022, 1040, 1041, 1042, 1050, 1051, 1052, 1053, 1054, 1060, 1090, 1140, 1141, 1203, 1213, 1239, 1241, 6090, 11130, 12140, 12141, 12142, 12143, 12330, 12331, 12332, 12340, 12341, 12350, 12360, 12361, 12362, 12380, 12420, 12430, 12999, 238300 |
| Ponderosa Pine Forest | 11030, 11031, 11032, 11033, 11035, 11090, 11091, 11092, 11093, 11210, 11211, 11212, 11213, 11214, 11215, 11216, 11320, 11330, 11340, 11341, 11350, 11380, 11390, 11391, 11392, 11400, 11460, 11500, 11999 |
| Ponderosa Pine -- Evergreen Oak | 11034, 11220, 11360, 11361, 11370, 11410, 11411, 11420, 11430, 11440, 32010, 32030, 32999, 33010, 33020, 33030 |
| PJ Evergreen Shrub | 3102, 204400, 230030, 230040, 230041, 230042, 230999, 231010, 232070, 233010, 233030, 233040, 233041, 233042, 233050 |
| PJ Woodland (persistent) | 202500, 202500, 204320, 204330, 204500, 232020, 232330, 233330 |
| PJ Sagebrush | 20406, 20410, 20411, 20431, 23204, 204021, 204022, 204023, 204024, 204300, 204350, 204370, 204999, 231020, 232030, 232999, 233020, 233021, 233022, 233999, 9000042 |
| PJ Deciduous Shrub | 20404, 204050, 204321, 2040303 |
| PJ Grass | 20406, 20410, 20411, 20431, 23204, 204021, 204022, 204023, 204024, 204300, 204350, 204370, 204999, 231020, 232030, 232999, 233020, 233021, 233022, 233999, 9000042 |
| Juniper Grass | 20140, 201010, 201011, 201020, 201040, 201331, 201332, 201333, 201340, 201350, 201400, 201410, 201999, 202320, 202321, 202330, 202331, 202999, 231021, 231030, 231040, 231050, 231999, 9000043 |
| Madrean Pinyon-Oak | 3101, 204360, 232050, 232060, 630010, 630030, 630040, 630043, 630050, 2040301, 2040302 |
| Madrean Encinal Woodland | 31999, 610010, 610020, 620010, 620020, 620021, 620030, 620999, 630020, 630041, 630042, 632999, 650010, 650999 |
| Gambel Oak Shrubland | 640999 |
| Semi-Desert Grassland | 201420, 201430, 210999 |
| Ponderosa Pine/Willow | 11470 |
| Arizona Walnut | 1130, 620040 |
| Rio Grande Cottonwood / Shrub | 104 |
| Narrowleaf Cottonwood - Spruce, Narrowleaf Cottonwood/Shrub | 103 |
| Upper Montane Conifer/Willow | 3 |

# Intermountain Region (Region 4)

Hamilton (1993) defines old-growth forest characteristics and sets regional old-growth definitions, along with the 2007 memo from Regional Forester Troyer clarifying that only age, size, and density should be used to determine old growth status (table 11). For a given forest type, as defined by composition, geography, and productivity, stands must meet the minimum number of trees per hectare over a threshold size and estimated age to be considered old growth.

**Table 11.**—Intermountain Region old-growth types and minimum criteria. Vegetation crosswalk code was used to determine which Intermountain Region old-growth type a given FIA observation was assigned to. Code uses variables in the FIA public database (Burrill et al. 2021) and abbreviations for FIA table names (c = condition table; p = plot table; t = tree table). Old-growth forest estimates for Pinyon-Juniper in southeast Utah were calculated for this national inventory using criteria in Table 11, consistent with Hamilton (1993) and based on Popp et al. (1992). Future estimates will employ current or updated criteria employed by Southwestern Region as directed by Hamilton (1993).

| Old-growth type | Minimum large tree age | Minimum large tree diameter (inches) | Minimum large trees per acre | Vegetation crosswalk code |
|---|---|---|---|---|
| Engelmann Spruce-Subalpine Fir-Warm-UT | 220 | 20 | 25 | (p.statecd not in(16) and ((c.fortypcd in(265,261)) or (c.fortypcd = 266 and c.physclcd > 20) or (c.fortypcd = 266 and t.spcd not in(113,101,72)))) |
| Engelmann Spruce-Subalpine Fir-Warm-ID | 220 | 24 | 25 | (p.statecd = 16 and ((c.fortypcd in(265,261)) or (c.fortypcd = 266 and c.physclcd > 20) or (c.fortypcd = 266 and t.spcd not in(113,101,72)))) |
| Engelmann Spruce-Subalpine Fir-Cold | 150 | 15 | 15 | ((c.fortypcd = 266 and c.physclcd < 20) or (c.fortypcd = 266 and t.spcd in(113,101,72)) or (c.fortypcd = 268 and c.siteclcd < 7)) |
| Engelmann Spruce-Subalpine Fir-Alpine | 150 | 12 | 10 | (c.fortypcd = 268 and c.siteclcd = 7) |
| Whitebark Pine | 250 | 18 | 15 | (c.fortypcd = 367) |
| Bristlecone Pine | 300 | 10 | 5 | (c.fortypcd = 365) |
| Douglas-Fir-High | 200 | 24 | 15 | (c.fortypcd = 201 and c.siteclcd < 6) |
| Douglas-Fir-Low | 200 | 18 | 10 | (c.fortypcd = 201 and c.siteclcd >= 6) |
| Grand Fir | 200 | 24 | 15 | (c.fortypcd = 267) |
| Blue Spruce | 250 | 16 | 10 | (c.fortypcd = 269) |
| Conifer Mixed Forests-Low | 256 | 29 | 11 | (c.fortypcd in(371, 262) and c.physclcd < 20) |
| Conifer Mixed Forests-Productive | 188 | 39 | 10 | (c.fortypcd in(371, 262) and c.physclcd > 20) |
| Aspen-Dry | 100 | 12 | 10 | (c.fortypcd = 901 and c.physclcd < 20) |

**Table 11.**—Intermountain Region old-growth types and minimum criteria, continued

| Old-growth type | Minimum large tree age | Minimum large tree diameter (inches) | Minimum large trees per acre | Vegetation crosswalk code |
|---|---|---|---|---|
| Aspen-Mesic | 100 | 12 | 20 | (c.fortypcd = 901 and c.physclcd > 20) |
| Lodgepole Pine | 140 | 11 | 25 | (c.fortypcd = 281) |
| Limber Pine-Lower | 250 | 16 | 10 | (c.fortypcd = 366 and c.siteclcd > 6) |
| Limber Pine-Montane | 500 | 16 | 10 | (c.fortypcd = 366 and c.siteclcd <= 6) |
| Ponderosa Pine-N-Seral | 200 | 24 | 10 | (c.fortypcd in(220,221,222,225) and c.adforcd in(402,412,413,414) and c.siteclcd > 5) |
| Ponderosa Pine-N-Climax | 200 | 24 | 5 | (c.fortypcd in(220,221,222,225) and c.adforcd in(402,412,413,414) and c.siteclcd <= 5) |
| Ponderosa Pine-RM-Seral | 200 | 20 | 14 | (c.fortypcd in(220,221,222,225) and c.adforcd not in(402,412,413,414) and c.siteclcd > 5) |
| Ponderosa Pine-RM-Climax | 200 | 16 | 7 | (c.fortypcd in(220,221,222,225) and c.adforcd not in(402,412,413,414) and c.siteclcd <= 5) |
| Pinyon-Juniper-NW-Low | 200 | 12 | 12 | (c.fortypcd in(182,184,185) and (c.adforcd in(402,403,412,413,414,415 ,417,420) or (c.adforcd in(418,419) and p.ECOSUBCD in('M331Dn', 'M331Do', 'M331Dv', 'M331Di'))) and c.physclcd < 20) |
| Pinyon-Juniper-NW-High | 250 | 18 | 30 | (c.fortypcd in(182,184,185) and (c.adforcd in(402,403,412,413,414,415 ,417,420) or (c.adforcd in(418,419) and p.ECOSUBCD in('M331Dn', 'M331Do', 'M331Dv', 'M331Di'))) and c.physclcd > 20) |
| Pinyon-Juniper-SE-Low | 150 | 9 | 12 | (c.fortypcd in(182,184,185) and (c.adforcd in(401,407,408,410) or (c.adforcd in(418,419) and p.ECOSUBCD not in('M331Dn', 'M331Do', 'M331Dv', 'M331Di'))) and c.physclcd < 20) |
| Pinyon-Juniper-SE-High | 200 | 12 | 30 | (c.fortypcd in(182,184,185) and (c.adforcd in(401,407,408,410) or (c.adforcd in(418,419) and p.ECOSUBCD not in('M331Dn', 'M331Do', 'M331Dv', 'M331Di'))) and c.physclcd > 20) |

# Pacific Southwest Region (Region 5)

The Pacific Southwest Region developed a series of white papers defining old-growth forest; the criteria were compiled in a table in Beardsley and Warbington (1996). These were modified by regional staff to reflect current knowledge and reduce the number of productivity classes (table 12). Vegetation types based on dominant tree species were grouped by productivity class based on Dunning's site index, with index <45 assigned to "low," otherwise "high." Old-growth criteria consisted of a minimum stand age and a minimum density of large diameter live trees. Defined vegetation types were crosswalked to FIA forest types; oak and pinyon-juniper forest types did not have applicable old-growth criteria and therefore had no potential to be classified as old growth. Criteria for some Region 5 forest types were distinguished by ecoregion code (ECOSUBCD in the FIA database). Because most applications of stand age are based on the oldest trees in a stand and not the average age of the overstory trees, this report uses either the age of the oldest increment-cored tree in the condition or the FIA stand age to determine whether age criterion was met. Conditions that met the minimum density of large trees and the age criteria were classified as old growth.

**Table 12.**—Pacific Southwest Region old-growth types, FIA forest type codes, and minimum criteria.

| Region 5 vegetation type name | FIA forest type code | Site | Minimum diameter (inches) | Minimum trees per acre | Minimum stand age |
|---|---|---|---|---|---|
| Coast Redwood | 341 | All | 40 | 15 | |
| Conifer Mixed Forests | 371, 226, 361 | Productive | 39 | 6 | 188 |
| Conifer Mixed Forests | 371, 226, 361 | Low | 29 | 5 | 256 |
| White Fir (NWFP area) | 261 | Productive | 30 | 5 | 160 |
| White Fir (NWFP area) | 261 | Low | 25 | 23 | 303 |
| White Fir (not NWFP) | 261 | Productive | 39 | 6 | 143 |
| White Fir (not NWFP) | 261 | Low | 29 | 8 | 239 |
| Pacific Douglas-fir | 201,202 | Productive | 40 | 12 | 180 |
| Pacific Douglas-fir | 201,202 | Low | 30 | 18 | 260 |
| Douglas-fir/Tanoak/Madrone | 941 | Productive | 30 | 10 | 180 |
| Douglas-fir/Tanoak/Madrone | 941 | Low | 30 | 8 | 300 |
| Mixed Subalpine (Western White Pine Association) | 241, 342, 365, 366, 367 | Productive | 30 | 9 | 150 |
| Mixed Subalpine (Western White Pine Association) | 241, 342, 365, 366, 367 | Low | 30 | 10 | 200 |

**Table 12.**—Pacific Southwest Region old-growth types, FIA forest type codes, and minimum criteria, continued.

| Region 5 vegetation type name | FIA forest type code | Site | Minimum diameter (inches) | Minimum trees per acre | Minimum stand age |
|---|---|---|---|---|---|
| Mixed Subalpine (Mountain Hemlock Association) | 270 | Productive | 30 | 12 | 150 |
| Mixed Subalpine (Mountain Hemlock Association) | 270 | Low | 30 | 6 | 200 |
| Mixed Subalpine (Western Juniper Association) | 369 | All | 30 | 5 | 200 |
| Mixed Subalpine (Quaking Aspen Association) | 901 | Productive | 18 aspen/ 30 conifer | 5 | 80 |
| Mixed Subalpine (Quaking Aspen Association) | 901 | Low | 18 aspen/ 30 conifer | 1 | 80 |
| Red Fir | 262 | Productive | 30 | 8 | 150 |
| Red Fir | 262 | Low | 36 | 5 | 200 |
| Jeffrey Pine | 225 | Productive | 30 | 3 | 150 |
| Jeffrey Pine | 225 | Low | 30 | 1 | 200 |
| Lodgepole Pine | 281 | Productive | 36 | 7 | 150 |
| Lodgepole Pine | 281 | Low | 36 | 4 | 200 |
| Interior Ponderosa Pine[1] | 221 | Productive | 21 | 19 | 150 |
| Interior Ponderosa Pine[1] | 221 | Low | 21 | 16 | 200 |
| Pacific Ponderosa Pine[a] | 221 | All | 30 | 9 | 125 |

[a] Ponderosa Pine is considered Interior Productive in ECOSUBCD= M261G*, 342B*, M261Ea, M261Eb, M261Ec, M261Ei, M261Ej, M261D* but not M261Di,M; Interior Low in ECOSUBCD=M261G*, 342B*, M261Ea, M261Eb, M261Ec, M261Ei, M261Ej, M261D* but not M261Di,M, otherwise Pacific.

# Pacific Northwest Region (Region 6)

Parts of the Pacific Northwest Region are managed under the Northwest Forest Plan (NWFP). In the NWFP areas, an old-growth structure index score for stand age 200 (OGSI 200) identified old growth (Davis et al. 2022) (table 13). For remaining lands in the Pacific Northwest Region (eastern Oregon and Washington), the 1993 "interim definitions" were used (https://ecoshare.info/2009/12/16/r6-old-growth-interim-definitions/) (table 14).

For both sets of criteria, tree and understory species on FIA plots were classified to plant association zone (PAZ) by regional ecology staff and matched to the old-growth criteria.

**Table 13.**—Pacific Northwest Region, Northwest Forest Plan area old-growth forest types and minimum threshold for old-growth status, OGSI 200.[a]

| Plant association zone | Large tree diameter (in)[b] | Large tree density (trees $ac^{-1}$) | Snag diameter (in)[b] | Snag density (trees $ac^{-1}$) | Cover of downed wood ≥9.8-in DBH | Diameter diversity index[c] |
|---|---|---|---|---|---|---|
| Grand fir/white fir | 29.5 | 6 | 19.7 | 4 | 2 | yes |
| Juniper | 19.7 | 6 | n/a | n/a | n/a | n/a |
| Mountain hemlock | 29.5 | 4 | 19.7 | 5 | 2 | yes |
| Oak woodland | 19.7 | 6 | n/a | n/a | n/a | n/a |
| Ponderosa pine | 29.5 | 4 | n/a | n/a | n/a | n/a |
| Port Orford cedar | 29.5 | 5 | 19.7 | 6 | 1 | yes |
| Redwood | 39.4 | 8 | 39.4 | 1 | 3 | yes |
| Shasta red fir | 29.5 | 10 | 19.7 | 4 | 1 | yes |
| Silver fir | 29.5 | 9 | 19.7 | 8 | 4 | yes |
| Sitka spruce | 39.4 | 7 | 39.4 | 5 | 6 | yes |
| Subalpine | 19.7 | 6 | 19.7 | 1 | 2 | yes |
| Tanoak | 39.4 | 5 | 39.4 | 2 | 2 | yes |
| Western hemlock | 39.4 | 4 | 39.4 | 3 | 4 | yes |
| Douglas-fir | 29.5 | 3 | 19.7 | 1 | 1 | yes |
| Lodgepole pine | 9.8 | 60 | n/a | n/a | n/a | n/a |
| Jeffrey pine/knobcone pine | 29.5 | 5 | n/a | n/a | n/a | n/a |

[a] Old Growth Structure Index (OGSI) is the sum of scores of four elements. The density required to exceed the OGSI200 score based on that attribute alone is shown. However, no stand can meet OGSI200 without at least 10 percent live tree cover and QMD >=50% of the minimum live diameter. For frequent-fire or sparse PAZ types, live trees were the only attribute used to calculate OGSI

[b] Conifers only, except in Oak woodland.

[c] Score is based on trees per acre of trees 2–9.8, 9.9–19.7, 19.8–39.4, and >39.4 inches.

**Table 14.**—Pacific Northwest Region old-growth criteria outside the Northwest Forest Plan area.

| Forest plant association zones | Site[a] | Large tree diameter (in) | Large tree density (trees $ac^{-1}$) | Tree age (years)[b] | Regional geography[c] |
|---|---|---|---|---|---|
| White/Grand fir | H | 21 | 15 | 150 | Central Oregon |
| White/Grand fir | L-M | 21 | 10 | 150 | Central Oregon |
| White/Grand fir | H | 21 | 20 | 150 | Blue Mountains |
| White/Grand fir | L-M | 21 | 10 | 150 | Blue Mountains |
| Douglas-fir (interior) | ALL | 21 | 8 | 150 | Eastside |
| Lodgepole pine | ALL | 12 | 60 | 120 | Central and southeast Oregon |
| Pacific silver fir | 5 | 22 | 9 | 260 | Westside |
| Pacific silver fir | 6 | 22 | 1 | 360 | Westside |
| Pacific silver fir | 2&3 | 26 | 6 | 180 | Westside |
| Pacific silver fir | 4 | 25 | 7 | 200 | Westside |
| Ponderosa pine | M-H | 21 | 13 | 150 | Eastside |
| Ponderosa pine (very late decadent) | M-H | 31 | 3 | 200 | Eastside |
| Ponderosa pine | L | 21 | 10 | 150 | Eastside |
| Ponderosa pine (very late decadent) | L | 31 | 2 | 200 | Eastside |
| Subalpine fir | H | 21 | 10 | 150 | Eastside |
| Subalpine fir | L | 13 | 10 | 150 | Eastside |
| Western hemlock | 1 | 42 | 8 | 200 | Westside |
| Western hemlock | 2 | 35 | 8 | 200 | Westside |
| Western hemlock | 3 | 31 | 8 | 200 | Westside |
| Western hemlock | 4&5 | 21 | 8 | 200 | Westside |

[a] FIA site classes 1+2 were assigned to high, 3+4 to medium, and >4 to low.
[b] The density of live trees greater than the minimum DBH was calculated, and the presence of any increment-cored trees greater than the minimum age. Any condition with more than the minimum density of large trees and at least one old tree was classified as old growth. In the absence of cored trees, stand ages were used.
[c] Central Oregon was defined as being in the east Cascades ecoregion (M242C) and not in Hood River or Wasco Counties, with the remaining areas assigned to the Blues and eastern Washington grouping.

# Southern Region (Region 8)

Definitions for characteristics of old growth in the Southern Region are listed by old-growth community type in Gaines et al. (1997), necessitating a crosswalk from FIA forest types to old-growth community types. To be considered old growth, each stand had to meet or exceed minimum values of live basal area (ft2 $ac^{-1}$; of trees ≥5 in DBH), stand age, dead trees density, and have ≥6 trees per acre that met a minimum diameter for a given old-growth community type (table 15). FIA forest types were often matched to more than one old-growth community type (table 16); if the thresholds were met for any of the stand's potential old-growth community types, the stand was considered old growth. Forests in Puerto Rico were considered old growth if in a wilderness area. Forest types dominated by commonly planted pine species were only considered old growth if they met the appropriate thresholds and were located in a county where the species is known to be native; information will be available in Pelz et al. (2023).

**Table 15.**—Southern Region old-growth community types and minimum criteria.

| Old-growth code | Old-growth type | Stand age | Stand basal area ($ft^2$ $ac^{-1}$) | Large tree diameter (inches) | Dead trees per acre |
|---|---|---|---|---|---|
| 1 | Northern hardwood forest | 100 | 40 | 14 | 13 |
| 2 | Conifer-northern hardwood forest | 140 | 40 | 20 | 6 |
| 5 | Mixed mesophytic and western mesophytic forest | 140 | 40 | 30 | 4 |
| 6 | Coastal plain upland mesic hardwood forest | 120 | 40 | 24 | 4 |
| 10 | Hardwood wetland forest | 120 | 40 | 20 | 0 |
| 13 | River floodplain hardwood forest | 100 | 40 | 16 | 0 |
| 14 | Cypress-tupelo swamp forest | 120 | 40 | 8 | 3 |
| 21 | Dry-mesic oak forest | 130 | 40 | 20 | 26 |
| 22 | Dry and xeric oak forest, woodland, and savanna | 90 | 10 | 8 | 10 |
| 24 | Xeric pine and pine-oak forest and woodland | 100 | 20 | 10 | 6 |
| 25 | Dry and dry-mesic oak-pine forest | 120 | 40 | 19 | 15 |
| 26 | Upland longleaf and south Florida slash pine forest, woodland, and savanna | 80 | 10 | 16 | 0 |
| 27 | Seasonally wet oak-hardwood woodland | 100 | 40 | 20 | 0 |
| 28 | Eastern riverfront forest | 100 | 40 | 25 | 6 |
| 29 | Southern wet pine forest, woodland, and savanna | 80 | 10 | 9 | 0 |
| 31 | Montane and allied spruce and spruce-fir forest | 120 | 40 | 20 | 14 |

**Table 16.**—FIA forest type codes cross-walked to Southern Region old-growth community types. Each FIA observation was classified as old growth if it met criteria for any matched old-growth community type.

| FIA forest type code(s) | Old-growth community type code(s) matched to forest type |
|---|---|
| 104, 105, 123, 124 | 2 |
| 129 | 31 |
| 141 | 26, 29 |
| 142, 166, 407 | 29 |
| 161 | 25 |
| 162, 163, 404, 405, 409 | 24, 25 |
| 165, 167 | 24 |
| 400 | 2, 24, 25, 26, 29 |
| 401 | 2 |
| 403 | 26 |
| 406 | 25 |
| 500 | 5, 13, 21, 22, 24, 27 |
| 501 | 22 |
| 502, 515, 519 | 21, 22 |
| 504 | 21, 27 |
| 505 | 21 |
| 506, 511, 516 | 5 |
| 508 | 13 |
| 510 | 21, 22, 24 |
| 514 | 22, 24 |
| 517, 800, 801, 805 | 1, 5 |
| 520 | 27 |
| 600 | 6, 10, 13, 22, 27, 28 |
| 601, 602, 605, 706 | 13 |
| 607, 609 | 14 |
| 608, 809 | 10 |
| 700 | 10, 28 |
| 702, 703, 704 | 28 |
| 705 | 13, 28 |
| 708 | 10, 13 |
| 709 | 28 |
| 902 | 312 |
| 962 | 1, 5, 6, 10, 13, 21, 22, 27, 28 |

# Eastern Region (Region 9)

Characteristics of old-growth forests derived from extensive field surveys by major vegetation types (Tyrell et al. 1998) were used as the primary basis for old-growth definitions in the Eastern Region. These field surveys of sites deemed by regional botanists and ecologists to be old growth were conducted decades ago in a nonsystematic manner using vegetation types that differ from FIA forest types. As such, upon consultation with contemporary regional staff, the Tyrell et al. (1998) vegetation types were classified into the old-growth types (10 types, including an "other" category) deemed most appropriate and aligned with specific FIA forest types. To be considered old growth, FIA plot measurements had to meet thresholds for stand age (100–160 years) and density (5–20 trees ac-1) of large trees at least 12- to 20-in DBH (table 17).

**Table 17.**—Eastern Region old-growth community types, corresponding FIA forest types, and large tree diameter and density and stand age minima.

| Old-growth type | FIA forest type code | Tree diameter (inches) | Trees per acre | Stand age (years) |
|---|---|---|---|---|
| Beech maple basswood | 805 | 16 | 10 | 141 |
| Northern hardwood | 520, 801, 802, 809 | 16 | 10 | 141 |
| Dry oak | 162, 163, 165, 167, 182, 184, 404, 405, 501, 502, 506, 507, 509, 510, 513, 515 | 16 | 20 | 101 |
| Mesic northern oak | 503, 504, 505, 511, 512, 516 | 20 | 5 | 161 |
| Wetland hardwood | 701, 702, 703, 704, 705, 706, 707, 708, 709 | 18 | 10 | 121 |
| Conifer northern hardwood | 104, 105, 401 | 16 | 10 | 141 |
| Northern pine | 101, 102, 103 | 12 | 20 | 101 |
| Montane spruce | 121, 123, 124, 128, 129 | 15 | 10 | 141 |
| Sub-boreal spruce/fir | 122, 125 | 12 | 10 | 141 |
| Other | All others | 14 | 10 | 101 |

# Alaska Region (Region 10)

The Alaska Region used old-growth forest definitions from Boughton et al. (1992a, 1992b) as the basis for their old-growth criteria. The team developed a crosswalk from the described old-growth types to available data on FIA plots using forest type, elevation, slope, the Pacific Northwest Research Station (PNW) topographic code, and understory vegetation composition. FIA plot records were identified as old growth if they met either minimum density of large live trees, minimum density of large dead trees, minimum stand age, or minimum-aged tree (table 18). Original definitions required meeting all four criteria.

Relaxing the definition to classify FIA site as old growth when any of four criteria were met agreed more closely with the independent map-based classification of old growth used by the Alaska Region.

The current FIA sample of coastal Alaska does not include designated and candidate wilderness areas due to restricted access, so these areas are not included in the inventory.

**Table 18.**—Alaska Region old-growth forest types and minimum threshold for old-growth

| National forest | Forest type name | FIA forest type code | Series | Age (years) | Large tree diameter (in) | Large tree density (trees ac-1) | Snag diameter (in) | Snag density (trees ac-1) |
|---|---|---|---|---|---|---|---|---|
| Chugach | Sitka Spruce - Alluvial | 305 | n/a | 150 | 16 | 24 | 16 | 3 |
| Chugach | Sitka Spruce - Other | 305 | n/a | 200 | 13 | 21 | 13 | 4 |
| Chugach | Western Hemlock - well Drained | 301 | n/a | 150 | 14 | 28 | 14 | 3 |
| Chugach | Western Hemlock - poorly drained | 301 | n/a | 170 | 10 | 61 | 10 | 16 |
| Chugach | Mountain Hemlock - Hi-elevation | 270 | n/a | 150 | 10 | 24 | 10 | 5 |
| Chugach | Mountain Hemlock -low elevation | 270 | n/a | 170 | 7 | 58 | 7 | 5 |
| Chugach | White Spruce | 122 | n/a | 150 | 7 | 37 | 7 | 22 |
| Chugach | Black Spruce | 125 | n/a | 200 | 5 | 150 | 5 | 10 |
| Chugach | Aspen | 901 | n/a | 80 | 5 | 73 | 5 | 6 |
| Tongass | Sitka Spruce - Alluvial | n/a | PISI | 260 | 27 | 6 | 27 | 2 |
| Tongass | Sitka Spruce - Other | n/a | PISI | 160 | 23 | 7 | 23 | 1 |
| Tongass | Western Hemlock - well Drained | n/a | TSHE | 150 | 19 | 21 | 19 | 2 |
| Tongass | Western Hemlock - poorly drained | n/a | TSHE | 180 | 15 | 17 | 15 | 3 |
| Tongass | Western Hemlock/ western redcedar - well Drained | n/a | THPL | 170 | 21 | 16 | 21 | 5 |
| Tongass | Western Hemlock/ western redcedar - poorly drained | n/a | THPL | 150 | 19 | 15 | 19 | 3 |
| Tongass | Western hemlock/ Alaska yellow cedar | n/a | CHNO | 150 | 15 | 26 | 15 | 3 |
| Tongass | Mixed conifer | n/a | MIXC | 170 | 11 | 12 | 11 | 4 |
| Tongass | Mountain hemlock | n/a | TSME | 160 | 13 | 12 | 13 | 2 |
| Tongass | Shore pine | n/a | PICO | 170 | 9 | 18 | 9 | 2 |

# Appendix 2: Mature Forest Working Definitions

Mature working definitions as applied to FIA data for the national inventory for each mature vegetation class (table 19). Mature vegetation classes were developed from old-growth regional vegetation types; old-growth regional vegetation types were merged into mature vegetation classes based on similar forest types when fewer than 10 old-growth plots were classified. Structural indicator variables (indicators) used in mature forest definitions are defined in table 3 of the main text.

**Table 19.**—Working definitions for mature forest as applied to FIA data for the national old-growth and mature forest inventory. Definitions were applied to each FIA plot record based on the Forest Service region and mature vegetation class.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 1 Douglas fir | 0.86 | ddiscore | 0.41 | 32.6 | 0.34 | R1 Douglas fir; R1 Douglas-fir group; R1 Douglas-Fir-High |
| | | badom | 0.39 | 82.5 | 0.33 | |
| | | QMDdom | 0.39 | 10.3 | 0.33 | |
| Region 1 Fir/spruce/ mountain hemlock group | 0.8 | ddiscore | 0.52 | 24 | 0.44 | R1 Engelmann Spruce-Subalpine Fir-Warm-ID; R1 Spruce/Fir (Fir/spruce/ mountain hemlock group); R1 Fir/spruce/mountain hemlock group; R1 Western white pine group; R1 Grand Fir |
| | | HTsd | 0.35 | 49.6 | 0.3 | |
| | | HTquart | 0.31 | 39.2 | 0.26 | |
| Region 1 Hardwoods (FIA aspen/ birch groupa) | 0.8 | ddiscore | 0.61 | 23.9 | 0.31 | R1 Alder/maple group; R1 Elm/ash/cottonwood group; R1 Aspen; R1 Gambel Oak; R1 Aspen/birch group; R1 Oak/hickory group; R1 Cottonwood; R1 Woodland hardwoods group |
| | | badom | 0.56 | 62 | 0.28 | |
| | | HTquart | 0.52 | 38.4 | 0.26 | |
| | | HTsd | 0.29 | 28 | 0.15 | |
| Region 1 Hemlock/ Sitka spruce group | 0.86 | ddiscore | 0.64 | 45 | 0.38 | R1 Hemlock/Sitka spruce group |
| | | HTsd | 0.48 | 74.4 | 0.28 | |
| | | HTquart | 0.35 | 69.2 | 0.21 | |
| | | tpadom | -0.22 | 70 | 0.13 | |
| Region 1 Lodgepole Pine | 0.49 | HTquart | 0.58 | 25 | 0.28 | R1 Lodgepole Pine; R1 Lodgepole pine group |
| | | ddiscore | 0.54 | 14.6 | 0.26 | |
| | | badom | 0.53 | 43.6 | 0.26 | |
| | | HTsd | 0.39 | 24 | 0.19 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 1 Pinyon Juniper - Western Softwoods | 0.8 | ddiscore | 0.61 | 24 | 0.3 | R1 Other Western Softwoods; R1 Other western softwoods group; R1 Pinyon/juniper group; R1 Pinyon-Juniper |
| | | HTquart | 0.52 | 28.6 | 0.25 | |
| | | QMDdom | 0.5 | 7 | 0.25 | |
| | | HTsd | 0.41 | 29.4 | 0.2 | |
| Region 1 Ponderosa Pine | 0.83 | ddiscore | 0.55 | 31.5 | 0.36 | R1 Ponderosa Pine; R1 Ponderosa pine group; R1 Ponderosa Pine-RM-Climax |
| | | QMDdom | 0.53 | 13 | 0.34 | |
| | | HTsd | 0.46 | 40.7 | 0.3 | |
| Region 1 Western larch group | 0.93 | QMDdom | 0.65 | 15.8 | 0.31 | R1 Western larch group |
| | | ddiscore | 0.65 | 53 | 0.31 | |
| | | HTsd | 0.43 | 80.9 | 0.21 | |
| | | tpadom | -0.34 | 69 | 0.16 | |
| Region 2 Aspen/ Cottonwood/ Oaks | 0.62 | HTquart | 0.67 | 32.9 | 0.31 | R2 Aspen; R2 Cottonwood; R2 Oak/hickory group; R2 Other hardwoods group |
| | | ddiscore | 0.59 | 18.6 | 0.27 | |
| | | badom | 0.56 | 55.1 | 0.26 | |
| | | HTsd | 0.33 | 25.3 | 0.15 | |
| Region 2 Douglas fir | 0.86 | ddiscore | 0.48 | 29.2 | 0.3 | R2 Douglas fir |
| | | badom | 0.33 | 65.8 | 0.21 | |
| | | HTquart | 0.28 | 40.6 | 0.18 | |
| | | QMDdom | 0.27 | 9.3 | 0.17 | |
| | | snagbatot | 0.24 | 21.3 | 0.15 | |
| Region 2 Gambel Oak | 0.8 | badom | 0.32 | 25.3 | 0.3 | R2 Gambel Oak |
| | | ddiscore | 0.26 | 8 | 0.25 | |
| | | HTquart | 0.25 | 10.4 | 0.24 | |
| | | QMDdom | 0.22 | 2.9 | 0.21 | |
| Region 2 Lodgepole Pine | 0.49 | QMDdom | 0.6 | 3.7 | 0.46 | R2 Lodgepole Pine |
| | | badom | 0.5 | 33.8 | 0.38 | |
| | | HTsd | 0.21 | 17.5 | 0.16 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 2 Other Western Softwoods | 0.8 | ddiscore | 0.69 | 24 | 0.32 | R2 Other Western Softwoods; R2 Other eastern softwoods group |
| | | QMDdom | 0.61 | 6.5 | 0.29 | |
| | | HTquart | 0.51 | 28.2 | 0.24 | |
| | | HTsd | 0.33 | 21.6 | 0.15 | |
| Region 2 Pinyon-Juniper | 0.8 | ddiscore | 0.51 | 33.5 | 0.55 | R2 Pinyon-Juniper |
| | | QMDdom | 0.42 | 8.6 | 0.45 | |
| Region 2 Ponderosa Pine (FIA Ponderosa Pine Groupa) | 0.83 | QMDdom | 0.42 | 11.8 | 0.33 | R2 Ponderosa Pine |
| | | ddiscore | 0.35 | 31.6 | 0.28 | |
| | | HTsd | 0.27 | 39 | 0.21 | |
| | | badom | 0.23 | 67.3 | 0.18 | |
| Region 2 Spruce/Fir | 0.79 | ddiscore | 0.57 | 28.8 | 0.31 | R2 Spruce/Fir (Fir/spruce/ mountain hemlock group); R2 Spruce/Fir (Spruce/fir group) |
| | | badom | 0.51 | 87.2 | 0.27 | |
| | | HTquart | 0.45 | 43.5 | 0.24 | |
| | | HTsd | 0.33 | 44.6 | 0.18 | |
| Region 3 Hardwoods (FIA Woodland Hardwoods Groupa) | 0.77 | QMDdom | 0.64 | 3.5 | 0.34 | R3 Arizona Walnut; R3 Rio Grande Cottonwood/Shrub; R3 Gambel Oak Shrubland; R3 Sycamore - Fremont Cottonwood; R3 Narrowleaf Cottonwood - Spruce, Narrowleaf Cottonwood/ Shrub; R3 Upper Montane Conifer/Willow; R3 Woodland hardwoods group; R3 Other |
| | | ddiscore | 0.63 | 7.7 | 0.34 | |
| | | HTquart | 0.37 | 10.8 | 0.2 | |
| | | tpadom | -0.22 | 69.5 | 0.12 | |
| Region 3 Juniper Grass | 0.8 | QMDdom | 0.59 | 10.7 | 0.3 | R3 Juniper Grass |
| | | HTquart | 0.53 | 11.2 | 0.27 | |
| | | ddiscore | 0.53 | 19 | 0.27 | |
| | | HTsd | 0.34 | 4 | 0.17 | |
| Region 3 Madrean Encinal Woodland | 0.8 | QMDdom | 0.6 | 8.8 | 0.36 | R3 Madrean Encinal Woodland |
| | | HTquart | 0.49 | 15.2 | 0.3 | |
| | | ddiscore | 0.3 | 16.8 | 0.18 | |
| | | tpadom | -0.26 | 56.4 | 0.16 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 3 Madrean Pinyon-Oak | 0.8 | QMDdom | 0.49 | 8.3 | 0.32 | R3 Madrean Pinyon-Oak |
| | | HTquart | 0.43 | 14.4 | 0.28 | |
| | | ddiscore | 0.35 | 23.8 | 0.23 | |
| | | HTsd | 0.24 | 10.4 | 0.16 | |
| Region 3 Mixed Conifer -- Frequent Fire | 0.82 | ddiscore | 0.61 | 21.4 | 0.41 | R3 Mixed Conifer -- Frequent Fire |
| | | QMDdom | 0.56 | 13.3 | 0.38 | |
| | | HTsd | 0.32 | 44.7 | 0.21 | |
| Region 3 Mixed Conifer w/ Aspen | 0.76 | ddiscore | 0.73 | 34.6 | 0.39 | R3 Mixed Conifer w/ Aspen; R3 Bristlecone Pine |
| | | HTsd | 0.45 | 41.2 | 0.24 | |
| | | HTquart | 0.4 | 36.3 | 0.22 | |
| | | snagbatot | -0.28 | 15 | 0.15 | |
| Region 3 PJ Grass - Sagebrush | 0.8 | ddiscore | 0.6 | 19.6 | 0.29 | R3 PJ Grass; R3 PJ Sagebrush; R3 Semi-Desert Grassland |
| | | QMDdom | 0.55 | 9.5 | 0.26 | |
| | | HTquart | 0.54 | 12.8 | 0.26 | |
| | | HTsd | 0.39 | 6.4 | 0.19 | |
| Region 3 PJ Shrub - Woodland | 0.78 | ddiscore | 0.51 | 20.2 | 0.46 | R3 Pinyon/juniper group; R3 PJ Woodland (persistent); R3 PJ Deciduous Shrub; R3 PJ Evergreen Shrub |
| | | QMDdom | 0.38 | 9.2 | 0.34 | |
| | | HTquart | 0.23 | 13.3 | 0.21 | |
| Region 3 Ponderosa Pine | 0.81 | ddiscore | 0.46 | 24.3 | 0.45 | R3 Ponderosa Pine Forest |
| | | badom | 0.29 | 40 | 0.28 | |
| | | QMDdom | 0.28 | 13.5 | 0.27 | |
| Region 3 Ponderosa Pine - Mixed | 0.81 | ddiscore | 0.63 | 32.4 | 0.5 | R3 Ponderosa Pine -- Evergreen Oak; R3 Ponderosa Pine/Willow |
| | | QMDdom | 0.41 | 9 | 0.32 | |
| | | HTsd | 0.23 | 24.1 | 0.18 | |
| Region 3 Spruce - Fir | 0.75 | ddiscore | 0.57 | 32.4 | 0.24 | R3 Douglas-fir group; R3 Spruce-Fir Forest |
| | | HTsd | 0.51 | 51.8 | 0.22 | |
| | | QMDdom | 0.44 | 11.4 | 0.19 | |
| | | HTquart | 0.44 | 43.5 | 0.19 | |
| | | badom | 0.41 | 57.4 | 0.17 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 4 Aspen-Dry | 0.51 | badom | 0.67 | 22.6 | 0.33 | R4 Aspen-Dry |
| | | ddiscore | 0.62 | 12 | 0.3 | |
| | | HTquart | 0.53 | 16.8 | 0.26 | |
| | | HTsd | 0.22 | 14.7 | 0.11 | |
| Region 4 Aspen-Mesic | 0.51 | HTquart | 0.68 | 29.1 | 0.39 | R4 Aspen-Mesic |
| | | ddiscore | 0.65 | 15.3 | 0.37 | |
| | | HTsd | 0.41 | 16.3 | 0.24 | |
| Region 4 Bristlecone/ Limber/ Whitebark Pines | 0.8 | QMDdom | 0.62 | 9.8 | 0.39 | R4 Bristlecone Pine; R4 Limber Pine-Lower; R4 Limber Pine-Montane; R4 Whitebark Pine |
| | | badom | 0.54 | 77.2 | 0.34 | |
| | | HTquart | 0.43 | 26.4 | 0.27 | |
| Region 4 Douglas fir | 0.82 | ddiscore | 0.41 | 33 | 0.43 | R4 Douglas-Fir-High; R4 Douglas-Fir-Low; R4 Fir/ spruce/mountain hemlock group; R4 Grand Fir; R4 Western larch group; R4 Conifer Mixed Forests-Productive |
| | | QMDdom | 0.32 | 11.1 | 0.34 | |
| | | HTquart | 0.22 | 40.2 | 0.23 | |
| Region 4 Elm/ ash/ cottonwood (FIA Elm/Ash/ Cottonwood Groupa) | 0.74 | badom | 0.46 | 47.5 | 0.42 | R4 Elm/ash/cottonwood group |
| | | ddiscore | 0.43 | 19.1 | 0.39 | |
| | | HTsd | 0.2 | 15.5 | 0.18 | |
| Region 4 Engelmann spruce | 0.8 | ddiscore | 0.55 | 29.8 | 0.32 | R4 Engelmann Spruce-Subalpine Fir-Warm-ID; R4 Engelmann Spruce-Subalpine Fir-Warm-UT; R4 Engelmann Spruce-Subalpine Fir-Alpine; R4 Blue Spruce; R4 Engelmann Spruce-Subalpine Fir-Cold; R4 Conifer Mixed Forests-Low |
| | | QMDdom | 0.46 | 8.3 | 0.27 | |
| | | HTquart | 0.4 | 35.4 | 0.23 | |
| | | HTsd | 0.3 | 57.4 | 0.18 | |
| Region 4 Lodgepole Pine | 0.49 | ddiscore | 0.62 | 14.7 | 0.3 | R4 Lodgepole Pine |
| | | HTquart | 0.55 | 23.5 | 0.26 | |
| | | badom | 0.54 | 41.8 | 0.26 | |
| | | HTsd | 0.37 | 18.1 | 0.18 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 4 Pinyon Juniper NW - Others | 0.8 | ddiscore | 0.57 | 24 | 0.42 | R4 Pinyon-Juniper-NW-High; R4 Pinyon-Juniper-NW-Low; R4 Woodland hardwoods group; R4 Other hardwoods group; R4 Other western softwoods group |
| | | QMDdom | 0.54 | 8 | 0.39 | |
| | | tpadom | -0.26 | 90.3 | 0.19 | |
| Region 4 Pinyon-Juniper-SE-High | 0.8 | QMDdom | 0.47 | 9.2 | 0.52 | R4 Pinyon-Juniper-SE-High |
| | | ddiscore | 0.44 | 32.9 | 0.48 | |
| Region 4 Pinyon-Juniper-SE-Low | 0.8 | ddiscore | 0.4 | 24 | 0.56 | R4 Pinyon-Juniper-SE-Low |
| | | QMDdom | 0.32 | 8.3 | 0.44 | |
| Region 4 Ponderosa Pine | 0.83 | QMDdom | 0.54 | 14.2 | 0.38 | R4 Ponderosa Pine-N-Climax; R4 Ponderosa Pine-N-Seral; R4 Ponderosa Pine-RM-Climax; R4 Ponderosa Pine-RM-Seral |
| | | ddiscore | 0.31 | 30.7 | 0.22 | |
| | | HTquart | 0.3 | 49 | 0.21 | |
| | | HTsd | 0.27 | 50.2 | 0.19 | |
| Region 5 Douglas-fir/ Tanoak/ Madrone | 0.8 | ddiscore | 0.57 | 53.3 | 0.45 | R5 Douglas-fir/Tanoak/ Madrone |
| | | QMDdom | 0.37 | 14.8 | 0.29 | |
| | | tpadom | -0.32 | 76.6 | 0.25 | |
| Region 5 Jeffrey Pine | 0.83 | QMDdom | 0.52 | 10.3 | 0.52 | R5 Jeffrey Pine |
| | | ddiscore | 0.25 | 30.8 | 0.25 | |
| | | HTsd | 0.23 | 31.5 | 0.23 | |
| Region 5 Mixed Conifer | 0.75 | QMDdom | 0.41 | 13.1 | 0.6 | R5 Conifer Mixed Forests; R5 Interior Ponderosa Pine; R5 Lodgepole Pine; R5 Mixed Subalpine (Western White Pine Association), R5 Mixed Subalpine (Mountain Hemlock Association) |
| | | ddiscore | 0.27 | 42.1 | 0.4 | |
| Region 5 Pacific Conifers | 0.83 | ddiscore | 0.55 | 52.6 | 0.4 | R5 Coast Redwood; R5 Pacific Douglas-fir; R5 Pacific Ponderosa Pine |
| | | QMDdom | 0.48 | 25.3 | 0.35 | |
| | | snagbatot | 0.36 | 2.7 | 0.26 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 5 Region Red Fir | 0.79 | ddiscore | 0.52 | 48.3 | 0.32 | R5 Red Fir |
| | | QMDdom | 0.46 | 18.1 | 0.28 | |
| | | HTquart | 0.38 | 66.2 | 0.23 | |
| | | HTsd | 0.28 | 43.6 | 0.17 | |
| Region 5 White Fir | 0.79 | ddiscore | 0.4 | 47.5 | 0.31 | R5 White Fir |
| | | HTquart | 0.4 | 68.5 | 0.31 | |
| | | badom | 0.27 | 150 | 0.21 | |
| | | snagbatot | 0.2 | 24.9 | 0.16 | |
| Region 5 Region 6 Hardwoods (FIA Western Oak Groupa) | 0.73 | ddiscore | 0.56 | 38.1 | 0.58 | R5 Alder/maple group; R5 Tanoak/laurel group; R5 Mixed Subalpine (Quaking Aspen Association); R5 Elm/ash/cottonwood group; R5 Western oak group; R5 Other hardwoods group; R5 Woodland hardwoods group;<br>R6 Elm/ash/cottonwood group; R6 Aspen/birch group; R6 Hardwoods; R6 Western oak group; R6 Other hardwoods group |
| | | QMDdom | 0.41 | 6.8 | 0.42 | |
| Region 5 Region 6 Pinyon Juniper - Western Softwoods | 0.8 | QMDdom | 0.43 | 14.2 | 0.54 | R5 Pinyon/juniper group; R5 Mixed Subalpine (Western Juniper Association); R5 Other western softwoods group;<br>R6 Other western softwoods group; R6 Pinyon/juniper group |
| | | badom | 0.36 | 30.9 | 0.46 | |
| Region 6 Douglas-fir (eastside) | 0.75 | QMDdom | 0.44 | 11.1 | 0.42 | R6 Douglas-fir (eastside); R6 Douglas-fir (interior); R6 Douglas-fir group |
| | | ddiscore | 0.4 | 30.2 | 0.38 | |
| | | badom | 0.22 | 60.1 | 0.21 | |
| Region 6 Douglas-Fir (NWFP) | 0.79 | QMDdom | 0.61 | 12.7 | 0.45 | R6 Douglas-Fir (NWFP) |
| | | ddiscore | 0.45 | 32.6 | 0.33 | |
| | | HTsd | 0.31 | 42.3 | 0.23 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 6 Mountain Hemlock | 0.79 | QMDdom | 0.58 | 13.1 | 0.29 | R6 Mountain Hemlock; R6 Fir/spruce/mountain hemlock group |
| | | badom | 0.4 | 126.6 | 0.2 | |
| | | HTsd | 0.4 | 58.5 | 0.2 | |
| | | HTquart | 0.37 | 42.7 | 0.19 | |
| | | tpadom | -0.23 | 77.4 | 0.12 | |
| Region 6 Ponderosa Pine - Lodgepole Pine | 0.78 | QMDdom | 0.43 | 7.7 | 0.34 | R6 Ponderosa Pine; R6 Jeffrey Pine; R6 Ponderosa pine group; R6 Lodgepole Pine |
| | | ddiscore | 0.36 | 15.3 | 0.28 | |
| | | HTsd | 0.28 | 31.2 | 0.22 | |
| | | tpadom | -0.21 | 31.7 | 0.16 | |
| Region 6 Ponderosa pine (very late decadent) | 0.71 | QMDdom | 0.4 | 8.7 | 0.43 | R6 Ponderosa pine (very late decadent) |
| | | ddiscore | 0.3 | 23.1 | 0.33 | |
| | | tpadom | -0.22 | 51.2 | 0.24 | |
| Region 6 Port Orford cedar - redwood | 0.74 | ddiscore | 0.44 | 44.4 | 0.62 | R6 Port Orford Cedar; R6 Redwood |
| | | QMDdom | 0.27 | 13 | 0.38 | |
| Region 6 Silver Fir | 0.83 | QMDdom | 0.62 | 17.1 | 0.29 | R6 Pacific silver fir; R6 Silver Fir; R6 California Red Fir -Shasta Red Fir |
| | | HTsd | 0.42 | 72.2 | 0.2 | |
| | | badom | 0.41 | 161.6 | 0.19 | |
| | | snagbatot | 0.38 | 39.7 | 0.18 | |
| | | tpadom | -0.31 | 53.1 | 0.14 | |
| Region 6 Sitka Spruce | 0.85 | QMDdom | 0.56 | 24.3 | 0.3 | R6 Sitka Spruce |
| | | HTsd | 0.42 | 63.5 | 0.22 | |
| | | badom | 0.38 | 184.6 | 0.2 | |
| | | tpadom | -0.28 | 37.6 | 0.15 | |
| | | snagbatot | 0.25 | 54.5 | 0.13 | |
| Region 6 Subalpine Fir - Engelmann Spruce | 0.74 | ddiscore | 0.39 | 33.2 | 0.42 | R6 Subalpine Fir - Engelmann Spruce |
| | | QMDdom | 0.33 | 8.8 | 0.35 | |
| | | HTsd | 0.21 | 42.9 | 0.23 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 6 Tanoak | 0.82 | QMDdom | 0.6 | 15.3 | 0.29 | R6 Tanoak |
| | | ddiscore | 0.5 | 56 | 0.24 | |
| | | HTquart | 0.34 | 51.7 | 0.16 | |
| | | tpadom | -0.33 | 55.9 | 0.16 | |
| | | HTsd | 0.32 | 64 | 0.15 | |
| Region 6 Western hemlock | 0.79 | QMDdom | 0.64 | 19.9 | 0.33 | R6 Western Hemlock |
| | | badom | 0.38 | 156.2 | 0.2 | |
| | | HTsd | 0.32 | 25.9 | 0.17 | |
| | | snagbatot | 0.32 | 63.2 | 0.17 | |
| | | tpadom | -0.27 | 42 | 0.14 | |
| Region 6 White/Grand fir | 0.78 | QMDdom | 0.51 | 12.3 | 0.33 | R6 White Fir - Grand Fir; R6 White/Grand fir |
| | | ddiscore | 0.48 | 40.1 | 0.31 | |
| | | HTsd | 0.3 | 46.8 | 0.2 | |
| | | snagbatot | 0.24 | 8.6 | 0.16 | |
| Region 8 Conifer southern hardwood | 0.8 | QMDdom | 0.41 | 8.3 | 0.42 | R8 Eastern hemlock; R8 Shortleaf pine/oak; R8 Eastern redcedar; R8 Eastern redcedar/ hardwood; R8 Slash pine/ hardwood; R8 Eastern white pine/northern red oak/ white ash; R8 Loblolly pine/ hardwood; R8 Other pine/ hardwood; R8 Virginia pine/ southern red oak |
| | | tpadom | -0.29 | 111.6 | 0.3 | |
| | | HTquart | 0.27 | 39.2 | 0.28 | |
| Region 8 Longleaf pine | 0.88 | QMDdom | 0.61 | 10.2 | 0.31 | R8 Longleaf pine; R8 Longleaf pine/oak |
| | | ddiscore | 0.45 | 19 | 0.23 | |
| | | tpadom | -0.45 | 54.7 | 0.23 | |
| | | HTsd | 0.24 | 24 | 0.12 | |
| | | badom | 0.23 | 44.7 | 0.12 | |
| Region 8 Oaks | 0.76 | QMDdom | 0.46 | 9.5 | 0.3 | R8 Chestnut oak; R8 Scarlet oak; R8 Chestnut oak/ black oak/scarlet oak; R8 Southern scrub oak; R8 Northern red oak; R8 White oak; R8 White oak/red oak/hickory; R8 Post oak/ blackjack oak |
| | | ddiscore | 0.42 | 22.8 | 0.28 | |
| | | HTquart | 0.33 | 44.1 | 0.22 | |
| | | badom | 0.31 | 55 | 0.2 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 8 Pines - Conifers | 0.93 | QMDdom | 0.57 | 11.4 | 0.38 | R8 Eastern white pine; R8 Eastern white pine/eastern hemlock; R8 Pond pine; R8 Slash pine; R8 Red spruce; R8 Table Mountain pine; R8 Loblolly pine; R8 Sand pine; R8 Virginia pine; R8 Pitch pine; R8 Shortleaf pine |
| | | tpadom | -0.39 | 60.4 | 0.26 | |
| | | HTquart | 0.29 | 65.8 | 0.19 | |
| | | HTsd | 0.25 | 38.6 | 0.17 | |
| Region 8 southern hardwoods | 0.8 | ddiscore | 0.5 | 30.1 | 0.31 | R8 Baldcypress/ pondcypress; R8 Mixed upland hardwoods; R8 Sassafras/persimmon; R8 Cherry/white ash/yellow-poplar; R8 Red maple/ lowland; R8 Sweetbay/ swamp tupelo/red maple; R8 Baldcypress/ water tupelo; R8 Other hardwoods; R8 Sugar maple/beech/yellow birch; R8 Cottonwood; R8 Red maple/oak; R8 Sweetgum/ Nuttall oak/willow oak; R8 Yellow-poplar; R8 Black cherry; R8 Overcup oak/water hickory; R8 Sugarberry/hackberry/ elm/green ash; R8 Elm/ash/ black locust; R8 Red maple/ upland; R8 Sweetgum/ yellow-poplar; R8 Yellow-poplar/white oak/northern red oak; R8 Black walnut; R8 Pin cherry; R8 Swamp chestnut oak/cherrybark oak; R8 Willow; R8 Hard maple/basswood; R8 River birch/sycamore; R8 Sycamore/pecan/American elm |
| | | HTquart | 0.41 | 43.8 | 0.26 | |
| | | badom | 0.35 | 59.1 | 0.22 | |
| | | HTsd | 0.33 | 48 | 0.21 | |
| Region 8 Wet and rain forestb | NA | NA | NA | NA | NA | R8 Lower montane wet and rain forest; R8 Palms; R8 Wet and rain forest |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 9 Conifer northern hardwood | 0.82 | QMDdom | 0.63 | 14 | 0.3 | R9 Conifer northern hardwood; R9 Oak/pine group |
| | | badom | 0.47 | 104.3 | 0.22 | |
| | | snagbatot | 0.39 | 14.5 | 0.19 | |
| | | tpadom | -0.34 | 73.4 | 0.16 | |
| | | HTsd | 0.27 | 32 | 0.13 | |
| Region 9 northern hardwood | 0.74 | QMDdom | 0.67 | 9.9 | 0.29 | R9 northern hardwood; R9 Aspen/birch group; R9 Beech maple basswood; R9 Oak/gum/cypress group; R9 Oak/hickory group; R9 Other hardwoods group; R9 wetland hardwood |
| | | HTquart | 0.46 | 43.3 | 0.2 | |
| | | badom | 0.41 | 60.9 | 0.18 | |
| | | tpadom | -0.42 | 97.6 | 0.18 | |
| | | HTsd | 0.33 | 32.9 | 0.14 | |
| Region 9 Northern pine | 0.85 | QMDdom | 0.65 | 11.9 | 0.3 | R9 Northern pine; R9 Loblolly/shortleaf pine group; R9 Exotic softwoods group; R9 Other eastern softwoods group |
| | | HTsd | 0.49 | 67.4 | 0.22 | |
| | | HTquart | 0.45 | 38 | 0.21 | |
| | | tpadom | -0.4 | 83.2 | 0.18 | |
| | | badom | 0.2 | 81.5 | 0.09 | |
| Region 9 oak | 0.82 | QMDdom | 0.57 | 12.7 | 0.37 | R9 dry oak; R9 mesic northern oak |
| | | tpadom | -0.35 | 73.4 | 0.22 | |
| | | HTquart | 0.33 | 52.9 | 0.21 | |
| | | HTsd | 0.31 | 36.5 | 0.2 | |
| Region 9 Spruce/ fir group | 0.74 | ddiscore | 0.36 | 22.2 | 0.4 | R9 Spruce/fir group ; R9 Montane spruce; R9 sub-boreal spruce/fir |
| | | badom | 0.32 | 76.2 | 0.36 | |
| | | HTquart | 0.22 | 32 | 0.24 | |
| Region 10 Black Spruce | 0.74 | HTsd | 0.54 | 8.3 | 0.43 | R10 Black Spruce SAF 204 |
| | | snagbatot | -0.39 | 6.4 | 0.31 | |
| | | tpadom | 0.32 | 13.4 | 0.26 | |
| Region 10 Mixed conifer | 0.71 | ddiscore | 0.51 | 21.3 | 0.58 | R10 Mixed conifer; R10 Shore pine |
| | | snagbatot | 0.37 | 19.7 | 0.42 | |
| Region 10 Mountain hemlock | 0.82 | HTsd | 0.43 | 33.6 | 0.32 | R10 Mountain hemlock; R10 Mountain Hemlock -SAF 225 Hi-elev; R10 Mountain Hemlock -SAF 225 low elev |
| | | QMDdom | 0.34 | 7 | 0.25 | |
| | | snagbatot | 0.31 | 6.9 | 0.23 | |
| | | badom | 0.27 | 64.4 | 0.2 | |

**Table 19.**—Working definitions for mature forest as applied to FIA data, continued.

| Mature vegetation class | Walkdown | Indicators | Correlation | Threshold | Weight | Old-growth regional vegetation types |
|---|---|---|---|---|---|---|
| Region 10 Sitka Spruce - Alluvial | 0.69 | QMDdom | 0.66 | 8.9 | 0.34 | R10 Sitka Spruce - Alluvial ; R10 Sitka Spruce - SAF 223 Alluvial ; R10 Aspen - SAF 217 |
| | | HTsd | 0.38 | 33.5 | 0.2 | |
| | | badom | 0.34 | 87.5 | 0.18 | |
| | | snagbatot | 0.31 | 3.9 | 0.16 | |
| | | tpadom | -0.25 | 82.9 | 0.13 | |
| Region 10 Sitka Spruce - Other | 0.82 | ddiscore | 0.45 | 42.8 | 0.35 | R10 Sitka Spruce – Other; R10 Sitka Spruce - SAF 223 Other |
| | | HTsd | 0.37 | 49.6 | 0.29 | |
| | | tpadom | -0.24 | 81.8 | 0.19 | |
| | | HTquart | 0.23 | 43.5 | 0.18 | |
| Region 10 Western Hemlock - poorly Drained | 0.71 | QMDdom | 0.51 | 7.1 | 0.63 | R10 Western Hemlock - poorly Drained; R10 Western Hemlock - SAF 224 poorly drained |
| | | badom | 0.3 | 48.1 | 0.37 | |
| Region 10 Western Hemlock - well Drained | 0.8 | QMDdom | 0.71 | 12.1 | 0.52 | R10 Western Hemlock - well Drained ; R10 Western Hemlock - SAF 224 well Drained |
| | | snagbatot | 0.39 | 18.2 | 0.28 | |
| | | tpadom | -0.27 | 52.7 | 0.2 | |
| Region 10 Western Hemlock/ Alaska yellow cedar | 0.82 | HTsd | 0.5 | 46.7 | 0.37 | R10 Western Hemlock/ Alaska yellow cedar |
| | | badom | 0.49 | 81.9 | 0.36 | |
| | | snagbatot | 0.36 | 30.1 | 0.27 | |
| Region 10 Western Hemlock/ western red cedar | 0.82 | ddiscore | 0.4 | 36.8 | 0.27 | R10 Western Hemlock/ western Redcedar - well Drained ; R10 Western Hemlock/western Redcedar - poorly Drained |
| | | tpadom | -0.35 | 102.8 | 0.23 | |
| | | snagbatot | 0.32 | 21.5 | 0.21 | |
| | | HTsd | 0.23 | 56.6 | 0.15 | |
| | | HTquart | 0.2 | 40.2 | 0.13 | |
| Region 10 White spruce | 0.66 | HTquart | 0.58 | 25.4 | 0.7 | R10 White Spruce SAF 201 |
| | | HTsd | 0.25 | 21.1 | 0.3 | |

[a] All plots are crosswalked to the FIA forest type group shown in parentheses due to less than 10 FIA old-growth plot records for the mature vegetation class.
[b] No mature plots due to not enough plots in this FIA tropical hardwoods group on lands managed by the Forest Service and BLM.

# Appendix 3: Area (acres) of Old-growth and Mature Forest Land by Fireshed

Mature and old-growth forest estimates for Forest Service and Bureau of Land Management lands are summarized by fireshed: https://www.fs.usda.gov/emc/mog/appendix3-fireshed-table.htm



**Forest stand managed for public recreation, Superior Ranger District, Lolo National Forest, Montana. USDA Forest Service photo by Elisa Stamm.**

# Appendix 4: FIA Evaluations and Inventory Years for Each State

**Table 20.**—FIA evaluations and inventory years for each state from FIA data used in the national inventory.

| State or Territory name | State code | EVAL_GRP | EVALID | Inventory start year | Inventory end year |
|---|---|---|---|---|---|
| Alabama | 1 | 12021 | 12101 | 2014 | 2021 |
| Alaska (coastal) | 2 | 22019 | 21921 | 2014 | 2019 |
| Alaska (interior) | 2 | 220192 | 21901 | 2009 | 2019 |
| Arizona | 4 | 42019 | 41901 | 2010 | 2019 |
| Arkansas | 5 | 52021 | 52101 | 2017 | 2021 |
| California | 6 | 62019 | 61901 | 2008 | 2019 |
| Colorado | 8 | 82019 | 81901 | 2010 | 2019 |
| Connecticut | 9 | 92020 | 92001 | 2014 | 2020 |
| Delaware | 10 | 102020 | 102001 | 2014 | 2020 |
| Florida | 12 | 122019 | 121901 | 2014 | 2019 |
| Georgia | 13 | 132020 | 132001 | 2015 | 2020 |
| Hawaii | 15 | 152019 | 151901 | 2019 | 2019 |
| Idaho | 16 | 162019 | 161901 | 2010 | 2019 |
| Illinois | 17 | 172021 | 172101 | 2015 | 2021 |
| Indiana | 18 | 182020 | 182001 | 2014 | 2020 |
| Iowa | 19 | 192021 | 192101 | 2015 | 2021 |
| Kansas | 20 | 202020 | 202001 | 2014 | 2020 |
| Kentucky | 21 | 212018 | 211801 | 2012 | 2018 |
| Louisiana | 22 | 222018 | 221801 | 2009 | 2018 |
| Maine | 23 | 232021 | 232101 | 2017 | 2021 |
| Maryland | 24 | 242019 | 241901 | 2013 | 2019 |
| Massachusetts | 25 | 252019 | 251901 | 2013 | 2019 |
| Michigan | 26 | 262019 | 261901 | 2013 | 2019 |
| Minnesota | 27 | 272019 | 271901 | 2015 | 2019 |
| Mississippi | 28 | 282020 | 282001 | 2016 | 2020 |
| Missouri | 29 | 292021 | 292101 | 2015 | 2021 |
| Montana | 30 | 302019 | 301901 | 2010 | 2019 |
| Nebraska | 31 | 312020 | 312001 | 2014 | 2020 |

**Table 20.**—FIA evaluations and inventory years for each state from FIA data, continued.

| State or Territory name | State code | EVAL_GRP | EVALID | Inventory start year | Inventory end year |
|---|---|---|---|---|---|
| Nevada | 32 | 322019 | 321901 | 2010 | 2019 |
| New Hampshire | 33 | 332020 | 332001 | 2014 | 2020 |
| New Jersey | 34 | 342019 | 341901 | 2015 | 2019 |
| New Mexico | 35 | 352019 | 351901 | 2010 | 2019 |
| New York | 36 | 362019 | 361901 | 2013 | 2019 |
| North Carolina | 37 | 372021 | 372101 | 2016 | 2021 |
| North Dakota | 38 | 382021 | 382101 | 2015 | 2021 |
| Ohio | 39 | 392019 | 391901 | 2013 | 2019 |
| Oklahoma | 40 | 402019 | 401901 | 2010 | 2019 |
| Oregon | 41 | 412019 | 411901 | 2008 | 2019 |
| Pennsylvania | 42 | 422020 | 422001 | 2014 | 2020 |
| Rhode Island | 44 | 442020 | 442001 | 2014 | 2020 |
| South Carolina | 45 | 452020 | 452001 | 2014 | 2020 |
| South Dakota | 46 | 462020 | 462001 | 2014 | 2020 |
| Tennessee | 47 | 472018 | 471801 | 2012 | 2018 |
| Texas | 48 | 482019 | 481901 | 2004 | 2019 |
| Utah | 49 | 492019 | 491901 | 2010 | 2019 |
| Vermont | 50 | 502020 | 502001 | 2014 | 2020 |
| Virginia | 51 | 512020 | 512001 | 2015 | 2020 |
| Washington | 53 | 532019 | 531901 | 2008 | 2019 |
| West Virginia | 54 | 542020 | 542001 | 2014 | 2020 |
| Wisconsin | 55 | 552021 | 552101 | 2015 | 2021 |
| Wyoming | 56 | 562019 | 561901 | 2011 | 2019 |
| American Samoa | 60 | 602012 | 601202 | 2012 | 2012 |
| Federated States of Micronesia | 64 | 646416 | 641622 | 2016 | 2016 |
| Guam | 66 | 662013 | 661322 | 2013 | 2013 |
| Marshall Islands | 68 | 682018 | 681802 | 2018 | 2018 |
| Northern Mariana Islands | 69 | 692015 | 691502 | 2015 | 2015 |
| Palau | 70 | 702014 | 701402 | 2014 | 2014 |
| Puerto Rico | 72 | 722019 | 721901 | 2016 | 2019 |
| U.S. Virgin Islands | 78 | 782014 | 781401 | 2014 | 2014 |

Evaluations used were consistent with the most recent inventory cycle available in FIADB, as of December 2022; not all States listed in the table contained forested Forest Service or BLM land.

# Appendix 5: Public Comment and Response Summary

### Comments opposed to a single definition or framework to serve the needs for any future policy work.

**Comment:** Some commenters suggested that trying to establish a common framework will result in conflicts with existing plans and protocols, and could hinder the project level management decisions that are best able to promote the desired forest condition. Others suggested there must be at least two different general definitions to deal with the fundamental differences in forest structure between older forests on sites that were historically frequently disturbed and older forests on sites historically subject to infrequent or episodic disturbances. That would address the major (fundamental) differences in older North American forests related to disturbance regime. The recognition of two fundamentally different types of forests helps motivate mature and old-growth forest conservation and can be used for planning and adaptive management. Policy in episodically disturbed forest types needs to focus on retention and protection of mature and old-growth forest stands. Policy in frequent-fire forests needs to accommodate and encourage active management to restore and maintain these forests during which existing mature and old trees are retained and their populations are rebuilt.

**Response:** Each Region was tasked, following the 1989 letter from then Forest Service Chief Robertson, with developing "Guidance for Conserving and Restoring Old-Growth Forest Communities on National Forests." Even at the Regional level, this effort has proven complex. In the Forest Service Southern Region, for instance, the Forest Service noted that "Sixteen old-growth forest community types have the potential of occurring on southern national forest lands," ranging from spruce-fir forests at higher elevations to humid, subtropical pine flatwoods along the Coastal Plain. Regionally rare subalpine spruce forests could be characterized by numerous, very old, but very small trees (due to poor sites, shallow soils, short growing seasons, and high winds), where lower elevation forests on better sites, but with similar stand establishment dates, could be characterized by large trees, multi-layered canopies, with broken and "decadent" trees. Any effort to sort and sift the "old growth" values on these wildly disparate forest types is entirely subjective and is inherently unrepeatable across the 193-million-acre National Forest System. Examples of "old growth" identified by outside advocacy groups illustrate the complexity of defining old growth and mature forests, even in a "universal definition framework." For instance, the Old-Growth Forest Network says that the Belfast Creek/Devil's Marble Yard area in the George Washington-Thomas Jefferson National Forest in Virginia is characterized by both "tall straight cove hardwoods" along creeks and "gnarly Chestnut oak" along drier ridges. While forest stands on both the cove bottoms and the drier ridges may have similar stand initiation dates, they are otherwise extraordinarily dissimilar,

with one being characterized by tall, straight trees and the other by stunted, "gnarly" trees that, despite being at least 100 years old, are less than 10 inches in diameter.

While a single definition that applies to all forests is not possible, a narrative framework that identifies the primary characteristics of mature and old forests is possible. Such a framework can set out criteria for appropriate structural characteristics in different forest types and the importance of certain structural features in some fire regimes and not others, thereby informing potential policy approaches. Taking into account the disturbances that are part of a functioning ecosystem is essential to a definition framework.

## Comments suggested incorporating ecological integrity into the definition framework.

**Comment:** Commenters recommended incorporating ecological integrity into the old-growth and mature forest definition framework to provide guideposts for establishing monitoring metrics and triggers for adaptive management.

**Response:** Ecological integrity may be harder to define than mature and old-growth forest. The framework will need to consider attributes of forests that are resilient to future disturbances or recognize high integrity alternative stable states following disturbance. Fortunately, detailed assessments of species diversity and ecosystem function are already embedded in agency planning rules.

A guiding principle of this effort is that any definition framework and subsequent policy will be compatible with current planning regulations. Current Forest Service planning rules and regulations define ecological integrity as "the quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence."

## Comments suggested 80 years old as a reasonable criterion for defining mature forests.

**Comment:** Commenters have suggested that 80 years is a reasonable age to identify a forest 'mature'. Setting a threshold at 80 years secures significant protection for carbon storage and sequestration capacity associated with older forests. 80 years is within the established indicators of maturation for forest types that are present in the US's federal forests, such as the peak of overall growth rate or the onset of sexual maturity. A threshold of 80 would deliver significant carbon sequestration benefits, including for ecological function, biodiversity protection, and hydrological functions. One approach for assessing stand maturity is by looking at the peak of net primary productivity (NPP). Almost all forest types in the National Forest System reach this peak before 80 years of age.

**Response:** It is well known that forests on productive sites develop structural attributes (for example, tree size, dead wood, decay) more rapidly than forests on low-productivity sites. While picking a single age for maturity of all forests would simplify classification, it does not appear to meet the EO intent for "accounting for regional and ecological variations." That

said, stand ages could provide a starting point and we are considering your suggestion. However, classification based solely on age is problematic for myriad reasons. Widely available stand age data is useful (e.g., FIA measurements) but potential problems become clear when evaluated as the sole indicator. For example, older trees are often difficult or impossible to age (such as due to rotten cores). Extremely accurate tree ages can sometimes be obtained through tree ring and bole cross-section analysis and cross-dating based on local patterns of ring widths, though this is prohibitively expensive for large areas. Cross-section dating is a destructive approach that confounds monitoring at fixed FIA locations. At the stand or 'forest' scale, protocols often define a forest age from a set of tree ages, which can result in a range of stand ages from a plot.

## Comments opposed to a definition that facilitates or promotes resource exploitation.

**Comment:** Commenters suggested that any definition whose conceptual basis facilitates or promotes resource exploitation must be excluded from this framework. Any definition that prioritizes human management of forests to maximize resource extraction or favors short-term economic gains and results in ecologic loss should be excluded. To exclude burned forests, for example, embraces logging dead trees—an industrial process which harms a fragile ecosystem status while undervaluing the critical ecological benefits of wildland fire.

**Response:** Our effort chose an ecologically based definition framework employing forest structure characteristics. Consequently, our definition framework represents a neutral statement of forest conditions that meet the ecological definition of mature and old-growth forests. Any management action or policy applied to these forests stems from a separate process from our effort to define and inventory. Regardless, few definitions currently in use would exclude forests that have experienced fire, unless there were few or no remaining live trees.

## Comments concerned about the management implications of a definition and associated inventory.

**Comment:** Commenters recommended that in order to be durable, the definition and inventory effort will need to ensure that it does not impede efforts to reduce fire danger, increase sustainable harvest, or require extensive planning efforts. If the framework impedes any of these efforts, it should not be developed or implemented. A durable definition will be adaptive to climate change, ecological, social and economic needs of local communities and provide assurance that the Forest Service is meeting all other obligations. It should also not impede planning efforts both on a project level and a forest planning level.

Commenters suggested that defining mature forests will be particularly challenging. The definition chosen for mature forests may have future implications on timber harvest. For example, if "mature" were to be considered stands that have reached CMAI, and at some future point it was determined that mature forests should not have regeneration harvest, this could severely limit timber harvest opportunities. Age, at least different ages

for different tree species and conditions, for even-aged stands, may have some value, but it is difficult to assess without boots on the ground and an increment borer.

Commenters stated that the Federal statutes regarding management of Federal forest lands do not prioritize or require old-growth or mature forest conservation. The Forest Service's authority to conduct land management on the National Forest System stems from four basic laws - the Forest Service Organic Act of 1897, the Multiple Use Sustained Yield Act of 1960, the Renewable Resources Planning Act of 1974, and the National Forest Management Act of 1976. These acts provide the legal basis for all management activities, including timber harvest, on the National Forest System. Congress has enacted several statutes streamlining the required analysis for certain types of forest management projects on the NFS, including the Healthy Forest Restoration Act of 2003 and the forestry provisions of the 2014 and 2018 Farm Bills. Congress has had numerous opportunities to enact specific protections for old-growth and mature forests and has elected not to do so.

**Response:** Our technical team recognizes the value of durable definitions of mature and old-growth forest and chose an approach designed to neither promote nor impede active management. We consider the effort to define and inventory older forests as a predecessor to efforts motivated by the EO to evaluate threats and risks or to set policy. The narrative framework allows for definitions that take into account regional variation in disturbance regime, including attributes that are meaningful for even or uneven-aged forests. Whether or how much mature forest may be excluded from regeneration harvest will be determined by subsequent policy. Any management action or policy applied to these forests is a separate process from the definition.

## Comments suggested using existing definitions found in forest plans and resource management plans.

**Comment:** Commenters recommended that definitions of “mature” and “old-growth” forests that are developed should begin with the current definitions found in forest plans and resource management plans (RMPs). Mature forests will likely be defined as forests that may become old growth, so the Forest Plan and RMP definitions can also provide a foundation for defining what is mature.

**Response:** Forest Plans, RMPs and land use plans are suitable starting points for consideration. Some regional or plan-specific definitions may not be fit into a nationally consistent inventory. Our technical team chose Forest Service regional old growth definitions for the inventory because they are suitable for a nation-wide inventory and were developed over three decades, structural characteristics are well documented in scientific literature, and they are readily interpretable by resource managers, including at local scales. The regional definitions were strongly recommended by a large number of commentors.

## Comments suggested measurable criteria at appropriate scales.

**Comment:** Commenters made recommendations to only include criteria that may be reasonably measured at the appropriate scale; reference a science-

based rationale for recommended criteria; clearly identify the values-based rationale for recommended criteria; and be general enough to allow for local adaption that can account for the considerable variability found among forests nationwide. Any predictive model of old-growth and mature forests must be validated.

**Response:** The narrative framework and associated working definitions are applied to field plot data from FIA which is considered the international model for forest inventory. FIA conducts a periodic forest inventory of all contiguous U.S. and some Alaska lands. FIA sampling was specifically designed for national-scale inventory that informs broadscale management at many levels of the agency. Structural characteristics were chosen for our inventory because they are consistent with Forest Service old growth definitions developed over three decades, they are well documented in scientific literature, and they are readily interpretable by resource managers, including at local scales. The regional definitions were strongly recommended by a large number of commentors. Furthermore, elements of many alternative approaches, such as carbon focused models, are highly correlated with old forest structures.

## Comments concerned about the technical ability and accuracy associated with inventorying mature and old-growth forests.

**Comment:** Commenters stated that it is unclear if a "mature" category can be well-separated from old growth using remote sensing data. Remote sensing data are often at coarser spatial resolutions than the processes being predicted and have varying degrees of uncertainty.

Commenters suggested that while the exact methodology used for identifying old-growth forests will differ based on its definition, it will likely be best achieved using a combination of optical and SAR remotely-sensed data and ground-based field measurements. This is because no single data source provides comprehensive forest information (e.g., optical satellites are unable to thoroughly assess the vertical variability within forest stands with dense canopy cover). Inclusion of auxiliary information (for example elevation and textural features; see Spracklen and Spracklen (2019)) may improve model performance when working with remotely sensed data. Model calibration and validation using ground-based field assessments (e.g., such as FIAdb) will be essential to this process given that relatively young and old-growth forests can have similar characteristics (e.g., such as closed canopies or down dead wood). Uncertainty, noise, and the spatial scales of each data source should be addressed throughout this process. It does not seem likely that appropriate ground-truthing can be accomplished in the timeframe for completing the inventory process (April 2023). Without ground-truthing, it is impossible to know if a classification method is working as intended and to quantify uncertainty. The Forest Service should clearly state the assumptions and limitations of a national inventory of old-growth and mature forests, especially if ground-truthing is not conducted.

**Response:** The assumptions and limitations are key for any inventory. While there are well-defined levels of certainty at the national and regional scales from application of FIA inventory

plots, any spatial prediction at the local (stand and landscape) scale may require additional information, which may include additional field collected or remotely sensed data sources. Our national inventory uses field measured data from FIA rather than relying on remotely sensed information.

## Comments concerned with definition and inventory consistency with existing federal statutes and mandates.

**Comment:** Commenters stated that any definition and inventory required by E.O. 14072 must be consistent with and comply with existing federal statutes and mandates. Any lack of clarity on this point will lead to policy and legal confusion; delays or lack of action on the ground; conflicts between stakeholders, and litigation in the courtroom. Commenters were concerned that these outcomes could delay necessary wildfire prevention work.

**Response:** Each national forest and BLM district has a land use plan governing its activities. This definition and inventory effort does not change management direction as set forth in existing land use plans, nor any existing policies or statutes. Any management action or policy applied to Forest Service and BLM lands is separate from the definition and inventory effort.

## Comments concerned with using tree age as a definition for mature and old growth.

**Comment:** Commenters recommended that tree age should be used only with extreme care, and stated that people, including professional foresters, often conflate size with age. While size and age are intuitively related, field staff generally receive no training in other characteristics of advanced age such as gnarled crowns, balding bark, and relatively large limbs for the size of the trunk (Pederson 2010). Consequently, when age is assessed in the field, the oldest age class is often missed and growth rates are systematically overestimated, which leads to systematically underestimating the age of stems that were not cored. These issues are further exacerbated by counting rings on core samples in the field that have not been carefully surfaced to make the rings more visible. Under those conditions, very narrow rings, common in old trees, are very difficult to see, which leads to further underestimation of tree ages. This issue arises because a characteristic of most types of old-growth forest is uneven age. This is particularly true in the Eastern United states where canopy gaps are the dominant forest disturbance (Barden 1989; Buchanan and Hart 2012). While many forest stand inventories assign a single age to each stand, old growth stands typically contain several to many cohorts that vary widely in age (Lorimer 1980; Seymour et al. 2002). Averaging ages from sampled trees, a common practice, obscures the oldest cohort and underestimates the overall stand age. Averaging ages has led to old growth stands being misidentified and ignored (see Gaddy 1998 for examples and discussion). Ages from coring different cohorts should not be averaged to produce stand age, and any old growth determination should be made based on the age of the oldest cohort. Basing definitions of old growth on the specific density of trees meeting a size or age threshold introduces additional problems. As people have recognized the impacts of fire suppression, there is a

growing appreciation of that many forests that are currently closed-canopied were once far more open, such as longleaf pine dominated areas in the Southeast and Ponderosa Pine ecosystems in much of the West. Unfortunately, just how open stands were historically varied considerably with site and is often difficult to estimate today. Hence, developing reliable estimates of how many large or old trees would be expected in an old-growth forest on a particular site is often not practical. Old or large tree thresholds also ignore the ideas of forest continuity and ecosystem age discussed above, and lead to narrow, exclusive definitions of old growth.

**Response:** Commentors express well-considered challenges to measuring tree age and application of age and/or tree size as criteria for identifying mature and old-growth forest. Our approach addresses this challenge in a couple of ways. Criteria for mature and old-growth forest are applied to more than 200 unique vegetation types. Doing so reduces the potential for misidentifying the relationship between tree size and age. The national scale inventory employs multiple structural indicators of mature and old growth applied to the FIA dataset, including elements that are easy to recognize and measure in the field in a consistent manner across scales or stand conditions.

## Comments concerning specific criteria for mature and old growth forests.

**Comment:** Commenters presented evidence suggesting that temperate old-growth forests around the world exhibit higher densities of large living trees, higher quadratic mean diameters, higher amounts of live aboveground biomass, and higher amounts of coarse woody debris than mature forests (Burrascano et al., 2013). Evidence also suggests that old-growth forests share high structural complexity and spatial heterogeneity, including decurrent tree crowns, small canopy gaps (<.5 acres), generally closed-canopy conditions (at least for mesic forest types), dead wood, patchy understories, a dominance of shade tolerant trees, and all-aged or uneven-aged conditions (Lorimer, 1980; Runkle, 1981; Spies, 1990). Patch size of an old-growth forest is important as it relates to the functional habitat it provides forest wildlife. For example, wood thrush are less likely to benefit from an old growth patch that is less than 250 acres in size (Lambert et al., 2017). Landscape context matters when evaluating where old growth occurs and how it relates to other stand conditions at the landscape-scale. Where old growth exists on the landscape, it is part of a spatially and temporally interconnected, ever-changing mosaic (Spies, 1990). The proximity and interspersion of seral classes is a key component of mature forest ecological integrity and habitat benefits.

**Response:** The structural characteristics approach was chosen for the inventory; it refers to measurable structural characteristics such as tree size and distribution or presence of snags. The structural approach was chosen because it is consistent with Forest Service old growth definitions developed over three decades, it is well documented in scientific literature, and it is readily interpretable by resource managers. Elements of many approaches are indirectly included in the structural approach or are highly correlated with old forest structures. For example, the narrative framework explicitly identifies Tribal and cultural values in addition to

ecological components as important for identifying old growth. And the structural approach applies unique criteria to define mature and old-growth forest within regional vegetation types which capture different disturbance regimes and productivity levels. The concept of ecologically mature forest is recognized in scientific practice, though it has not been well defined for management application at national scale in the scientific literature. The Society of American Foresters (SAF) provides a definition of mature as: “of trees or stands pertaining to a tree or even-aged stand that is capable of sexual reproduction (other than precocious reproduction), has attained most of its potential height growth, or has reached merchantability standards – note within uneven-aged stands, individual trees may become mature but the stand itself consists of trees of diverse ages and stages of development” (SAF Dictionary of Forestry 2018). The national inventory of mature and old-growth forest does not consider the vulnerability, relative habitat value, nor neighboring forest characteristics. Where appropriate, these will be examined during the threat analysis and risk assessment as called for in Section 2(c) of the Executive order.

## Comments concerning social aspects (e.g., spirituality, sense of place, recreation) included in any definition.

**Comment:** Commenters recommended that definition criteria need to reflect cultural and spiritual values, including local and indigenous knowledge. To advance the broader goals of the EO, there should be mechanisms provided to integrate: local, place-based knowledge; communication and history-telling, such as stories, oral tradition, and oral histories; and for community participation in the planning and adaptive management of forests. The value of old growth forests go beyond their important role as sinks for carbon dioxide. Their spiritual value and beauty should be experienced by every American.

Mature and old-growth forests are of social, cultural, and spiritual importance across the nation and the globe. While these benefits are difficult to quantify, the positive impact of older, intact forests on human community and identity are extensively documented. Older forests are also strongly related to cultural identity and understandings of generational heritage. Mature and old-growth forests also serve as spiritual sanctuaries in ways that are not associated with young forests. Of particular importance to those who associate older forests with spiritual connection was the sense of solitude and associated tranquility, the feeling of being "away from human disturbance," and feeling "a lack of separation" between themselves and the ecosystem. The association between large trees and sacred importance is not unique to this country - at a global level, the idea of untouched, immense, and extremely old trees and forests is revered by many. Again, federal management decisions about older forests should take these values, and the positive impacts of spiritual sanctuary on the wellbeing of the public, into account.

**Response:** In the current effort to define, identify, and inventory old-growth and mature forests on federal lands, we are relying primarily on the ecological attributes of these ecosystems. This is due largely to the timeline of the effort, which required use of existing methodologies and data and an emphasis

on quantifiable metrics. However, the narrative frameworks developed through this effort leave open opportunities to integrate social, cultural, and economic values; a variety of ecosystem services; local and Indigenous Knowledge; and place-based meanings into the ways we define, identify, and steward old-growth and mature forests into the future. We will continue to create opportunities to engage Tribes, stakeholders, and the public in dialogue about mature and old-growth forests and consider which processes might be used to integrate these perspectives into the stewardship of these ecosystems.

## Comments concerning Traditional Ecological Knowledge, values and practices in any understanding of mature and old growth definition framework and tribal interests and concerns represented in any definition and associated inventory.

C**omment:** Commenters stated that a complete inventory of mature and old growth forests to enable and support tribal cultural and subsistence activities, protect biodiversity, and offset climate impacts will affirm the federal government's treaty obligations and trust responsibility, and should be undertaken expeditiously. Any definition and inventory framework requires close tribal consultation and coordination with tribal governments in order to evaluate potential impacts on tribal rights and interests.

**Response:** The USDA Forest Service Office of Tribal Relations held a Tribal forum in the summer of 2022, during which Forest Service and BLM representatives shared information about the joint effort to define, identify, and inventory old-growth and mature forests on federal land; discussed potential Tribal implications; and requested input on the definition and inventory process. The Forest Service also opened a Tribal Consultation on December 23, 2022 to provide Tribal leaders with opportunities to inform subsequent phases of this effort, including the development of policy related to old-growth and mature forests. Consistent with longstanding trust and treaty responsibilities as well as recent action plans that renew attention to co-stewardship with Tribal Nations, the Forest Service will continue to seek Tribal participation in the stewardship of mature and old-growth forests. While the current inventory relies on existing ecological data and methods, processes are evolving for the meaningful integration of Indigenous Knowledge with scientific perspectives in forest management. The narrative frameworks developed through this effort leave open opportunities to incorporate Tribal expertise and Indigenous Knowledge into the ways we define, identify, and steward old-growth and mature forests into the future.



Live version as of 2/20/2025

The requested page could not be found.

# EXHIBIT P

Archived version as of 01/22/2025

Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Bureau of Land Management
U.S. DEPARTMENT OF THE INTERIOR

FS-1215c | June 2024

# **Mature and Old-Growth Forests:** Analysis of Threats on Lands Managed by the Forest Service and Bureau of Land Management

## in Fulfillment of Section 2(c) of Executive Order No. 14072

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at How to File a Program Discrimination Complaint and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

# Contents


1 **Executive Summary**

3 **Contributors**

3 Technical Team

4 Executive Team

4 USDA Forest Service Extended Team

4 Acknowledgements

5 **Introduction**

7 **Methods**

7 Condition-Based Evaluations

10 Remeasured Forest Inventory and Analysis Plots

12 Forest Inventory and Analysis Data Projected into the Future

13 Spatial Analysis of Historical, Current, and Future Conditions

14 Mature and Old Growth Condition Assessment

16 **Results**

16 Fire

20 Fire Exclusion

27 Insects and Disease

31 Extreme Weather Events

34 Climate Change

37 Tree Cutting

45 Roads

48 Mature and Old Growth Condition Assessment

51 **Discussion**

58 **Management Considerations and Challenges**

63 **Conclusion**

68 **Appropriate Use of Data**

68 **Refinements and Opportunities for Future Research**

69 **Next Steps**

70 **Glossary**

A.1 **Appendixes**

# Figures


7 **Figure 1.**–Illustration of the framework adapted from EPA (Brown et al. 2017) and employed to identify when a disturbance such as fire—a driver or stressor—results in a threat versus an outcome that is neutral or beneficial. This framework is particularly applied in the qualitative, condition-based evaluation reviewed for each potential threat in the results.

17 **Figure 2.**–Net changes (and 95-percent confidence intervals) in area of mature and old-growth forests that experienced fire disturbance over an average of 9 years from remeasured FIA plots (mostly 2000s to 2010s). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

18 **Figure 3.**–Fireshed-scale exposure of inventoried mature and old-growth forests to moderate- to high-severity fire (SSP5-RCP8.5). The color scale represents exposure classes defined in table 2 below.

20 **Figure 4.**–Observed (2020) and projected (2030-2070) trends in annual rates of tree mortality from moderate- to high-severity fires in mature and old-growth forests (mature and old growth combined) (CONUS). Solid lines reflect the median trend line of the median GCM (out of the five GCMs). The dashed lines represent the maximum and minimum values for the interquartile ranges (the middle 50 percent of the 100 replications) of projections across the five GCMs.

21 **Figure 5.**–Examples of written historical records illustrating the effects of frequent-fire exclusion on oak forests in the eastern United States from the "Report on the Forests of North America—Exclusive of Mexico" (Sargent 1884). Map courtesy of Brice Hanberry. Percentages represent areal extents of open forests within the delineated boundaries.

22 **Figure 6.**–Photograph taken near Mt. Shasta, CA (circa 1949) with the caption stating "…it appears that the pine stand may gradually be replaced by a Douglas-fir, white fir stand." (Source: Wieslander Vegetation Type Mapping Collection, courtesy of the Marian Koshland Bioscience, Natural Resources & Public Health Library, University of California, Berkeley, http://guides.lib.berkeley.edu/Wieslander

23 **Figure 7.**–Forest Vegetation Simulator images of FIA plots 40389335010690 (left) and 188772478020004 (right). Both plots are in the Intermountain Region. The mature and old-growth inventory report identified some FIA plots classified as old-growth forest that supported uncharacteristic stand structure.

24 **Figure 8.**–Photograph of an oak/hickory stand taken near Asheville, North Carolina. Many of the large trees are chestnut oak, with the majority of the midstory made up of red maple. Tulip poplar, red maple, sassafras, and some smaller oaks are in the understory (photo courtesy of Margaret Woodbridge).

24 **Figure 9.**–Forest Vegetation Simulator images of FIA plots 480977014489998 (left) and 740834556290487 (right). Both plots are in the Southern Region. The mature and old-growth inventory identified some FIA plots classified as old-growth forest that show evidence of some of the threats identified in this report, especially mesophication and ingrowth of shade-tolerant species due to fire suppression.

26 **Figure 10.**–Spatial patterns at the project area scale and area estimates (with 95-percent confidence intervals) of inventoried mature and old-growth forests exposed to wildfire threats based on fire deficit.

29 **Figure 11.**–Net changes (and 95-percent confidence intervals) in area of mature and old-growth forests from insect/disease disturbance over an average of 9 years from remeasured FIA plots (mostly 2000s to 2010s). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

30 **Figure 12.**–Map depicting spatial patterns at the project area scale of inventoried mature and old-growth forests exposed to threats from insects and disease.

32 **Figure 13.**–Net changes (and 95-percent confidence intervals) in mature and old-growth forests that experienced weather disturbance over an average of 9 years from remeasured FIA plots (mostly 2000s to 2010s). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

33 **Figure 14.**–A graphical representation of recent extreme weather events in the United States (https://www.noaa.gov/news/record-drought-gripped-much-of-us-in-2022).

35 **Figure 15.**–Fireshed-scale exposure of inventoried mature and old-growth forests to extreme heat (days/year ≥90 °F (RCP8.5).

36 **Figure 16.**–Fireshed-scale exposure of inventoried mature and old-growth forests to climatic water deficits (RCP8.5).

38 **Figure 17.**–Forest Service timber harvest rates since 1980 (cut records from Forest Service Activity Tracking System [FACTS] database). Even-aged harvesting removes all or most of the trees, uneven-aged leaves a mix of tree sizes, intermediate and stand improvement harvesting entails thinning of some trees for various purposes.

40 **Figure 18.**–Net changes (and 95-percent confidence intervals) in area of mature and old-growth forests that experienced tree cutting disturbance over an average of 9 years based on remeasured FIA plots (mostly 2000s and 2010s). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

42 **Figure 19.**–Solid lines reflect the median trend line of the median GCM (out of the five GCMs). The dashed lines represent the minimum and maximum values for the interquartile ranges (the middle 50 percent of the 100 replications) of projections across the five GCMs.

46 **Figure 20.**–Net area changes in (acres) of mature and old-growth forest by distance classes from roads. Time 1 represents first plot measurement and time 2 the second measurement. See appendix 4 for information on FIA plot measure periods. Error bars are 95-percent confidence limits.

47 **Figure 21.**–Forest disturbances in mature (left) and old-growth forests (right) varied by distance to maintained roads.

48 **Figure 22.**–Spatial patterns at the project area scale and area estimates (with 95-percent confidence intervals) of inventoried mature and old-growth forest current condition related to road density.

49 **Figure 23.**–Flow diagram (using project area maps) of the mature and old growth condition assessment (MOGCA) analysis. The bottom graph shows area (acres) of inventoried mature forest (left) and old-growth forest (right) in each ecological integrity class (from very good to very poor integrity).

51 **Figure 24.**–National-scale results of disturbances to mature and old-growth forests recorded in remeasured FIA plots, ordered (from left to right) by smallest to largest net change in acres.

52 **Figure 25.**–Forest disturbances from remeasured FIA plots at the national scale. Disturbances are ordered (from left to right) by proportion of total area disturbed by moderately severe (ModSev) to severe disturbances (>60 percent live tree basal area mortality).

55 **Figure 26.**–Long-term trends in slow/chronic forest disturbance as loss of live tree canopy cover and tree mortality above historical background levels. Data from the Landscape Change Monitoring System Program Data Explorer (https://apps.fs.usda.gov/lcms-viewer/).

57 **Figure 27.**–Observed (2020) and projected (2030-2070) trends in mature and old-growth forests (mature and old growth combined) (CONUS). Solid lines reflect the median trend line of the median GCM (out of the five GCMs). The dashed lines represent the minimum and maximum values for the interquartile ranges (the middle 50 percent of the 100 replications) of projections across the five GCMs

58 **Figure 28**.–Net percentage area changes in mature and old-growth forest (and 95-percent confidence intervals) since the first measurement (time 1) over an average of 10 years within and outside of reserved areas, from remeasured FIA plots.

61 **Figure 29.**–Mill processing capacity overlayed with potential threats from fire deficit, fire threat, and insect/disease at the fireshed level for firesheds containing mature and old-growth forest managed by the Forest Service and BLM. Mill capacity was a sum of total volume within the fireshed, plus a 50km buffer. Very low= 0–6, 250 MCF (1,000 cubic feet); low= 6,251–18,000 MCF; moderate= 18,001–33,750 MCF; high= 33,751–61,750 MCF; very high= 61,751–111,625 MCF.

62 **Figure 30.**–Overlay analysis of housing unit change from 1990 to 2020 summarized to firesheds and fire deficit condition for Federal mature and old-growth forest firesheds.

66 **Figure 31.**–"It was inevitable that our timber resources should shrink rapidly before this terrific onslaught. The story is told in the maps showing the approximate extent of the virgin forests in 1620, 1850, and 1920." (Greeley 1925). Maps from Greeley (1925) were transcribed onto firesheds as percentage of fireshed and represent all land ownerships.

67 **Figure 32.**–Fireshed maps of mature and old-growth forests on Forest Service and BLM lands. Old growth (top), mature (middle), and combined (bottom).

# Tables


17 **Table 1.**–The five forest type groups with the most change in area of mature and old-growth forest in forests that experienced fire disturbance over an average 9-year period from remeasured FIA plots. Area and 95-percent confidence intervals (CI) are in thousands of acres; percents are the proportional change of the forest type group in the mature or old growth class.

19 **Table 2.**–Proportion (total and averaged annually) of Forest Service and BLM forest burned by moderate to high-severity wildfires. Historical data for Monitoring Trends in Burn Severity only extends back in time to 1984.

23 **Table 3.**–Tree diameter distributions (inches at breast height) from FIA plot 40389335010690 located in the Intermountain Region.

23 **Table 4.**–Tree diameter distributions (inches at breast height) from FIA plot 188772478020004 located in the Intermountain Region.

25 **Table 5.**–Tree diameter distributions (inches at breast height) from FIA plot 480977014489998 located in the Southern Region.

25 **Table 6.**–Tree diameter distributions (inches at breast height) from FIA plot 740834556290487 located in the Southern Region.

28 **Table 7.**–The six forest type groups with the most change in area of mature and old-growth forest in forests that experienced insect and disease disturbance over an average 9-year period from remeasured FIA plots. Area and 95-percent confidence intervals (CI) are in thousands of acres; percents are the proportional change of the forest type group in the mature or old growth class.

32 **Table 8.**–The five forest type groups with the most change in area of mature and old-growth forest due to weather over an average 9-year period. Area and 95-percent confidence intervals are in thousands of acres; percents are the proportional change of the forest type group in the mature or old growth class.

40 **Table 9.**–The five forest type groups with the most change in area of mature and old-growth forest due to cutting over an average 9-year period from FIA remeasurement. Area and 95-percent confidence intervals are in thousands of acres; percents are the proportional change of the forest type.

59 **Table 10.**–Estimates of mature and old growth forest contained within Wildfire Crisis Strategy priority firesheds.

# Executive Summary

This report was prepared in response to Executive Order (E.O.) 14072, which instructed the U.S. Department of Agriculture (USDA), Forest Service and U.S. Department of the Interior, Bureau of Land Management (BLM) to analyze threats to mature and old-growth forests on lands managed by these agencies and implement a series of actions intended to foster resilience in the Nation's forests.

This is the second report regarding mature and old-growth forests prepared in response to E.O. 14072. The first report, "Mature and Old-Growth Forests: Definition, Identification, and Initial Inventory on Lands Managed by the Forest Service and Bureau of Land Management" was completed in April 2023 (revised April 2024). This report details the initial analysis of threats to the mature and old-growth forests inventoried in the first report.

The initial threat analysis found that mature and old-growth forests have high exposure to a variety of threats—climate and disturbance projections show this exposure will likely increase. Currently, wildfire, exacerbated by climate change and fire exclusion, is the leading threat to mature and old-growth forests, followed by insects and disease in the West, while more varied disturbances threaten older forests in Alaska and in eastern regions. The analysis also found that two-thirds of mature forests and just over half of old-growth forests are vulnerable to these threats. Tree cutting (any removal of trees) is currently a relatively minor threat despite having been a major disturbance historically, as from 1950 to 1990 these practices were the primary reason for loss of old-growth forests.

Since 2000:

- Wildfires were associated with a net decrease of 2.6 million acres of mature forest, and 700,000 acres of old-growth forest.
- Insects and disease corresponded with a net decline of 1.9 million acres of mature forest and 182,000 acres of old-growth forest.
- Tree cutting that resulted in 24 percent-or-more basal area loss by the Forest Service and BLM was associated with a net decrease of 214,000 acres of mature forest and 9,000 acres of old-growth forest.
- Where no severe forest disturbances have occurred, mature forests had a net increase of 2.21 million acres and old-growth forests by 1.20 million acres.
- Combined, there has been a 2.51-million-acre net decline of mature forests, with about a tenth of this becoming old growth (a 0.28 million acre net increase in old growth).

Projections over the next 50 years show growth of young and mature forests may result in an increase of older forests, despite increased disturbances. However, gains lessen with each passing decade and the expanding wildland-urban interface complicates mitigation of threats. Projections of increasing mature and old-growth forests are tempered by the reality that American forests are entering uncharted territory with climate change. Climate change has already increased threat levels and is altering where, and what types of, mature and older forest can persist.

This introductory threat analysis should be considered a first step towards understanding the myriad interacting biophysical and social factors that threaten the persistence of older forests on public lands across the Nation. This initial threat analysis, and future monitoring of the status, trends, and disturbances of these forests will inform understanding both causality for observed patterns and associated climate-informed adaptive management options. Most importantly, the likely environment of the future, not that of the past, should guide mature and old-growth forest policy and management considerations. As our understanding of the implications of climate change evolves, so will understanding the places and methods to best steward and conserve our Nation's older forests.



**Old-growth stand on Bitterroot National Forest, Montana. USDA Forest Service photo by Shelagh Fox.**

# Contributors

## Technical Team

Sarah Anderson, U.S. Department of Agriculture, Forest Service

Scott Barndt, U.S. Department of Agriculture, Forest Service

Jessica Barnes, U.S. Department of Agriculture, Forest Service

Jennifer Costanza, U.S. Department of Agriculture, Forest Service

John Coulston, U.S. Department of Agriculture, Forest Service

Raymond Davis, Team Leader, U.S. Department of Agriculture, Forest Service

Madelyn Dillon, U.S. Department of Agriculture, Forest Service

Andrew Gray, U.S. Department of Agriculture, Forest Service

Shannon Groff, U.S. Department of Agriculture, Forest Service

Franklin Halprin, U.S. Department of Agriculture, Forest Service

Jessica Halofsky, U.S. Department of Agriculture, Forest Service

Douglas Havlina, U.S. Department of the Interior, Bureau of Land Management

Greg Hayward, U.S. Department of Agriculture, Forest Service

Donald Helmbrecht, U.S. Department of Agriculture, Forest Service

Maria Janowiak, U.S. Department of Agriculture, Forest Service

Erik Johnson, U.S. Department of Agriculture, Forest Service

Aaron Kamoske, U.S. Department of Agriculture, Forest Service

John Kim, U.S. Department of Agriculture, Forest Service

Shanna Kleinsmith, U.S. Department of Agriculture, Forest Service

Frank Koch, U.S. Department of Agriculture, Forest Service

Frank Krist, U.S. Department of Agriculture, Forest Service

Joseph Krueger, U.S. Department of Agriculture, Forest Service

Charlie Luce, U.S. Department of Agriculture, Forest Service

Kate Marcille, U.S. Department of Agriculture, Forest Service

Charles Mchugh, U.S. Department of Agriculture, Forest Service

Julie Minde, U.S. Department of Agriculture, Forest Service

Miranda Mockrin, U.S. Department of Agriculture, Forest Service

Amy Nathanson, U.S. Department of Agriculture, Forest Service

Dave Peterson, U.S. Department of Agriculture, Forest Service

Kevin Potter, U.S. Department of Agriculture, Forest Service

Matt Reilly, U.S. Department of Agriculture, Forest Service

Keith Reynolds, U.S. Department of Agriculture, Forest Service

Jennifer Ross, U.S. Department of Agriculture, Forest Service

Chris Schumacher, U.S. Department of the Interior, Bureau of Land Management

Jason Simmons, U.S. Department of the Interior, Bureau of Land Management

Kari Tilton, U.S. Department of Agriculture, Forest Service

David Walker, U.S. Department of Agriculture, Forest Service

Nathan Walker, U.S. Department of Agriculture, Forest Service

Sarah Wiener, U.S. Department of Agriculture, Forest Service

## Executive Team

Jamie Barbour, Project Leader, U.S. Department of Agriculture, Forest Service

Chris Swanston, U.S. Department of Agriculture, Forest Service

Chad Van Ormer, U.S. Department of Agriculture, Forest Service

Linda Heath, U.S. Department of Agriculture, Forest Service

Peter Nelson, Overstory Strategies

Susanne Tracy, U.S. Department of Agriculture, Forest Service

Wade Salverson,* U.S. Department of the Interior, Bureau of Land Management

Thomas Schuler,* U.S. Department of Agriculture, Forest Service

Juli Slivka, U.S. Department of the Interior, Bureau of Land Management

## USDA Forest Service Extended Team

Marisa Anderson, Ela Autumn, Dave Bell, Elizabeth Berkley, Gabrielle Bohlman, Sarah Browne, Ramona Butz, Phil Cannon, Susan Catton, Susan Charnley, Brandon Collins, Robyn Darbyshire, Brie Darr, Jean Daniels, Becky Estes, Kendra Fallon, Alison Foster, Shelagh Fox, Randy Fuller, Barbara Garcia, Andrew Graves, Lacey Hankin, Wendy Haskins, Sarah Hennessy, Keri Hicks, Stacy Hishanuma, Kevin Hood, Kevin James, Tamara Kerr, Frank Lake, Elizabeth Larry, Chelsea Leitz, Ariel Leonard, Blakey Lockman, Erin Lonergan, Jonathan Long, Megan Lowell, James McFarland, Celie Meier, Kyle Merriam, Marc Meyer, Nicole Molinari, Natalie Morgan, Patrick Murphy, Monique Nelson, Timory Peel, Iral Ragenovich, Stephanie Rebain, Hilary Rigby, Gregory Rishdahl, Jason Rodrigue, Ramiro Rojas, Dana Roth, Joe Sherlock, Donna Shorrock, Kimberly Smolt, Ben Soderquist, Tova Spector, Cara Staab, Elisa Stamm, Thomas Timberlake, Jack Triepke, Jessica Washebeck, Pek Wijayratne, Lorena Wisehart, Rowena Yeahquo, James Youtz, and Damien Zona.

## Acknowledgements

Matthew (Sean) Patterson, Ryan Rock, Chad Delany, and Abigail Schaaf contributed extensive contract analytical support that made the threat analysis possible on a very tight timeline. Kathleen Rutherford Riggs provided invaluable strategic stakeholder engagement advice and support. This report was immeasurably strengthened by numerous thorough and thoughtful reviewers.

* Team members that contributed on both the Technical Team and Executive Team.

# Introduction

**E.O. 14072 (also known as "Strengthening the Nation's Forests, Communities, and Local Economies") instructed the Department of the Interior, Bureau of Land Management (BLM) and U.S. Department of Agriculture (USDA), Forest Service to implement a set of actions focused on the health of the Nation's forests. Section 2(c).ii specifically directed the agencies to analyze the threats to mature and old-growth forests on associated Federal lands, including from wildfires and climate change. To fulfill this direction, the agencies created this report.**

The analysis in this document is based on the initial inventory and definitions of mature and old-growth forests described in the report, Mature and Old-Growth Forests: Definition, Identification, and Initial Inventory on Lands Managed by the Forest Service and Bureau of Land Management in Fulfillment of Section 2(b) of Executive Order No. 14072 (USDA and USDI 2023—hereafter, referred to as the mature and old-growth forest inventory report; Pelz et al. 2023, Woodall et al. 2023, Gray et al. 2023). The mature and old-growth forest inventory report was also a fulfillment of Section 2(b) of E.O. 14072, which was released to the public on April 20, 2023.

Interest in the Nation's mature and old-growth forests, specifically what remains on federally managed lands, has been increasing since the 1980s (USDA Forest Service 1989). A series of recent governmental actions highlight the increased national interest (appendix 1).

For this analysis, threats are defined as disturbances or stressors, either current or projected, that can contribute to the enduring loss or degradation of the characteristic conditions, functions, or values of existing mature and old-growth forests. Threats identified in the Executive order include wildfire, climate change, insect outbreaks, disease, and decades of fire exclusion. However, recognizing the vast geographic diversity in mature and old-growth forests as well as disturbances, social, cultural, and economic conditions across the Nation, each Forest Service region was asked to review and expand upon (if necessary) the list from the Executive order. The result added invasive species, impacts from large mammal foraging, ungulate browsing, human activities, and management approaches and challenges (including those derived from policy and social restrictions on management). Multiple forms of engagement with Tribal leaders, stakeholders, the public, and Forest Service and BLM staff yielded additional inputs, such as: threats from timber harvest and vegetation management, natural disturbances, and human activities (such as road construction, expansion of the wildland-urban interface, and activities on State and private lands adjacent to Forest Service and BLM forestlands [see appendix 2]). Given time and data constraints, this report analyzed the following potential threats to lands managed by the Forest Service and BLM:

- Fire
- Fire exclusion
- Insects and disease
- Extreme weather events
- Climate change
- Tree cutting
- Roads

In this report, the characterization of threat considers two criteria:

1. The direct effects that result in losses of mature or old-growth forest based on the definitions from the mature and old-growth forest inventory report (USDA and USDI 2023), including outcomes that could result in future or enduring loss, such as from climate change.
2. Context-based consideration for whether effects result in adverse outcomes for ecological, social, cultural, and economic values.

American society's values for, benefits from, and manners of interaction with mature and old-growth forests could be associated with individual forest components, such as individual trees, or those broadly spread across a region. They might be associated with a specific forest type and are generally uniformly distributed across a forest. Consideration of socio-cultural valuation associated with forest ecosystems has become increasingly significant in Western scientific literature (Velasco-Muñoz et al. 2022). This includes scientific literature highlighting values associated particularly with old growth and arguing to ensure its future existence. These changes are commonly linked to a record of focus on timber (Moyer et al. 2008) as well as changes in forest values, especially after the second half of the 20th century (Bengston 2020). Of note, literature highlighting values associated particularly with old growth has become more distinct as well as arguments to ensure its future presence. For example, “Large old trees are an important part of our combined cultural heritage, providing people with aesthetic, symbolic, religious, and historical cues. Bringing their numerous environmental, oceanic, ecological, therapeutic, and socio-cultural benefits to the fore, and learning to appreciate old trees in a holistic manner could contribute to halting the worldwide decline of old-growth forests” (Gilhen-Baker et al. 2022).

Forest managers and policy makers must carefully consider and balance multiple forest values that are commonly marked by contradiction and uncertainty (Anderson et al. 2018). The spectrum of values has been both revealed through—and amplified by—the increase in public input. Particularly with the institution of the National Environmental Policy Act (1970), public interest and participation in the planning process has dramatically increased, including in forest management (such as Paletto et al. 2013). An additional factor is the recent, greater inclusion and participation of historically marginalized and underserved communities when it comes to understanding forest values (Charnley et al. 2008).

# Methods

Qualitative and quantitative analytical methods were used to analyze the potential threats to mature and old-growth forests. The intent was to integrate the biophysical, socioeconomic, and cultural evaluations. Much of this analysis used the Forest Inventory and Analysis (FIA) spatially balanced network of field plots across the United States; FIA formed the foundation for the mature and old-growth forest inventory report. Because FIA plots are monumented and remeasured on a 5 to 10-year cycle, depending on location, and are located within lands managed by the Forest Service and BLM, they provide an unbiased assessment of current forest condition and trends over time. Condition-based evaluations, remeasured FIA plot analyses, projections of the FIA inventory into the future, as well as spatial analyses to examine recent historical, current, and future conditions and exposures to potential threats were used in this analysis. These methods complemented each other, providing a rich understanding of past and future threats to the Nation's mature and old-growth forests. Each approach is briefly described in the following sections.

The analyses in this report encompass land managed by the Forest Service and BLM. In many places of this report, the data is summarized by Forest Service region, but include data for both the Forest Service and BLM. This was mutually agreed upon by both agencies.

## Condition-Based Evaluations

We examined the relationship between forest disturbances and threats through a qualitative condition-based evaluation—an examination of the influence of initial forest conditions on the outcome (positive, neutral, adverse) of a disturbance (such as fire or forest insects). This analysis combined principles and observations from disturbance ecology with adverse outcome criteria adapted from Environmental Protection Agency (EPA) evaluations and the definition of adverse outcome used in environmental threat analyses (Brown et al. 2017).

Whether or not disturbances constitute threats to mature and old-growth forests depend on their severity and duration (first box—Driver/Stressor), the local

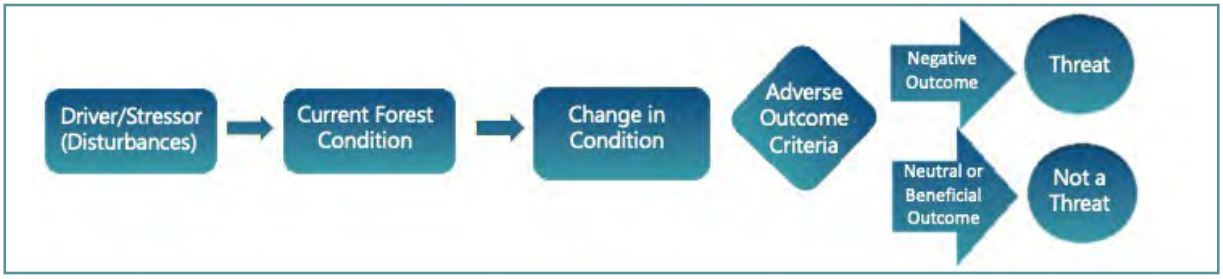



**Figure 1.**—Illustration of the framework adapted from EPA (Brown et al. 2017) and employed to identify when a disturbance such as fire—a driver or stressor—results in a threat versus an outcome that is neutral or beneficial. This framework is particularly applied in the qualitative, condition-based evaluation reviewed for each potential threat in the results.

ecological, social, economic, and cultural conditions under which the disturbance occurs (second box—Current Forest Condition), and the nature of change resulting from the disturbance (remainder of figure 1). Applying adverse outcome criteria that reflect the ecological, social, economic, and cultural values of mature and old-growth forests helps to determine if a change in condition is considered a negative outcome (top arrow of figure 1) or a neutral or beneficial outcome (bottom arrow of figure 1). Disturbances that result in a decline in the abundance of desirable mature and old-growth forest, or an enduring loss of mature and old-growth conditions, functions, or values were considered as having negative outcomes, and thus identified as *threats*. Disturbances that resulted in neutral or beneficial outcomes, such as no change in abundance or an increase in the extent of mature and old-growth forest, were not considered threats (see following example).

The example (box 1) illustrates that we recognize an ecological adverse outcome when the change in condition following a disturbance results in the forest no longer being classified as mature or old growth. When the condition of mature or old-growth longleaf pine forest includes dense trees with ladder fuels, a crown fire capable of removing the large trees would be likely and the forest would be transformed to an earlier developmental stage. Because of the forest condition, fire resulted in the adverse outcome of losing the largest and oldest trees. The fire, in an uncharacteristically dense stand, was a clear threat to the mature or old-growth forest component. The condition-based analysis also considers outcomes evaluating social, cultural, and economic values. Assessing threats, particularly through a social, cultural, and economic lens begs the question, "of what, to what, and to whom?" Ecological disturbances may change a range of forest conditions but may not alter their value to humans. This report explores a small subset of social, cultural, and economic values to ground the ecological outcomes in the human environment in which they occur, as the next example shows (box 2).

**Fire is a very common disturbance affecting many types of forests. However, fire is not always a threat. Frequent, low-intensity surface fires (driver) may burn through many hundreds of acres of mature or old-growth longleaf pine forest without removing the mature or old-growth forest component. The forest condition is such that the fire remains a surface fire based on the absence of dense trees or other fuels that would change the fire to a widespread crown fire (stressor). Alternatively, if the condition of a mature or old-growth longleaf pine forest includes dense trees with ladder fuels, a crown fire capable of removing large swaths of large trees—an adverse outcome—would be likely, and the forest would be transformed to an earlier developmental stage. Because of the forest condition, which in this second case was uncharacteristically dense, the fire was a clear threat to the mature or old-growth forest component.**

**Box 1.**—Example of how forest conditions influence a disturbance as a threat.

**Many mature and old-growth forests support unique medicinal plants and other features that are a source of important cultural values. For example, some Tribes and Alaska Native populations use exceptionally large trees to build canoes, housing, and other structures. Very large birch, large yellow cedar, and other large trees are harvested and play a critical role in the cultural life of peoples that live near mature and old-growth forests. A disturbance may kill the species of tree used for the cultural resource, such as yellow cedar, without killing other species of trees. Consequently, a disturbance may result in a cultural adverse outcome (such as death of most large yellow cedar) in a stand that remains classified as old growth based on remaining forest structural components for that old-growth forest type.**

**Box 2.**—Example of a disturbance resulting in an adverse outcome for social and cultural values.

Ecological and social factors interact in complex ways, which can influence whether the outcome of a disturbance results in a threat and what form it takes. The Executive order clearly framed the importance of mature and old-growth forests to social, cultural, and economic values. Forests, and the physical changes they undergo, are better understood when viewed in the context of the relationships that humans have with them. This enables a richer discussion on what the physical changes mean to wide ranging groups of people and interests. For this analysis, the Forest Service and BLM explicitly integrated social, cultural, and economic lenses with ecological lenses when evaluating threats. This helped inform how the ecological, social, cultural, and economic outcomes from a disturbance (whether a threat or not) differ. Outcomes from disturbances are generally threats to the ecological structure of mature and old-growth forests if they change a stand's classification to an earlier stage of development. Threats could be defined differently. For this national evaluation we defined threats to ecological conditions as a change in developmental stage. Determining whether disturbances lead to other negative ecological, social, cultural, and economic outcomes requires local context.

Forest characteristics as well as the local social, economic, and cultural environment—identified as critical in these analyses in determining whether a disturbance results in a threat—are often fine-grained and beyond the resolution of a national evaluation. As a result, this report generally does not attempt to identify specific values threatened by specific stressors in specific locations. Rather it identifies patterns that illustrate potential threats at broader scales that can ultimately be analyzed more effectively at local scales. This qualitative, condition-based evaluation provides the knowledge to place potential threats in context for informed, future local evaluation.

Worksheets (see methods in appendix 3) were completed by several resource specialists (for example, social scientists,

ecologists, and silviculturists) in each Forest Service region to inform the condition-based evaluation. The goal of the worksheets was to systematically examine the forest conditions that determine whether various disturbances result in an adverse outcome—and thus constitute a threat—or produce a neutral or beneficial outcome. These expert elicitations, a social science method by which experts in their fields make statements that can be trusted as information, brought local information to the analysis, and made it more context specific, adding to what exists in the published literature. This framework was used to examine disturbances such as fire or hurricanes in relation to different forest types and structural stages, providing critical context for how drivers and stressors affect diverse types of mature and old-growth forests in different regions.

## Remeasured Forest Inventory and Analysis Plots

An analysis of FIA plot data was used to estimate the net change in mature and old-growth forest acreage. This analysis used FIA plots that were measured more than once between 2000 and 2020 (measurement year and remeasurement intervals vary by State; see appendix 4). In addition to site and detailed tree information, FIA field crews record disturbances that have occurred, to include: fire (both wildfire and prescribed fire activities), insect and disease, animal damage, weather damage, and geological disturbances. Disturbance is recorded when it is at least 1 acre in size, there is mortality and/or damage to 25 percent of all trees in a stand, or 50 percent of



**Old-growth stand on Bitterroot National Forest, Montana. USDA Forest Service photo by Shelagh Fox.**

an individual tree species is affected. If a disturbance affects land and/or vegetation, but not initially the growth and health of the trees, such as grazing and flooding, then it is recorded when at least 25 percent of the soil surface or understory vegetation has been affected. Cutting—the removal of trees due to a silvicultural treatment, including thinning of smaller diameter trees and/or harvesting of larger diameter trees with the intention to move the stand from its current condition towards a desired future condition—is recorded when the treatment is at least 1 acre in size. Cutting does not include sparse removals of firewood or Christmas trees (USDA Forest Service 2024). Disturbance and cutting are recorded on a plot if they occurred since the previous measurement. For this analysis, disturbance and cutting were grouped by disturbance type. A hierarchical grouping was applied; if either fire or cutting were identified, those stands were classified as "cut" or "fire" (a subset where both occurred were classified as "cut+fire"). If neither of those were present, but insect or disease damage was present, then "insect/disease" was classified. If none of the above were present, then "weather" disturbance was classified. This could include extreme drought mortality, wind damage, avalanches, floods, and landslides. More information on FIA disturbance codes is available from Burrill et al. (2023).

Disturbance severity was classified by the percentage of live tree basal area[1] change between the first and second measurements:

- Low basal area loss (**Low**): less than 25 percent basal area loss (including basal area gain)
- Moderate basal area loss (**Mod**): 25–60 percent basal area loss
- Moderately severe basal area loss (**ModSev**): 60–90 percent basal area loss
- Severe basal area loss (**Severe**): equal to or greater than 90 percent basal area loss

Mature and old-growth forest FIA plots were identified using definitions and criteria applied in the initial mature and old-growth forest inventory report (USDA and USDI 2023). Results are first presented in terms of mature and old-growth forest at the initial measurement (Woodall et al. 2023) that experienced disturbance during the remeasurement period. Because a disturbance can cause a forest to either gain or lose mature or old-growth status, or a forest may change status regardless of direct disturbance effects, the impacts associated with the occurrence of disturbance are expressed as the net change in status, regardless of the status at the first measurement. The magnitude of change is expressed in acres as well as the percent of forest area in mature or old-growth status at the initial measurement. The area estimates represent change over an average period of 9 years between plot measurements, with most initial measurements occurring in the 2000s (2000–2009) and remeasurements occurring in the 2010s (2010–2019) (appendix 4). Some results

1 Basal area is the cross-sectional area of the boles of a tree in a stand (for example, $ft^2$/ac), generally measured 4.5 feet above the surface of the ground.

are presented by forest type group (Perry et al. 2022), which is a classification based on the dominant species in a stand (Burrill et al. 2023, appendix D). Statistical significance of change is assessed using 95-percent confidence intervals of the sampling error estimated from standard FIA post-stratified estimation techniques (Bechtold and Patterson 2005).

## Forest Inventory and Analysis Data Projected into the Future

An analysis of forest inventory projections was used to estimate net change in future mature and old-growth forest acreage under climate and socioeconomic scenarios. The Resources Planning Act (RPA) Assessment's Forest Dynamics Model (FDM) is a stochastic modeling system that projected observed (2000–2019) FIA plot-level variables in 2020 forward to the period 2030–2070 for the contiguous United States (Coulston et al. 2023). Projections were based on observed relationships between plot conditions in the observed FIA inventory and environmental and socioeconomic variables, including climate, timber prices, human population, and income based on location of the plot. Plot conditions are projected under future scenarios by a set of sub-models representing harvest choices, forest disturbance, growth, aging, regeneration, and forest type transitions over time (Coulston et al. 2023). We used results from the FDM to quantify the projected live volumes affected by harvest and wildfire in mature, old-growth, and nonmature as well as the projected areas of those forests over time. Relationships were modeled separately by RPA region and ownership to incorporate regional patterns.

- **Future wildfire sub-model**—This sub-model is based on past tree mortality resulting from fire recorded on FIA plots. Because of the limited ability of FIA field crews to detect low-severity fires, fires that did not lead to tree mortality are omitted. Thus, the projections represent annual volumes of tree mortality resulting from moderate and high-severity wildfires over time (Costanza et al. 2023). This sub-model links to other sub-models that modify forest fuel characteristics over time, including basal area, down woody material, stand age, tree species composition, and harvest probability over time in response to the scenarios described below.
- **Future harvest choice sub-model**—This sub-model is based on empirical relationships linked to prices and demand for wood nationally and globally. These relationships were modeled separately by RPA Assessment region and varied by land ownership and management practices. Historical price sensitivities of different forest ownership categories were accounted for.

We used future scenarios developed for the 2020 RPA Assessment to project the FIA inventory over the next 50 years. The four RPA Assessment scenarios incorporate future climate, population, and socioeconomic change by pairing two alternative atmospheric warming futures (Representative Concentration Pathways, or RCPs) with four alternative socioeconomic futures (Shared

Socioeconomic Pathways, or SSPs) in the following combinations (see O'Dea et al. 2023 for more information on scenarios):

1. high warming and high growth (**HH**) – RCP8.5 and SSP5
2. high warming and moderate growth (**HM**) – RCP8.5 and SSP2
3. high warming and low growth (**HL**) – RCP8.5 and SSP3
4. lower warming and moderate growth (**LM**) – RCP4.5 and SSP1

Within each RPA scenario, projections were made using five different climate models (Global Circulation Models, or GCMs), selected to capture a wide range of future temperature and precipitation projections across the continguous United States (O'Dea et al. 2023, Joyce and Coulson 2020).

1. MRI-CGCM3 – least warm
2. HadGEM2-ES – hot
3. IPSL-CM5A-MR – dry
4. CNRM-CM5 – wet
5. NorESM1-M – middle-of-the-road

All forested FIA plots on lands managed by the Forest Service and BLM were included in this analysis, and within that set of plots mature and old-growth forest plots were identified using definitions and criteria applied in the mature and old-growth forest inventory report (USDA and USDI 2023). Only plots that met the RPA definition of forest land[2] were used in this analysis; thus, the extent of mature and old growth used in this analysis does not directly match the extent of the inventory from the initial mature and old-growth forest inventory report. Additionally, while the area of mature and old-growth forests changes over time in these projections, it was assumed that forests on lands managed by the Forest Service and BLM remained in forest use (even if the forest cover temporarily changed) for the life of the projections. Furthermore, because the projections were based on the FIA inventory, sampling error associated with inventory design is inherent in these projections, remained constant over time at 2020 levels for all variables projected, and is not shown explicitly in the figures, although the sampling error associated with individual realizations comprises a portion of the variability across model realizations.

## Spatial Analysis of Historical, Current, and Future Conditions

The purpose of this analysis was to understand the amount and distribution of mature and old-growth forests exposed to various potential threats or conditions—and how that exposure has changed since recent historical times and might change in the future. The spatial analysis was conducted at the fireshed scale (250,000 acres). Firesheds are part of a national, nested spatial framework (the Fireshed Registry[3]) that divide the United States into similarly shaped and sized polygons to serve as analytical units for the assessment of

2 An international forest land definition that yields a slightly smaller forest land base than when using the FIA forest land definition because of its minimum height requirement (16.5 ft) that excludes some woodlands, primarily in the southwestern United States (Oswalt et al. 2019).

3 Fireshed Registry: https://www.arcgis.com/home/item.html?id=d4dc3690c18f4656b3f1595477c1b4c4

wildfire risk and other natural resource management priorities and trends (Ager et al. 2021). Only the forested portions of lands managed by the Forest Service and BLM within each fireshed were analyzed because those areas relate directly to the mature and old-growth forest inventory estimates (USDA and USDI 2023). Where the data allowed, recent historical conditions (the last two to three decades of the last century) were included. Early-century, mid-century, and end-century conditions were based on the most up-to-date monitoring data or modeled from various climate change scenarios. Results were represented as current area of inventoried mature and old-growth forests (based on FIA estimates at the fireshed scale) that spatially coincided with (were exposed to) potential threats or ecological/socioeconomic conditions. For this analysis, the term exposure is defined as the magnitude or degree of change in climate or other factors a species or system is likely to experience. Historical and future estimates of mature and old-growth forest (by fireshed) were not available for this initial analysis and exposure for those time periods was based on current amounts.

Exposure of mature and old-growth forests to moderate- to high-severity wildfire (Eidenshink et al. 2007) was analyzed using recently published datasets projecting wildfire risk in the forests of the contiguous United States under two different Coupled Model Intercomparison Project 6 (CMIP6) scenarios based on SSPs tied to RCPs used in CMIP5—SSP2-RCP4.5, and SSP5-RCP8.5 (Anderegg et al. 2022). Exposure to climate change was based on two metrics: extreme heat and decreased water availability to forest vegetation. Exposure to extreme heat was based on climate models for number of days in a year that exceed 90 °Fahrenheit (USDA Forest Service 2018). Climatic water deficit (CWD) was used as the metric for exposure to decreased water availability as it relates to drought stress on vegetation (Stephenson 1998). This dataset comprises modeled change in CWD estimated for the recent historical period (1970−1999), early-century (2000–2029), mid-century (2035–2064), and end-century (2070−2099) using output from MC2 dynamic global vegetation model (DGVM) output (EPA 2017). Climatic water deficit is calculated as the difference between potential evapotranspiration (PET) and actual evapotranspiration (AET). MC2 DGVM was calibrated for the contiguous United States, and PET and AET were output using climate data averaged from 17 GCMs. GCM data are from the Localized Constructed Analogs (LOCA) downscaled climate dataset (Pierce et al. 2014, 2023) and represent RCP8.5 climate change scenario. Each GCM drives a single MC2 simulation. Additional geospatial layers were used for analyzing current conditions and potential threats in the following section and are described (including data sources) in appendix 5.

## Mature and Old Growth Condition Assessment

To better understand the multiple drivers and stressors that interact in ecosystems, the Terrestrial Condition Assessment (TCA) model framework (Cleland et al. 2017) was adapted to focus on potential threats and ecological conditions that could degrade areas with mature and old-growth forests. The TCA

is designed to support assessments of ecological integrity as described in the 2012 Planning Rule (36 CFR 219, FSM 1921.02, FSH 1909.12). The TCA leverages nationally consistent datasets to model ecological conditions related to stressors, disturbances, and vegetation conditions for landtype associations (Cleland et al. 2017, Anderson et al. 2021). Landtype associations (LTAs) are mapped units that represent landscape-scale ecosystems in the National Hierarchical Framework of Ecological Units (NHFEU, DeMeo et al. 2001, Nelson et al. 2015, Winthers et al. 2005). The TCA is supported through the Ecosystem Management Decision Support (EMDS) logic model, which allows incorporating information about relationships among the indicators and metrics TCA considers (Reynolds and Hessburg 2014). The TCA summarizes data into different metrics and measures that are evaluated for each LTA, producing continuous scores ranging from +1 (representing very good ecological conditions) to -1 (representing very poor ecological conditions). Metrics are aggregated to provide a score for each indicator, and indicator scores are aggregated to provide information on the ecological conditions of the analysis unit. The Forest Service runs the TCA annually.[4]

For this analysis, the TCA was modified to evaluate drivers and stressors most relevant to mature and old-growth forests under current ecological conditions, informed by historical trends and patterns to create the Mature and Old Growth (MOG) Condition Assessment (MOGCA). The modification required focusing on indicators relevant to forest ecosystems (such as dropping TCA indicators focused on grassland conditions), revising the model structure, and changing analysis units to align with the mature and old-growth forest inventory report. The mature and old-growth forest inventory report used fireshed polygons to display estimates of mature and old-growth forests (USDA and USDI 2023). However, firesheds were too large and ecologically diverse for a TCA-like analysis, so smaller units from the registry were used. The registry calls these smaller units "project areas," and they are approximately 25,000 acres in size. Within each analysis unit, ecological indicators and metrics were summarized only on forestlands managed by the Forest Service and BLM. Conditions were upscaled to firesheds using an area-weighted averaging approach of continuous scores, so that results could be related to the mature and old-growth forest inventory. The areas analyzed covered from 75.8 to 81.1 million acres of mature forest and 24.7 to 27.5 million acres of old-growth forest in the contiguous United States.

By adapting the TCA to focus on areas with mature and old-growth forests, the model provides a means to analyze stressors, disturbances, and potential threats both individually and in conjunction with one another. Refer to appendix 5 for more details on the MOGCA, including the modification process, model details, and specific datasets used.

4 (https://terrestrial-condition-assessment-usfs.hub.arcgis.com/)

# Results

## Fire

Fire, whether wildfire, Indigenous burning, or prescribed, is a dominant ecological disturbance in many forest ecosystems and can behave as a driver or stressor. Adverse effects from fire depend on the forest conditions, the severity and extent of the fire, and ultimately the forest condition following the fire as it relates to the social, economic, and cultural values the forest provided prior to (and after) burning. For example, forest visitors might avoid recently burned mature and old-growth forests, reducing economic benefits in those areas, and possibly increase recreation-associated overuse in unburned areas.

Information from the worksheets for the condition-based evaluation show how different ecosystems throughout Forest Service regions interact with fire as a threat or beneficial outcome (appendix 3). Pacific Northwest Region employees relayed that, when members of the public place existence value on certain species such as the iconic Douglas-fir, loss of this old growth tree due to fire inherently manifests as a negative social outcome. In reference to oak woodlands, employees from the Pacific Southwest Region took the same stance, "There are psychological and emotional benefits associated with the mere presence…that would be lost." Those existence values can vary in scale; sometimes interest is in a smaller area, whereas other vegetation types garner national attention. The threat to—or loss of—individual giant sequoias is of heightened concern across the country, garnering national media coverage when fires occur. Pacific Southwest Region employees went on to assert that, in addition to the tourism and income these trees provide to surrounding communities' economies, they are "…natural wonders treasured on an international scale and their loss is widely felt." Along a similar vein, uncharacteristic wildfire among ponderosa pine in the Rocky Mountain Region leads to loss of culturally modified trees, impacting Indigenous sense of place (Timmons et al. 2012).

Nationally, a total of 2,434 FIA plots on forested lands managed by the Forest Service and BLM experienced fire disturbance during the remeasurement period. An estimated 7.1 million acres of mature forest (8.8 percent of all mature forest) and an estimated 1.7 million acres of old-growth forest (5.6 percent of all old-growth forest) were disturbed by fire (approximately 710,000 and 170,000 acres per year, respectively). In forests disturbed by fire, there was a 2.6 million-acre decrease of mature forest (3.2 percent of all mature) and a 0.7 million-acre decrease of old-growth forest (2.2 percent of all old-growth forest). Forty-three percent of the fire disturbance in mature forest, and 31 percent in old-growth forest was in the low basal area loss category (less than 25 percent). Forests that experienced low basal area loss showed net gains in both mature and old-growth forest (figure 2). Thirty-three percent of the fire disturbance in mature forest, and 34 percent in old-growth forest, had severe (greater than or equal to 90 percent) basal area loss. Forests that experienced severe (equal to or greater than 90 percent) basal area loss showed statistically significant net losses of mature and old-growth forest between measurements. Net area changes varied for areas that experienced moderate (25–60 percent) and moderately severe

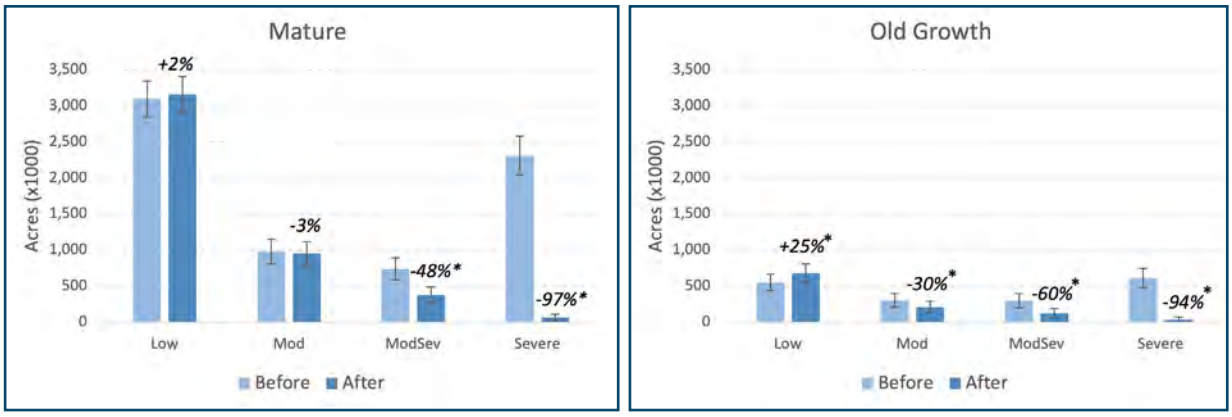



**Figure 2.**—Net changes (and 95-percent confidence intervals) in area of mature and old-growth forests that experienced fire disturbance over an average of 9 years from remeasured FIA plots (mostly 2000s to 2010s). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

(60–90 percent) basal area loss from fire. Fire effects varied by Forest Service region (see appendix 6). No fires were recorded on plots in the Alaska Region. Losses of mature and old growth in forests that burned were greatest in fir/spruce/mountain hemlock, Douglas-fir, and lodgepole pine forest type groups (table 1).

The spatial analysis of historical, current, and future conditions examining exposure to fire was done at the fireshed scale for only the contiguous United States due to existing data limitations. Historically (1980–1999), less than half of inventoried older forests had high exposure to high risks (Anderegg et al. 2022) from moderate- to high-severity fire as defined by Monitoring Trends in Burn Severity (MTBS) classes (Eidenshink et al. 2007). During the first two decades of this century (2000–2019), between 70 and 80 percent have high exposure. Climate change projections predict an increase in this exposure to between 90 and 95

**Table 1.**—The five forest type groups with the most change in area of mature and old-growth forest in forests that experienced fire disturbance over an average 9-year period from remeasured FIA plots. Area and 95-percent confidence intervals (CI) are in thousands of acres; percents are the proportional change of the forest type group in the mature or old-growth class.

| Forest Type Group | Mature Area Estimate | Mature 95%CI | Mature Percent | Old-Growth Area Estimate | Old-Growth 95%CI | Old-Growth Percent |
|---|---|---|---|---|---|---|
| Fir/spruce/mountain hemlock | -930 | 187 | -6.6 | -248 | 88 | -3.5 |
| Douglas-fir | -326 | 146 | -3.5 | -147 | 80 | -4.2 |
| Lodgepole pine | -375 | 123 | -4.8 | -122 | 72 | -7.3 |
| Piñon/juniper | -441 | 131 | -3.0 | -93 | 65 | -1.0 |
| Ponderosa pine | -258 | 130 | -3.9 | -81 | 73 | -5.8 |

percent for mature forests and 95 and 100 percent for old-growth forests by the end of the century (2080–2099), depending on the socioeconomic and climate change scenario. The current threat from wildfire primarily exists in the West; however, climate change is predicted to expand the range of wildfires to most of the East by the end of the century. The northeast region is projected to remain at low exposure throughout this century (figure 3).

The largest percent change from historical conditions is projected to occur in the fir/spruce/mountain hemlock and Douglas-fir groups in the West, and the oak/hickory, loblolly/shortleaf, and maple/beech/birch groups in the East. The largest absolute modeled risk value change from historical conditions is projected to occur in the ponderosa pine, Douglas-fir, California mixed conifer, piñon/juniper, and the fir/spruce/mountain hemlock groups in the

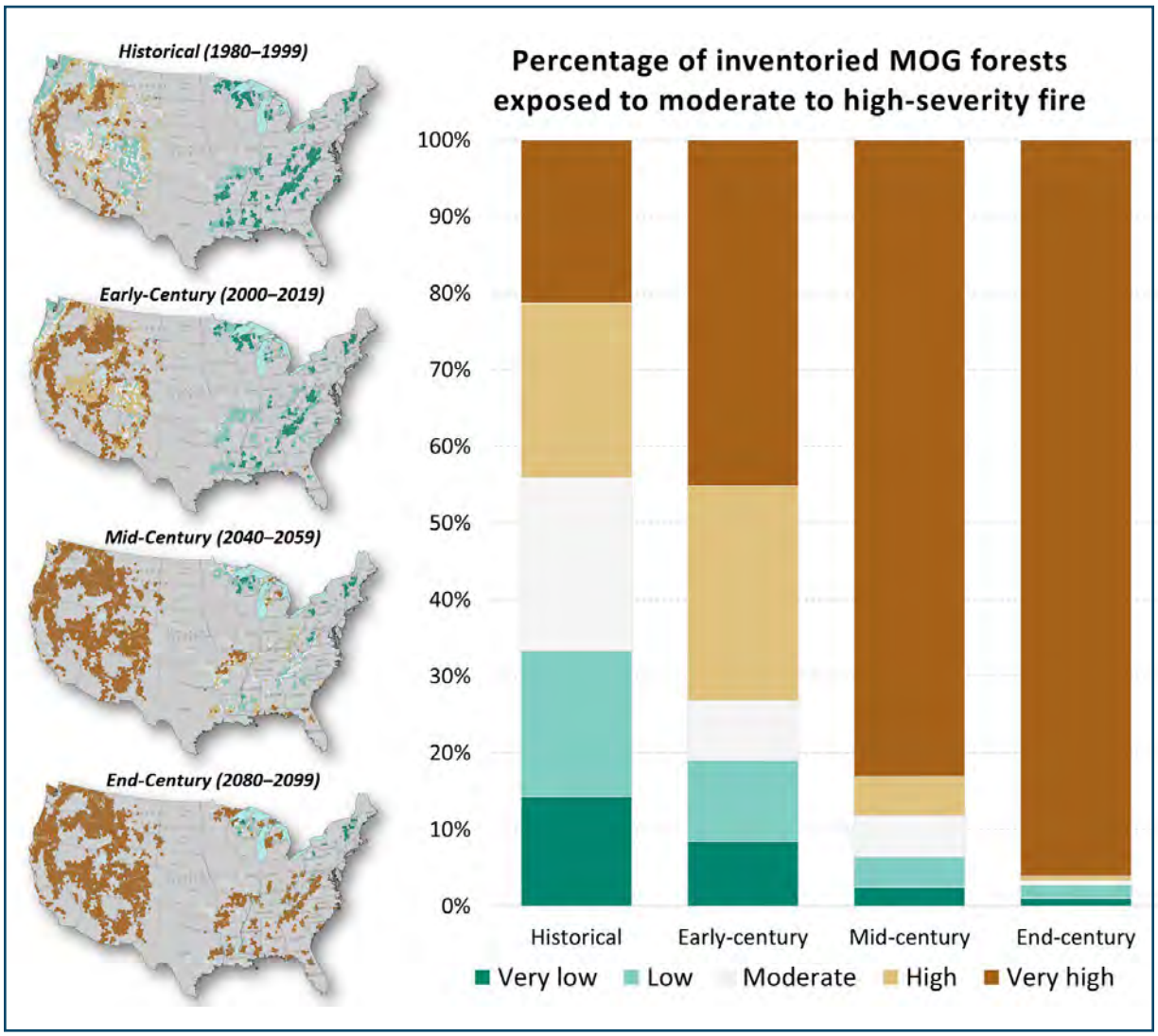



**Figure 3.**—Fireshed-scale exposure of inventoried mature and old-growth forests to moderate- to high-severity fire (SSP5-RCP8.5). The color scale represents exposure classes defined in table 2 below.

West, where wildfire-related mortality is a persistent stressor throughout the century. Absolute risk value changes were low in the East and forests in the New England States were persistently low in exposure to wildfire mortality under both scenarios.

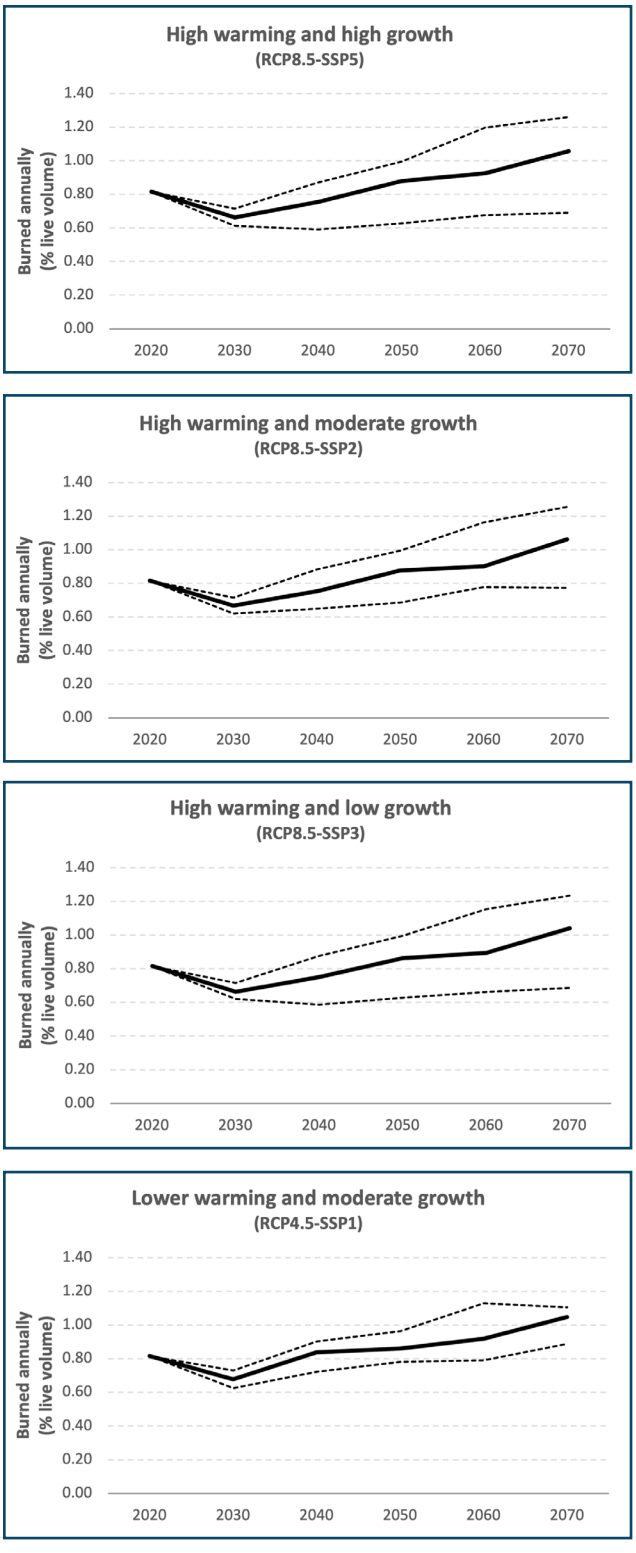
Increasing fire exposure means that an increasingly higher proportion of mature and old-growth forests will likely experience annual adverse effects from fire. Wildfires have increased in frequency and extent compared to the last two decades of the 20th century and account for most of the losses of mature and old-growth forests on lands managed by the Forest Service and BLM. An analysis of area burned by moderate- to high-severity wildfire was conducted using MTBS data (masked to Forest Service and BLM forestlands) for each map exposure class in figure 3 (combined across all firesheds) for the historical period (1980–1999) and early-century period (2000–2019) (see appendix 7). The area burned during the early-century period (2.5 million acres) was more than four times what was burned during the historical period (0.6 million acres) (table 2).

Based on FIA inventory data projections from the RPA Forest Dynamics Model, the proportion (by tree volume) of live mature and old-growth forest burned annually by moderate- to high-severity wildfire is projected to decrease in the first decade (2020–2030) then increases almost the same for all scenarios (figure 4). The initial decrease is likely due to large, high-severity fires in the Pacific Coast and South regions that occurred just prior to, or during, 2020 that are captured in the observed 2020 FIA numbers (see regional projections of area burned by moderate- and high-severity fires in appendix 8). The Forest Dynamics Model projects a return to earlier levels of wildfire by 2030 and increases over time after that.

The RPA Assessment (USDA Forest Service 2023) estimates that the largest increases in fire will occur disproportionately in the West among Douglas-fir, ponderosa pine, and piñon/juniper forests, as well as woodland hardwoods. In the East, fire-related mortality in the oak/hickory forest type group is projected to at least double (by volume) by 2070 and annual area of high-severity fires is projected to increase in all future scenarios (Costanza et al. 2023).

**Table 2.**—Proportion (total and averaged annually) of Forest Service and BLM forest burned by moderate- to high-severity wildfires. Historical data for Monitoring Trends in Burn Severity only extends back to 1984.

| Exposure Class | Historical (1984–1999) | | Early Century (2000–2019) | |
|---|---|---|---|---|
| | *Total (%)* | *Annual (%)* | *Total (%)* | *Annual (%)* |
| Very low | 0.09 | 0.005 | 0.65 | 0.033 |
| Low | 0.46 | 0.023 | 1.4 | 0.07 |
| Moderate | 1.75 | 0.088 | 2.86 | 0.143 |
| High | 2.27 | 0.113 | 6.66 | 0.333 |
| Very high | 2.94 | 0.147 | 10.61 | 0.53 |




# Fire Exclusion

Fire exclusion is the effort of deliberately excluding or preventing fire in an area, regardless of whether fire is natural or human caused. Federal fire-management policies which emphasized fire suppression rather than continuation of fire as an ecological and socio-cultural process began in the early-1900s (Pyne 1997). However, fire exclusion began long before the wildfire suppression era. Fire exclusion began centuries ago, with European visitations and colonization of forested regions, removing or displacing Indigenous populations. Removing Indigenous populations also removed frequent cultural burning that maintained nonforested areas and open forests and favored fire-adapted tree species. However, use of fire varied across Indigenous groups and regions and was not applied to all forested landscapes at the same levels. Historical, recorded observations remarked upon some of the changes in forested conditions that followed the cessation of this frequent (often annual) burning (figure 5).

There is an increasing body of research documenting the effects of prolongued fire exclusion in forest types that are characteristically maintained by frequent disturbance regimes (Hanberry et al. 2020, Reilly et al. 2021, Woodbridge et al. 2022, Brodie et al. 2023). There is general agreement among stakeholders that fire suppression and exclusion alters disturbance processes that eventually result in adverse outcomes, such as

**Figure 4.**—Observed (2020) and projected (2030–2070) trends in annual rates of tree mortality from moderate- to high-severity fires in mature and old-growth forests (mature and old growth combined) (CONUS). Solid lines reflect the median trend line of the median GCM (out of the five GCMs). The dashed lines represent the maximum and minimum values for the interquartile ranges (the middle 50 percent of the 100 replications) of projections across the five GCMs.

uncharacteristically severe fires or mesophication within forested systems. However, the magnitude and geography of fire exclusion, and stewardship response, is a topic of debate in both the eastern United States (for example, Oswald et al. 2020, Abrams and Nowacki 2020) and the West (for example, Hagmann et al. 2021, Gilhen-Baker et al. 2022).

The geographical and temporal extent of adverse outcomes from fire exclusion depends on the underlying fire regime and types of forests. For example, closed-canopy western hemlock, a fire-sensitive tree species, occur in cooler and moister climates with longer fire return intervals, whereas oak woodlands and pine forests occur in warmer and drier climates with shorter fire return intervals (Reilly et al. 2021). The effects of fire exclusion depend on the length of time exceeding the characteristic fire return interval, where longer exclusion (relative to the fire return interval) results in more uncharacteristic forest conditions.

Currently, some of the inventoried mature and old-growth forest FIA plots can be considered uncharacteristic due to fire exclusion. One example in western regions is the dense understory of Douglas-fir ingrowth in historical ponderosa pine forests. High tree densities of Douglas-fir in the understory

1 *"… the annual burning has been stopped, trees which were formerly confined to the river bottoms have gradually spread to the uplands. Small prairies situated just within the western edge of the forest have entirely disappeared within the memory of persons still living; the oak openings-open forests of large oaks through which the annual fires played without greatly injuring the full-grown trees-once the characteristic feature of these prairies, have disappeared. They are replaced by dense forests of oak…"*

2 *"The forest area has somewhat increased in the prairie region of the state since its first settlement and the consequent decrease of destructive prairie fires. The growth of trees has gradually spread from the bottom lands of the streams to the hills, and the oak forests upon the uplands have gradually encroached upon the prairie, losing their open, park-like character by the appearance of a young growth which has sprung up among the old trees."*

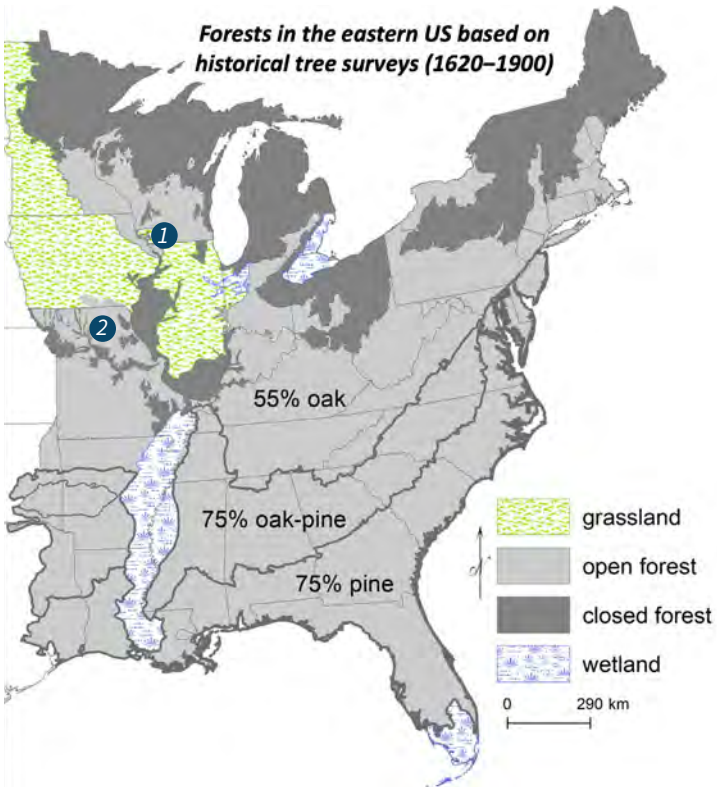



**Figure 5.**—Examples of written historical records illustrating the effects of frequent-fire exclusion on oak forests in the eastern United States from the "Report on the Forests of North America—Exclusive of Mexico" (Sargent 1884). Map courtesy of Brice Hanberry. Percentages represent areal extents of open forests within the delineated boundaries.

indicate the absence of fire in ponderosa pine forests (figure 6, figure 7, table 3, table 4). Small diameter Douglas-fir can suppress pine regeneration and may outcompete the large pines in the long term. Evidence indicates that high density of small-diameter trees leads to extreme fire behavior and loss of the larger, older trees when a fire does occur (for example, Fiedler and Arno 2015). Another example is red maple, a fire-sensitive, shade-tolerant species that flourishes in the absence of fire disturbance. One of the threats to mature or old-growth forests identified by eastern regions is mesophication, and its presence can be seen by the ingrowth of red maple, where high proportions of maple lead to the elimination of the oak over the long term (figure 8, figure 9, table 5, table 6). Uncharacteristically dense forests also display reduced resistance to insect pests, drought, and other environmental stressors (Vose et al. 2018).



**Figure 6.**—Photograph taken near Mt. Shasta, CA (circa 1949) with the caption stating "…it appears that the pine stand may gradually be replaced by a Douglas-fir, white fir stand." (Source: Wieslander Vegetation Type Mapping Collection, courtesy of the Marian Koshland Bioscience, Natural Resources & Public Health Library, University of California, Berkeley, http://guides.lib.berkeley.edu/Wieslander)

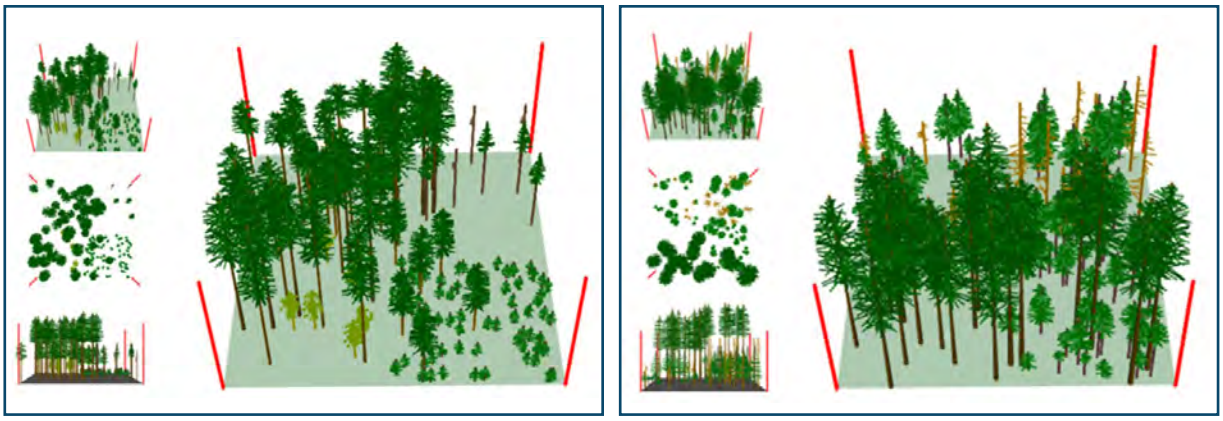


**Figure 7.**—Forest Vegetation Simulator images of FIA plots 40389335010690 (left) and 188772478020004 (right). Both plots are in the Intermountain Region. The mature and old-growth inventory identified some FIA plots classified as old-growth forest that supported uncharacteristic stand structure.

**Table 3.**—Tree diameter distributions (inches at breast height) from FIA plot 40389335010690 located in the Intermountain Region.

| Common Name | 1-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-40 | 40-50 |
|---|---|---|---|---|---|---|---|---|
| Ponderosa pine | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 6 |
| Douglas-fir | 6 | 30 | 18 | 18 | 0 | 0 | 0 | 0 |

**Table 4.**—Tree diameter distributions (inches at breast height) from FIA plot 188772478020004 located in the Intermountain Region.

| Common Name | 1-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-40 | 40-50 |
|---|---|---|---|---|---|---|---|---|
| Ponderosa pine | 0 | 0 | 0 | 12 | 6 | 12 | 12 | 0 |
| Douglas-fir | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lodgepole pine | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |
| Quaking aspen | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |



**Figure 8.**—Photograph of an oak/hickory stand taken near Asheville, NC. Many of the large trees are chestnut oak, with the majority of the midstory made up of red maple. Tulip poplar, red maple, sassafras, and some smaller oaks are in the understory (photo courtesy of Margaret Woodbridge).

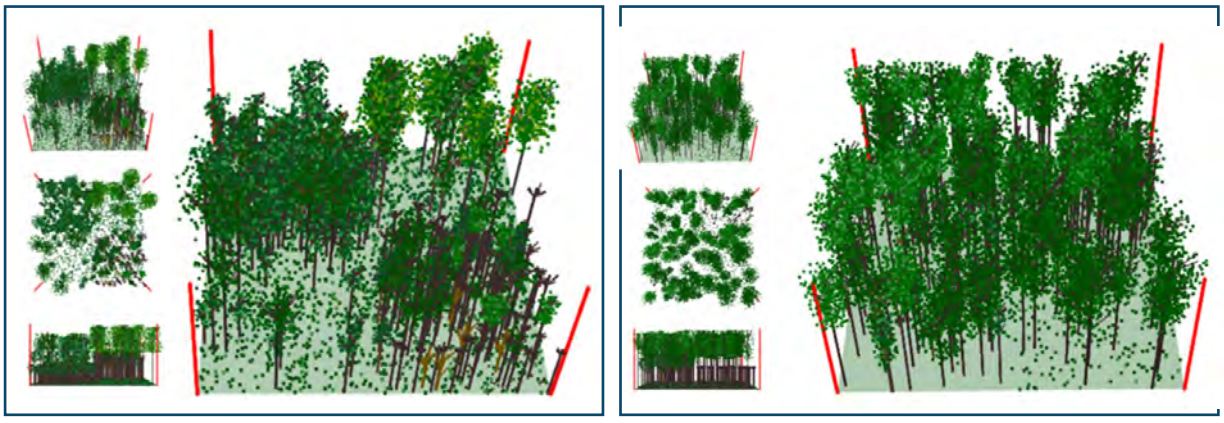


**Figure 9.**—Forest Vegetation Simulator images of FIA plots 480977014489998 (left) and 740834556290487 (right). Both plots are in the Southern Region. The mature and old-growth inventory identified some FIA plots classified as old-growth forest that show evidence of some of the threats identified in this report, especially mesophication and ingrowth of shade-tolerant species due to fire suppression.

**Table 5.**—Tree diameter distributions (inches at breast height) from FIA plot 480977014489998 located in the Southern Region.

| Common Name | 1-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-40 | 40-50 |
|---|---|---|---|---|---|---|---|---|
| Chestnut oak | 0 | 12 | 6 | 0 | 6 | 0 | 0 | 0 |
| Scarlet oak | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 0 |
| Mockernut hickory | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Black gum | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eastern white pine | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 |
| American basswood | 0 | 6 | 6 | 0 | 0 | 0 | 0 | 0 |
| Red maple | 231 | 12 | 0 | 6 | 0 | 0 | 0 | 0 |

**Table 6.**—Tree diameter distributions (inches at breast height) from FIA plot 740834556290487 located in the Southern Region.

| Common Name | 1-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-40 | 40-50 |
|---|---|---|---|---|---|---|---|---|
| Chestnut oak | | 0 | 12 | 18 | 6 | 0 | 0 | 0 |
| Black oak | 0 | 0 | 12 | 12 | 6 | 0 | 0 | 0 |
| White oak | 0 | 0 | 18 | 6 | 6 | 0 | 0 | 0 |
| Black gum | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red maple | 0 | 14 | 0 | 6 | 0 | 0 | 0 | 0 |

The following results were based on the MOGCA analysis (appendix 5). Areas where the time between recorded wildfire (going back to 1923 and including escaped prescribed burns) has exceeded historical mean fire return intervals were considered as “fire deficit” for this analysis. The spatial scale of this analysis was at the project area scale for the contiguous United States.

About 30 percent of mature forests currently have very low exposure to this threat, with smaller amounts in low exposure (16 percent), moderate exposure (18 percent), high exposure (16 percent), and very high exposure (20 percent). Mature forest types with the highest exposure were dominated by the fir/spruce/mountain hemlock, Douglas-fir, and ponderosa pine forest types. About 37 percent of old-growth forests currently have very low exposure to this threat, low exposure (18 percent), moderate exposure (20 percent), high exposure

(14 percent), and very high exposure (11 percent). The extent of Federal forest demonstrating fire deficits were highest (ranked by proportion of forest type group with high to very high deficits) in loblolly/shortleaf pine (95 percent), oak/hickory (87 percent), ponderosa pine (68 percent), Douglas-fir (37 percent), and piñon/juniper (31 percent) (figure 10).

While the degree of fire exclusion varies by forest type, certain conclusions can be drawn. Mature and old-growth forest types which historically experienced frequent fire exhibit dramatic increases in stand density, surface fuel loading, and species makeup. In fire-infrequent environments, certain fire-sensitive tree species have expanded in range and density which may increase fire risk and future fire severity. Increased vegetation density can also result in increased competition for site moisture and nutrients, resulting in stressed vegetation and the inability of the tree's natural defense to ward off insect attacks and mitigate disease infections. Forest development into uncharacteristic structure has raised the likelihood of high-severity fire in some forest systems and the incidence of insects and disease.

Historical contexts are factors in the legacy of fire exclusion and the susceptibility to adverse effects that follows. It has derived not only from direct suppression efforts but also removing Indigenous people from their

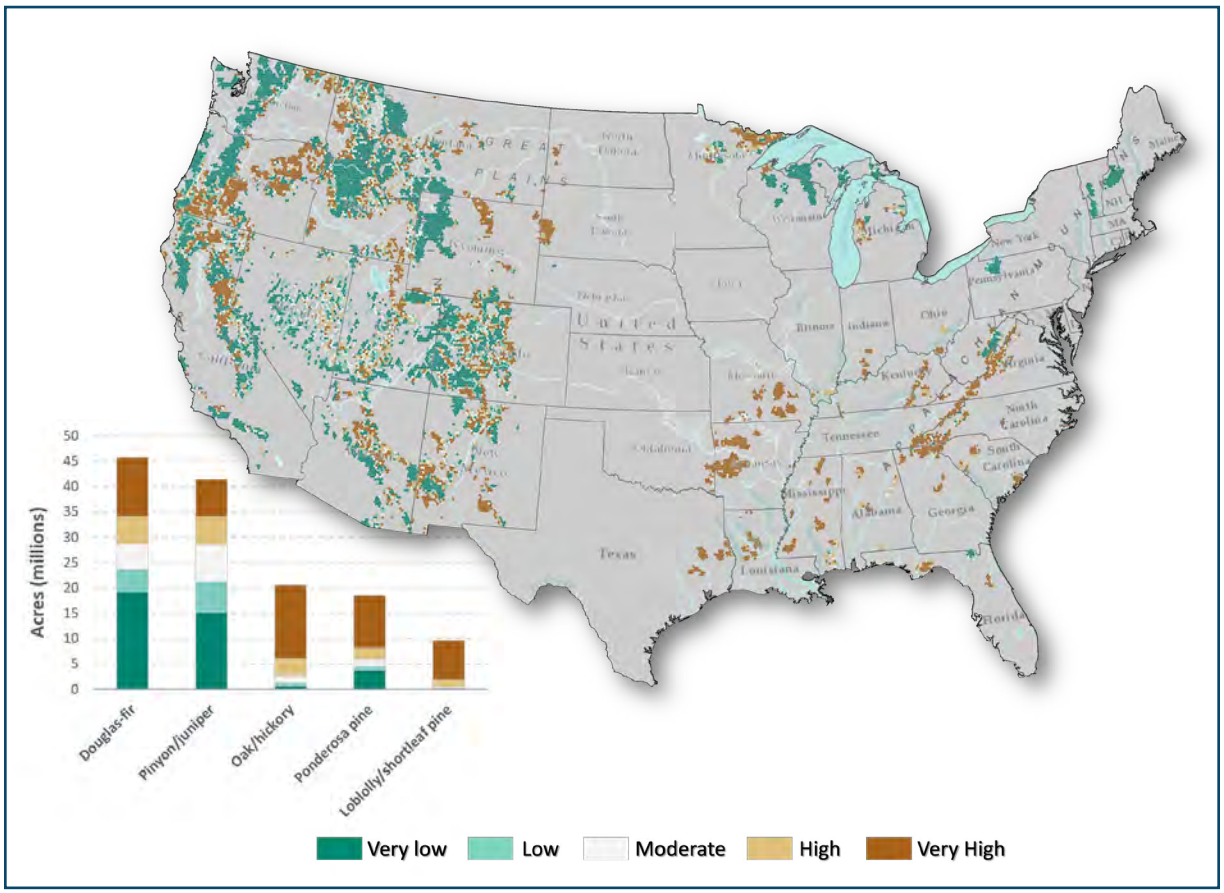



**Figure 10.**—Spatial patterns at the project area scale and area estimates (with 95-percent confidence intervals) of inventoried mature and old-growth forests exposed to wildfire threats based on fire deficit.

lands and prohibiting their cultural burning practices. Those actions resulted in negative ecological and social outcomes. Cultural burning promoted the Nation's mature and old-growth forest characteristics for centuries and is an important cultural practice (Long et al. 2021; Abrams and Nowacki 2015, 2020; Delcourt and Delcourt 1997). The frequency and extent of fires attributed to Indigenous burning practices on fire-forest processes in some regions is debated—some contest it was historically less than currently attributed (Matlack 2013, Oswald et al. 2020, Tulowiecki et al. 2023).

## Insects and Disease

Tree mortality from endemic populations of native insects and tree diseases sometimes results in substantial loss of mature and old-growth forest stands. In contrast, nonnative insects and disease have caused extensive mortality of dominant overstory trees in several areas, sometimes moving mature and old-growth forests to earlier stages of forest development. Conditions that increase the vulnerability of forests to threats from both native and nonnative forest insects and disease can include increased frequency of heat and drought owing to climate change, damaging wind or ice storms due to climate change, and unnaturally high tree densities resulting from fire exclusion in frequent-fire forest types. Even when mature and old-growth forests remain after infestations, the changes to these forests may have substantial negative social, cultural, and economic impacts.

Nationally, a total of 5,177 FIA plots on forested lands managed by the Forest Service and BLM experienced insect or disease disturbance during the remeasurement period. An estimated 15.7 million acres of mature forest (19 percent of all mature forest) and 5.7 million acres of old-growth forest (18 percent of all old-growth forest) were disturbed by insects and disease (both native and nonnative species). In forests disturbed by insects and disease, there was a 1.9 million-acre (2.3 percent) decrease of mature forest and a 182,000-acre (0.6 percent) decrease of old-growth forest. The severity of the effects was mostly low (less than 25 percent basal area loss) in 67 percent of mature and 73 percent of old-growth plots. Results suggest no significant change in mature forest area but a significant net gain in old-growth area, likely owing to increases in dead tree components that are elements of some old growth definitions. About 33 percent of mature and 27 percent of old growth plots affected by insects or disease with greater than 25 percent basal area loss had statistically significant net losses—mature and old growth representing an adverse outcome. In general, the changes associated with insects and disease varied based on a range of conditions. Depending on which region the disturbance occurred in, and whether the stand was mature or old growth, the area estimates before and after occurrence varied substantially (appendix 9). Losses of mature and old growth in forests that experienced insects and disease disturbance were greatest in lodgepole pine, fir/spruce/mountain hemlock, and other western softwoods (primarily limber and whitebark pine) forest type groups (table 7).

Current effects from insects and disease were highest (ranked by proportion of forest type group with high to very high threat) in lodgepole pine (81 percent), fir/

**Table 7.**—The six forest type groups with the most change in area of mature and old-growth forest in forests that experienced insect and disease disturbance over an average 9-year period from remeasured FIA plots. Area and 95-percent confidence intervals (CI) are in thousands of acres; percents are the proportional change of the forest type group in the mature or old growth class.

| Forest Type Group | Mature Area Estimate | Mature 95% CI | Mature Percent | Old-Growth Area Estimate | Old-Growth 95% CI | Old-Growth Percent |
|---|---|---|---|---|---|---|
| Lodgepole pine | -706 | 202 | -9 | -295 | 122 | -17.6 |
| Fir/spruce/ mountain hemlock | -812 | 218 | -5.8 | -110 | 160 | -1.5 |
| Other western softwoods | -188 | 105 | -8.4 | -78 | 63 | -11.7 |
| Aspen/birch | 69 | 121 | 2 | -59 | 88 | -4.6 |
| Piñon juniper | -144 | 93 | -1 | 87 | 69 | 1 |
| Douglas-fir | -122 | 172 | -1.3 | 123 | 94 | 3.5 |

spruce/mountain hemlock (63 percent), ponderosa pine (63 percent), Douglas-fir (61 percent), and piñon/juniper (56 percent). Tree-killing insects and disease are characteristic elements of high-integrity mature and old-growth forests and can result in positive outcomes, as indicated by a net gain of old growth in the plot data when disturbance magnitudes were low (figure 11).

Nonnative insects and disease may impact mature and old-growth forests with a variety of negative social, cultural, and economic outcomes. Even when mature and old-growth forests persist after substantial tree mortality, impacts may be substantial. For example, specialists in the Southern Region explained how hemlock woolly adelgid can cause hemlock mortality in southeast maple/beech/birch forests. The loss of hemlock creates substantial changes in the forest composition and structural conditions. In conjunction with diminished tree species diversity, mortality from the adelgid diminishes scenic quality.

In addition to aesthetics and recreation, the economic value of mature and old-growth forests also includes consumptive uses. When nonnative pathogens lead to oak loss, specialists in the Southern Region went on to say, decreases in mast availability for wildlife result in diminished deer and turkey hunting opportunities. Tree harvest also provides revenue and, when insects and disease lead to loss of the economically valuable white ash, economic revenue declines.

Cultural values can be realized through both consumptive and nonconsumptive uses. Historically, many Tribes derived large portions of their food from the flour made by milling the acorns of tanoak. Loss of tanoak from Sudden Oak Death (*Phytophthora ramorum*) impacts the

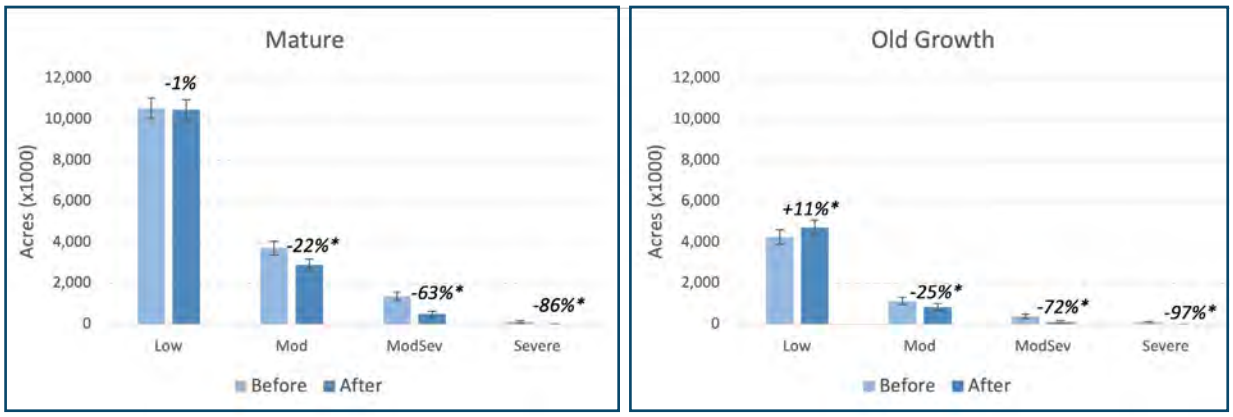



**Figure 11.**—Net changes (and 95-percent confidence intervals) in area of mature and old-growth forests from insect/disease disturbance over an average of 9 years from remeasured FIA plots (mostly 2000s to 2010s). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

ability of Tribes to sustain traditional lifeways (Ortiz 2008, Halpern et al. 2022).

Stressors can interact with each other to create or worsen threats. In the Pacific Northwest, tanoak killed by insects and disease lead to increased fire hazard—especially in the wildland-urban interface. In California's subalpine fir, many of the root diseases are exacerbated by management activities that result in wounded host trees.

Similar to other ecological disturbances, tree-killing insects and tree pathogens occur at low to modest levels in all forests increasing ecological diversity, species diversity, and structural diversity. Regional specialists identified native forest insects and disease pathogens as the primary threat to only a few forest ecosystems. Several eastern and western pine and spruce forest types experience substantial overstory tree mortality, sufficient to change from mature or old growth to an earlier stage of development when forest conditions and climate combine to form epidemic insect outbreaks.

Most western coniferous forests experience bark-beetle (for example, Douglas-fir beetle, mountain pine beetle, spruce beetle) outbreaks that threaten mature and old-growth forests. Mountain pine beetle outbreaks have affected millions of acres of forest throughout the West in Oregon, Colorado, Montana, and Wyoming over multiple decades. Uncharacteristically high tree density and homogeneity combined with drought and repeated mild winters (which are increasingly likely with climate change) represent the conditions leading bark beetles from endemic to threatening conditions.

Spatial analyses examining exposure showed that recent outbreaks (2012–2021) contributing to tree mortality events have been concentrated in the California mixed conifer, ponderosa pine, and fir/spruce/mountain hemlock forest types. In total, 392 project areas had tree mortality from insects and disease across a large enough extent to be classified as poor or very poor, representing just over 4 percent of the federally managed

forested land considered in this analysis, or about 6.7 million acres (appendix 5). More than 90 percent of project areas representing approximately 149 million acres of federally managed forested land had very small areas or no significant tree mortality observed between 2012 and 2021, which resulted in higher modelled scores representing good and very good ecological conditions. Some of these areas have had significant amounts of tree mortality in the preceding time periods (prior to 2012).

Based on the MOGCA analysis, about 83 percent of mature forests currently have very low exposure to tree mortality events caused by insects or disease, low exposure (10 percent), moderate exposure (4 percent), high exposure (2 percent), and very high exposure (1 percent) (figure 12). Mature forest types with the highest exposure were dominated by the fir/spruce/mountain hemlock, Douglas-fir, and ponderosa pine forest types. About 85 percent of old-growth forests had very low exposure to this threat, low exposure (9 percent), moderate exposure (4 percent), high exposure (1 percent), and very high exposure (1 percent) (figure 12). Old-growth forest types with the highest exposure were dominated by the fir/spruce/mountain hemlock, Douglas-fir, and ponderosa pine forest types.

Eastern oak forests represent a clear example of changes in land use history

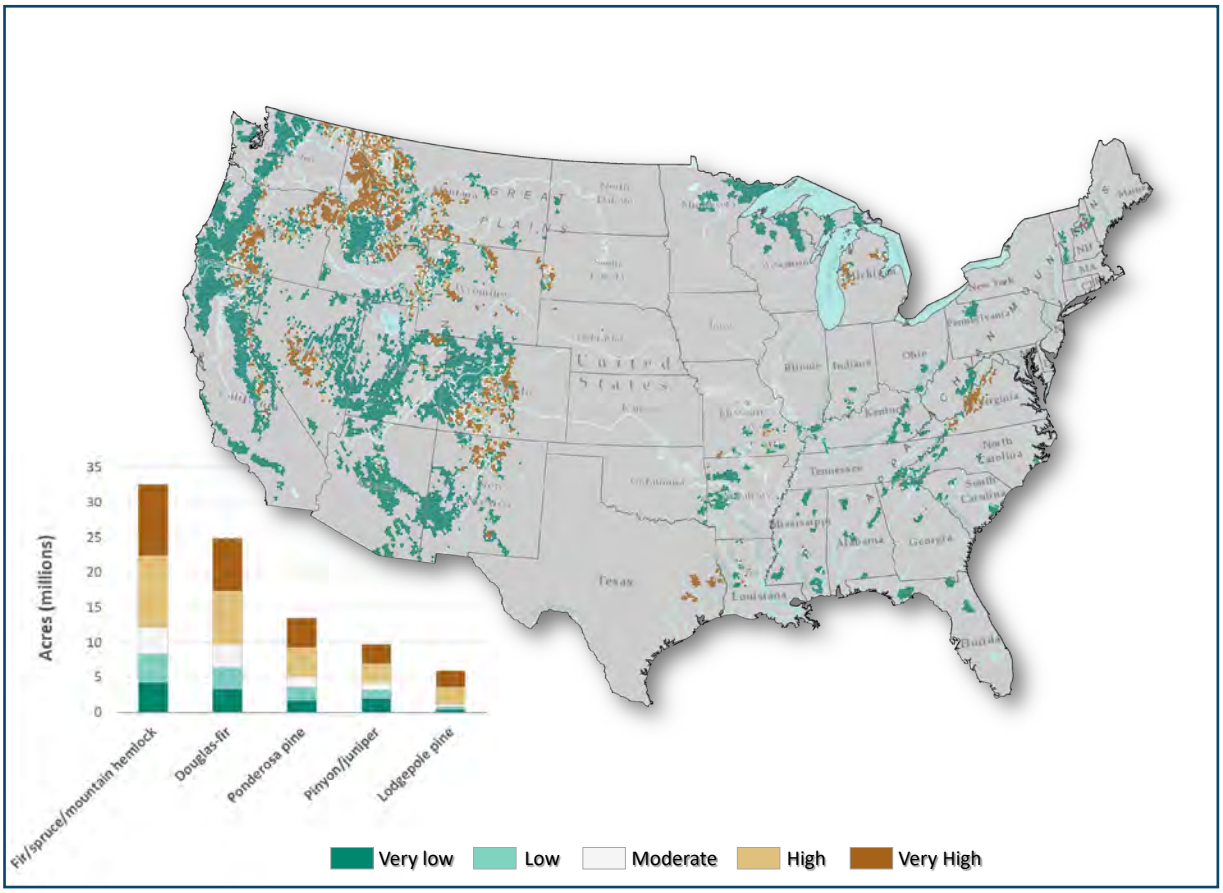



**Figure 12.**—Map depicting spatial patterns at the project area scale of inventoried mature and old-growth forests exposed to threats from insects and disease.

interacting with native and nonnative tree diseases threatening mature and old-growth forest types under particular and potentially widespread conditions. Oak forests that become uncharacteristically dense with shade-tolerant species, such as maple, in the absence of intermediate disturbance such as fire are also vulnerable to oak decline, a complex set of factors that kill large oak and therefore threaten mature and old-growth forests.

While native insects are most threatening to pine and spruce forests, and generally under uncharacteristic tree density for frequent-fire forest types, nonnative insects and pathogens threaten both deciduous and coniferous mature and old-growth forests—and the threat is rarely associated specifically with stand structure. Recent insect-caused mortality appears to be far outside what has been documented since Euro-American settlement and is likely related to climate change (Vose et al. 2018). With nonnative insects, it is more than just climate change. Increased global trade and transportation of vectors have increased the likelihood of nonnative insects finding novel suitable environments (Hulme 2009).

## Extreme Weather Events

Threats from extreme weather and abiotic events are much more isolated and their impacts are highly dependent on the ecosystem. Ice storms, windstorms (including hurricanes and tornados), flooding, and landslides are some examples. Based on FIA plot remeasurements since the start of this century, extreme weather events have not accounted for much change in the areal extent of mature and old-growth forests. Yet, the episodic nature of these events does not make them less important to consider. The occurrence of extreme weather events can have adverse effects, especially in areas where mature and old-growth forests are rare, highly fragmented, and isolated. Extreme weather events will become more frequent with climate change, driving changes in forest structure and function that can make mature and old-growth forests more susceptible to other potential threats across large landscapes (Vose et al. 2018).

Nationally, a total of 3,066 FIA plots on forested lands managed by the Forest Service and BLM experienced weather-related disturbances including weather damage, ice, flooding, wind (hurricanes and tornados), drought, or avalanches during the remeasurement period. An estimated 1.1 million acres of mature forest (1.4 percent of all mature forest) and an estimated 0.6 million acres of old-growth forest (1.8 percent of all old growth) were disturbed by weather between remeasurements. In forests disturbed by weather, there was an 83,000-acre (0.1 percent) decrease of mature forest and a 10,000-acre (0.03 percent) increase of old-growth forest; neither change was statistically significant. Eighty percent of the weather disturbance in mature forest, and 91 percent in old-growth forest, was in the low severity basal area loss category. Forests that experienced low (less than 25 percent basal area loss) weather disturbance gained mature and old-growth forest area, likely owing to creation of snags and down wood (figure 13). Forests affected by severe weather (greater than or equal to 90 percent basal area loss) experienced losses of 1.3 percent of mature and 1.5 percent of old-

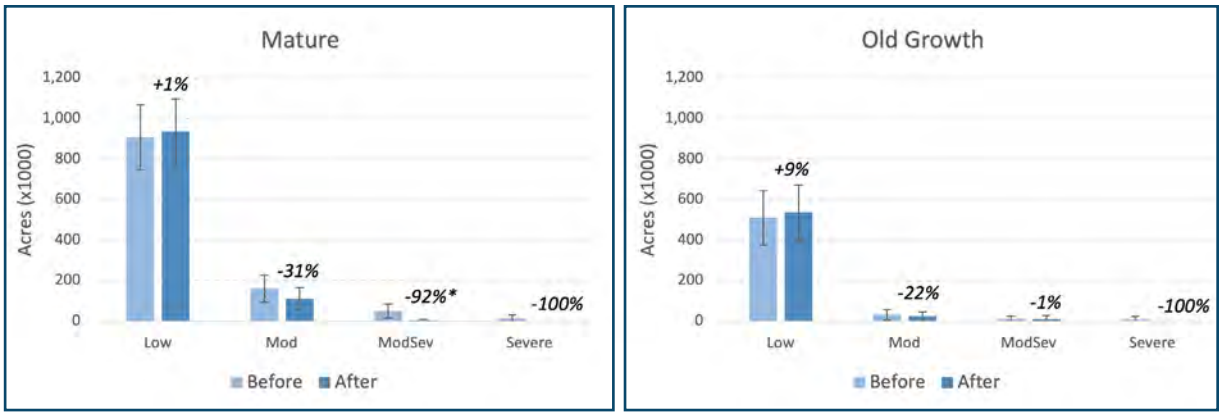



**Figure 13.**—Net changes (and 95-percent confidence intervals) in area of mature and old-growth forests that experienced weather disturbance over an average of 9 years from remeasured FIA plots (mostly 2000s to 2010s). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

growth forests. Moderate (25–60 percent basal area loss) to moderately severe weather (60–90 percent basal area loss) corresponded with intermediate levels of net declines for both mature and old-growth forests. Weather effects varied by region (see appendix 10).

The area classified as being affected by weather (meeting FIA disturbance thresholds) was sufficiently small that the analysis by forest type group suggested no significant changes at the 95-percent confidence level (table 8).

Extreme weather usually disturbs mature and old-growth forests in small patches or damages and kills limited numbers of large trees, rarely transforming it to earlier developmental stages. East coast hurricanes represent an exception; individual storms can rapidly transform

**Table 8.**—The five forest type groups with the most change in area of mature and old-growth forest due to weather over an average 9-year period. Area and 95-percent confidence intervals are in thousands of acres; percents are the proportional change of the forest type group in the mature or old growth class.

| Forest Type Group | Mature Area Estimate | Mature 95% CI | Mature Percent | Old-Growth Area Estimate | Old-Growth 95% CI | Old-Growth Percent |
|---|---|---|---|---|---|---|
| Fir/spruce/ mountain hemlock | -32.5 | 63.3 | -0.2 | -3.9 | 32.6 | -0.1 |
| California mixed conifer | -23.6 | 32.7 | -0.8 | 4.1 | 20.4 | 0.4 |
| Western oaks | -16.1 | 20.5 | -1.8 | | | |
| Oak hickory | -14.3 | 18.7 | -0.2 | | | |
| Lodgepole pine | -13.9 | 34.9 | -0.2 | -5.2 | 25.3 | -0.3 |

mature and old-growth forests over large areas. While storm events can extend over a large swath, the adverse impacts are often patchy. Similarly, long-track tornados can produce large swaths of forest loss, such as the 1974 tornado outbreak in the Ohio Valley (Corfidi et al. 2010). Since 2000, weather caused the biggest net loss (17,000 acres) of mature and old-growth forests in the Southern Region; the region where hurricanes are most common. Nationally, about 100,000 acres (0.1 percent) of mature forest and 27,000 acres (0.09 percent) of old growth were lost over the same time period. Weather impacts were of low severity (less than 25 percent basal area mortality) in 80 percent of mature and 91 percent of old-growth forests and even resulted in gains in old-growth forest. About 1.3 percent of mature and 1.5 percent of old-growth forests had net area losses. Given the small sample size, there were no significant changes at the 95-percent confidence level, but the data suggest that the largest losses due to weather were in the fir/spruce/mountain hemlock, California mixed conifer, lodgepole pine, western oak, and oak/hickory forest type groups. Despite the fine-grain spatial pattern of tree mortality and limited loss of mature and old-growth forests, extreme weather events pose real threats to many social, cultural, and economic values (figure 14).

Disturbance by extreme weather events is inextricably linked to climate change (Marvel et al. 2023). While ice storms, windstorms, flooding, and similar extreme events have always disturbed forests, climate change is known to increase both the frequency and intensity of extreme weather events. Also, these events are becoming more erratic and extreme due to climate change. In recent years, Caribbean tropical hardwood forests across Puerto Rico, for example,

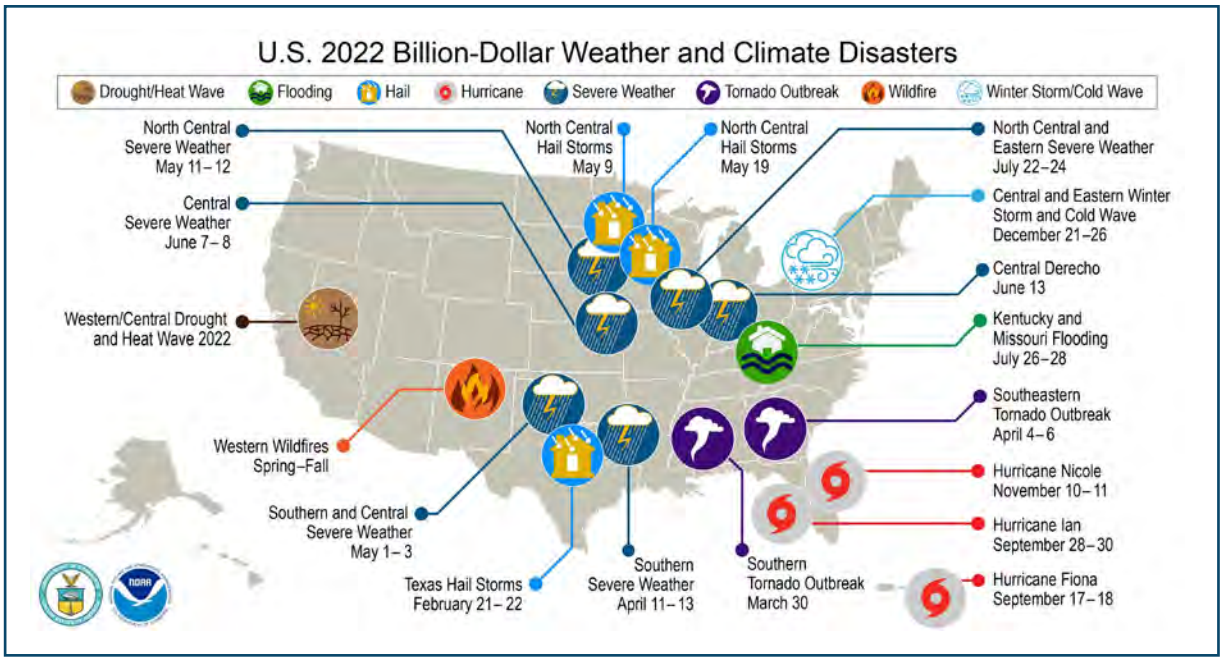



**Figure 14.**—A graphical representation of recent extreme weather events in the United States (https://www.noaa.gov/news/record-drought-gripped-much-of-us-in-2022 ).

experienced the most extreme drought, wind, and precipitation events since at least the 1950s (Herrera and Ault 2017, Keellings and Alaya 2019), which in the short term reduced forest height and cover, increased tree mortality, and increased some invasive species biomass (Helmer et al. 2023, Vargas-Gutierrez et al. 2023). Longer-term and compound effects of these and other climate stressors of tropical forests, like atmospheric water stress (Bauman et al. 2022), are not well known. Concern exists about whether cyclonic storms might allow greater establishment of nonnative or nonnative invasive species that might affect the structure and species composition of mature and old-growth forest, which in turn affect ecosystem properties and socioeconomic and cultural values (USDA Forest Service 2023).

## Climate Change

Climate change is a complex stressor, interacting with and exacerbating other stressors or threats (fires, insects, etc.)—consequences will take different forms in different regions and forest types (USDA Forest Service 2023). In virtually every climate scenario, the ecosystem services and values enjoyed by various communities are likely to change (Voggesser et al. 2013, Weiskopf et al. 2020, Domke et al. 2023, McElwee et al. 2023).

The most recent year (2023) marks the hottest year, globally, on record.[5] Historically (1970–1999), about one-third (32 percent) of the inventoried mature and old-growth forests in the contiguous United States rarely exceeded 90 °Fahrenheit in any given year (less than 1 day per year; very low exposure), about 36 percent had low exposure (1 day to 1 week per year), 21 percent had moderate exposure (1 week to 1 month per year), 8 percent had high exposure (1–2 months per year), and 3 percent were exposed to 2 or more months per year (very high exposure). Currently (2010–2039), from 82 to 84 percent of mature and old-growth forests are exposed to temperatures exceeding 90 °Fahrenheit for at least 1 day during any given year and exposure to 2 or more months has more than doubled (6.9–7.5 percent). Depending on the atmospheric warming scenario (RCP4.5 and 8.5), from 14 to 33 percent of inventoried mature and old-growth forests may experience 2 or more months of extreme heat by the end of this century (2070–2099). Under RCP8.5, less than 1 percent will *not* experience less than 1 day per year of extreme heat (figure 15).

The time series maps below illustrate predicted changes in climate exposure and were based on the spatial analysis of historical, current, and future conditions. The following figure represents the number of days in a year that exceed 90 °Fahrenheit (figure 15). Each map represents a three-decade climate normal, beginning with the last three decades of last century. This climate metric identifies exposure to high temperatures, such as heat domes, which can have direct adverse effects on mature and old-growth forests (Still et al. 2023), but can also highlight drought effects, including higher metabolic respiration and more extended periods with closed stomata and increasing stress on trees (Klein et al. 2022).

5 See https://www.noaa.gov/news/2023-was-worlds-warmest-year-on-record-by-far and https://climate.copernicus.eu/global-climate-highlights-2023

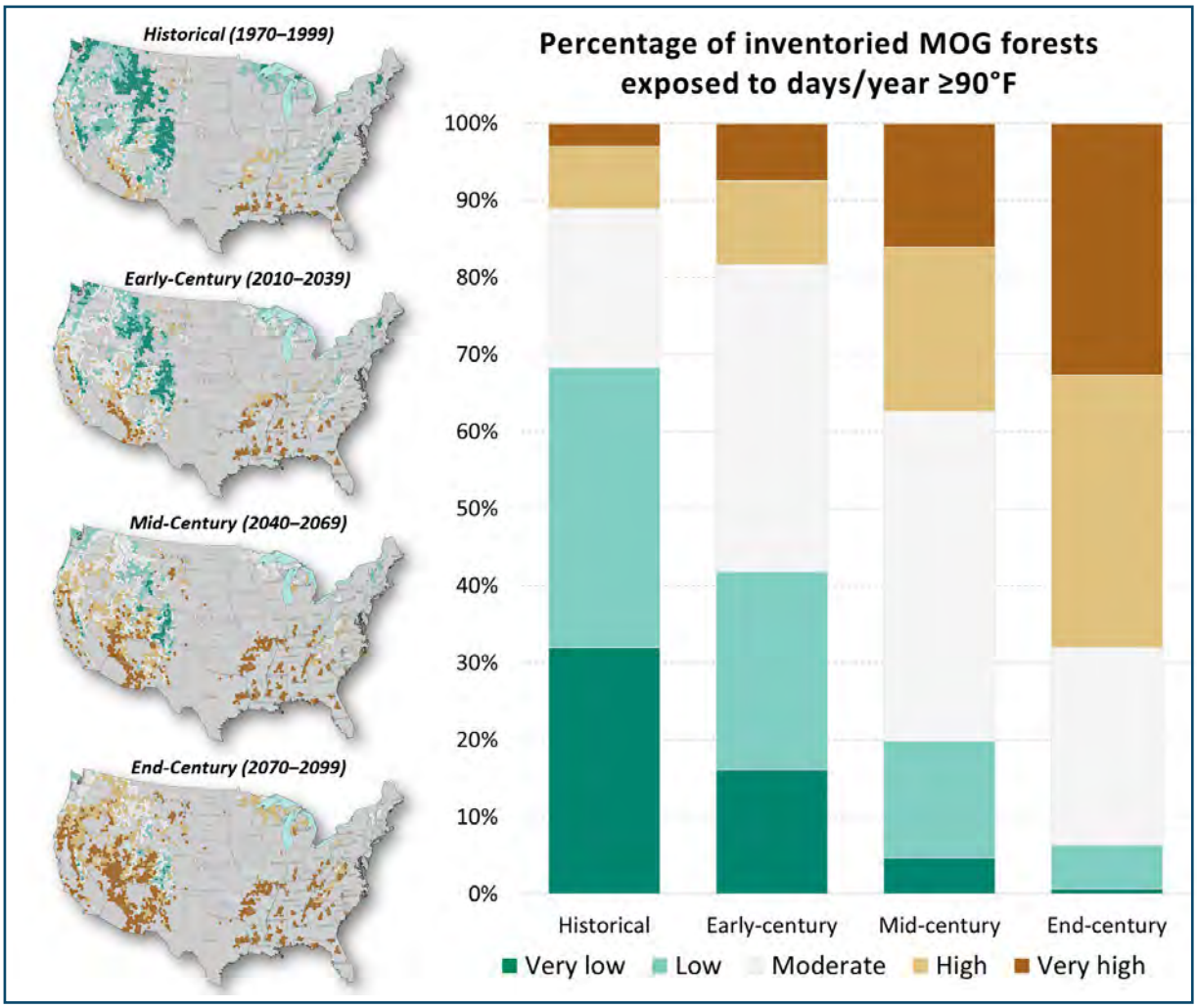



**Figure 15.**—Fireshed-scale exposure of inventoried mature and old-growth forests to extreme heat (days/year ≥90 °F (RCP8.5)).

The highest absolute changes (from historical levels) are predicted to occur (from highest to lowest) in the piñon/juniper, oak/hickory, loblolly/shortleaf pine, woodland hardwoods, and longleaf/slash pine forest types. The highest percentage change (from historical levels) is predicted to occur (from highest to lowest) in the fir/spruce/mountain hemlock, Douglas-fir, piñon/juniper, lodgepole pine, and aspen/birch types.

Higher temperatures are expected to cause changes in the distribution and abundance of dominant forest species, with heat-tolerant species becoming more competitive. In forests, hotter temperatures will accelerate evapotranspiration as soils dry faster and as vegetation takes up water earlier and faster during the growing season.

Geographically extensive and long-duration drought conditions across the United States set several records in 2022 (NOAA). Higher temperatures result in higher levels of climatic water deficit, where available soil moisture is less than required for normal growth and results in tree stress (Vose et al. 2016). Climatic water deficit was used to identify

firesheds where mature and old-growth forests might experience drought, or moisture stress, depending on the type and condition of the forest. The amount of mature forest area that historically (1970–1999) had very low exposure to drought has already decreased by about half and old-growth forest by about 43 percent (based on RCP8.5 models). By the end of the century (2070–2099) less than 1 percent of inventoried mature and old-growth forests are projected to have very low exposure. On the other end of the exposure spectrum, the amount of mature forest area that historically had very high exposure to drought has already increased by a factor of 1.9 and old growth by a factor of 2.7 (RCP8.5 models). By the end of the century, these exposures are projected to increase from historical values by factors of 18.0 and 14.1, respectively.

The time series maps illustrate how climatic water deficit has already changed and might change into the future (figure 16). This climate metric correlates well with several effects related to drought. Each map below represents a three-decade climate normal, beginning with the last three decades of last century. Drought sensitivity varies by forest type

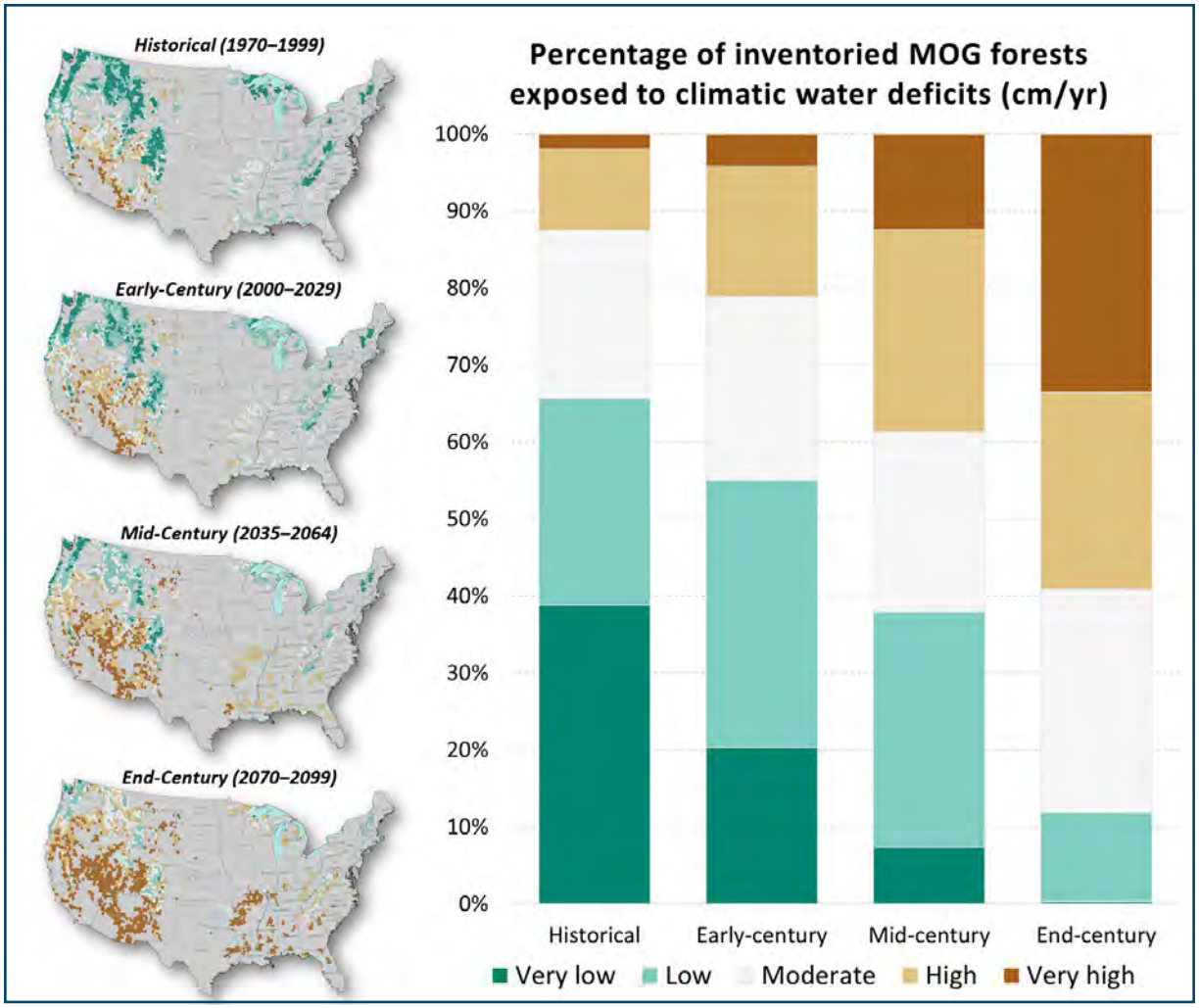



**Figure 16.**—Fireshed-scale exposure of inventoried mature and old-growth forests to climatic water deficits (RCP8.5).

and environmental factors such as, but not limited to, elevation, latitude, and topography.

The largest percent change from historical conditions is predicted to occur in the fir/spruce/mountain hemlock, Douglas-fir, and lodgepole groups in the West, and the maple/beech/birch and oak/hickory groups in the East. The largest absolute change from historical conditions is predicted to occur in the piñon/juniper group in the West and the loblolly/shortleaf pine, oak/hickory, woodland hardwoods, and longleaf/slash pine groups in the East.

According to the most recent RPA Assessment (USDA Forest Service 2023), recent exposure to drought was higher in the West than the East, and drought exposure for forests is expected to increase by 2070, with the largest increases in the Southwest. Climate change projections indicated levels of drought exposure will far exceed recent exposure for many forest type groups. By mid-century, over half of the piñon/juniper, woodland hardwoods, aspen/birch, and ponderosa pine type groups are projected to exceed the historical median exposure to severe or extreme drought.

Drought interacts with many other disturbances, both drivers and stressors, reinforcing the disturbance and most often increasing the potential threat of disturbances, such as fire, insects, and disease. Regional specialists did not identify drought as the primary stressor leading to adverse outcomes for mature and old-growth forest but instead frequently noted the interaction of a primary disturbance with climate change, particularly extended drought.

## Tree Cutting

Forest disturbance from tree cutting includes a complex range of human activities that result in the felling and often removal of standing trees. For example, tree cutting can range from firewood removal for personal use or hazard tree removal, to both precommercial and commercial thinning, to commercial timber harvest, to restoration fuel treatments. The intensity and scale of tree cutting can range from removal of an individual tree for cultural uses, tree felling for wildlife habitat, to removal of many trees for wood fiber. There are various traditional and cultural purposes for tree cutting by American Indians, Alaskan Native People, and other non-Tribal communities (Conners 2002, Dockry and Hoagland 2017). The volume of wood removed, area impacted, and resulting forest condition are directly linked to the objective and methods used to remove standing trees. In instances of forest thinning, the objectives are primarily to improve forest health, while other forest management activities include removal for forest products and serving other social or cultural goals. Tree cutting on Forest Service and BLM lands is guided by Land Management Plans (LMPs) for each plan area. LMPs outline broad desired outcomes and are written through a public involvement process that influences the outcome for mature and old-growth forests. Currently, these plans generally limit stage-changing tree cutting in old-growth forest, and therefore, as illustrated in the analysis below, tree cutting seldom results in transformation of old-growth forest to an earlier developmental stage—but sometimes it does change the status of mature forests.

Tree cutting directly alters forest structure, surface fuel loading, and tree species composition along with many other characteristics. The outcome of tree cutting depends on the initial forest condition, the specific forest treatment, forest condition after tree cutting, and the forest type. Tree cutting in old forests can produce positive, neutral, or adverse outcomes, outlined below. Furthermore, outcomes from the same tree cutting activity may result in differing social, cultural, economic, and ecological outcomes (appendix 11). As an example, consider cutting of several large birch trees for cultural wood from an old forest. Some people may perceive removal of any large tree or down log as an adverse outcome. Users of certain extraordinary forest resources, such as the large birch for cultural wood, perceive the cutting differently (Nyholm 1981, Zasada 2002). Historically, Indigenous people's use of larger older trees, for example extracting planks for housing construction, would be done by removing sections of tree trunk while maintaining structural integrity. Down logs in old forest were often used for canoes and other domestic and ceremonial products (Gidmark 1995, Stryd and Feddema 1998, Turner et al. 2011).

Before presenting results of specific analyses examining current disturbances of mature and old-growth forests by tree cutting, it is helpful to consider the current extent of timber harvest relative to the past (figure 17). As outlined by Riddle (2022), commercial tree harvest on Federal lands varied over time. As Forest Reserves (later named national forests) were being established in the late 1800s

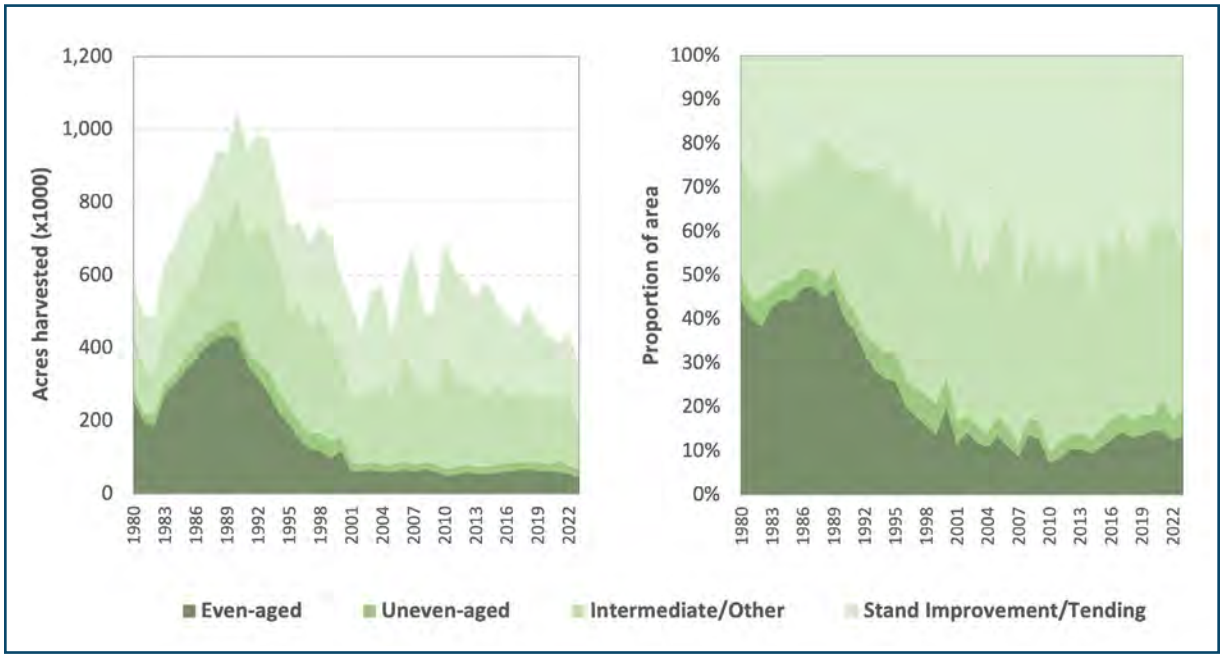



**Figure 17.**—Forest Service timber harvest rates since 1980 (management activity records from Forest Service Activity Tracking System [FACTS] database). Even-aged harvesting removes all or most of the trees, uneven-aged leaves a mix of tree sizes, intermediate and stand improvement harvesting entails thinning of some trees for various purposes.

and early 1900s, much of the commercial timber came from private land. As this source declined, harvesting of public forest lands increased through to the 1940s, providing 2 percent of national timber supply. To meet the increasing demand for timber following WWII, the Forest Service increased harvest rates and by the 1970s, provided about 16 percent of the total U.S. harvest. Economic recessions in the early 1980s lowered demand and harvest rates (Riddle 2022). After the recession, harvest rates began increasing and peaked when the northern spotted owl (*Strix caurina occidentalis*) was listed under the Endangered Species Act in 1990.

Agency policy has changed through development and revision of LMPs, and tree cutting is no longer the most extensive threat to old-growth forest in most regions. LMPs generally include components limiting the threat of tree cutting to old-growth forest. Currently, national Forest Service annual harvest rates (not evaluated by forest development class) are about at the same level as in the 1940s and prescriptions for harvest have evolved over time. The geography of timber harvest volume on lands managed by the Forest Service reflects major production regions and milling infrastructure (Riddle 2022: Fig. 3). The Pacific Northwest Region cuts the most, followed by the Southern Region and Eastern Region. Timber harvesting on lands managed by the BLM (established in 1946) followed a similar pattern. Timber harvest began increasing in the 1950s, peaked in the 1980s, and then began decreasing in the early 1990s to current levels (Riddle 2022). Oregon and California lands provide a large share of the timber harvested from BLM lands.

Time series evaluation of national Forest Service and BLM mature and old-growth forest inventory provides evidence regarding the extent to which tree cutting removed mature and old growth during the recent past (figure 18). Remeasurement of FIA plots suggest an estimated 2.1 million acres of mature forest and 400,000 acres of old growth experienced some level of tree cutting. Hence, an estimated 2.6 percent of mature forests and 1.3 percent of old-growth forests experienced some level of tree cutting during the remeasurement period.[6] In forests experiencing tree cutting, there was an estimated net decline of 200,000 acres (0.3 percent) of mature forest and 9,000 acres (0.03 percent) of old-growth forest. In forests disturbed by cutting, impacts were low severity in 50 percent of mature and 67 percent of old-growth forests and slight increases in the extent of both occurred. This increase in extent indicates that, in many areas, tree cutting was not associated with a transition of forests to an earlier developmental stage. Impacts were severe in an estimated 6 percent of mature and 11 percent of old-growth forests where cutting occurred and were associated with net losses for both. Moderate to moderately severe cutting disturbance occurred in an estimated 44 percent of mature forests and 22 percent of old-growth forest with cutting but were associated with lower levels of net losses for both than found in severely impacted forests (figure 18). These results

6 Severity classes: low live tree loss, less than 25 percent basal area loss (including basal area gain); moderate live tree loss, 25–60 percent basal area loss; moderately severe live tree loss, 60–90 percent basal area loss; severe live tree loss greater than 90 percent basal area loss.

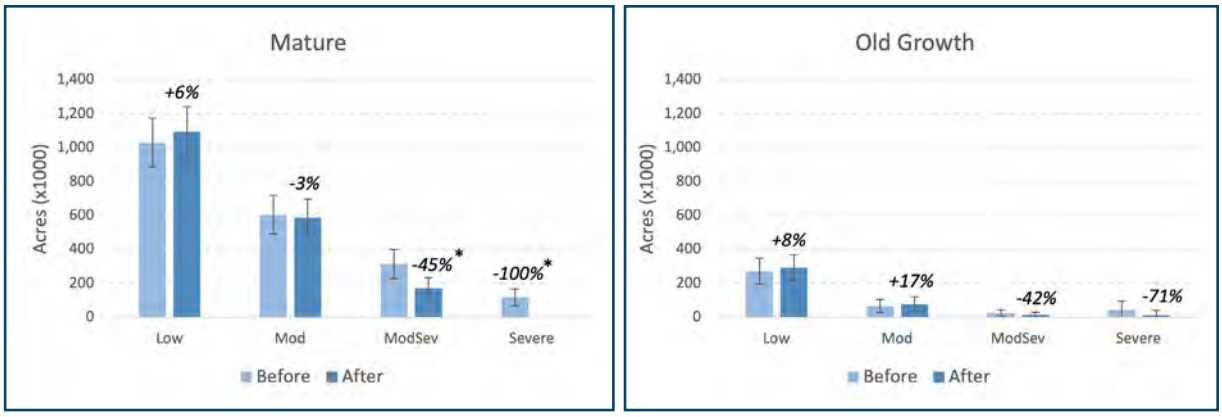



**Figure 18.**—Net changes (and 95-percent confidence intervals) in area of mature and old-growth forests that experienced tree cutting disturbance over an average of 9 years based on remeasured FIA plots (mostly 2000's and 2010's). Percentages represent net change by severity class and asterisks (*) indicate statistically significant net changes.

demonstrate the relationship between disturbance severity, forest condition before the disturbance, and condition following the disturbance. Threats from tree cutting occur in a subset of forest experiencing this disturbance.

The area classified as affected by cutting was sufficiently small that analysis by forest type group suggested few significant changes during the remeasurement period (at 95 percent confidence level). Nevertheless, evidence indicates the largest losses in mature forest where cutting occurred were in the Douglas-fir, lodgepole pine, fir/spruce/mountain hemlock, and ponderosa pine forest type groups (table 9). The only estimated reduction in old-growth that

**Table 9**.—The five forest type groups with the most change in area of mature and old-growth forest due to cutting over an average 9-year period from FIA remeasurement. Area and 95-percent confidence intervals are in thousands of acres; percents are the proportional change of the forest type.

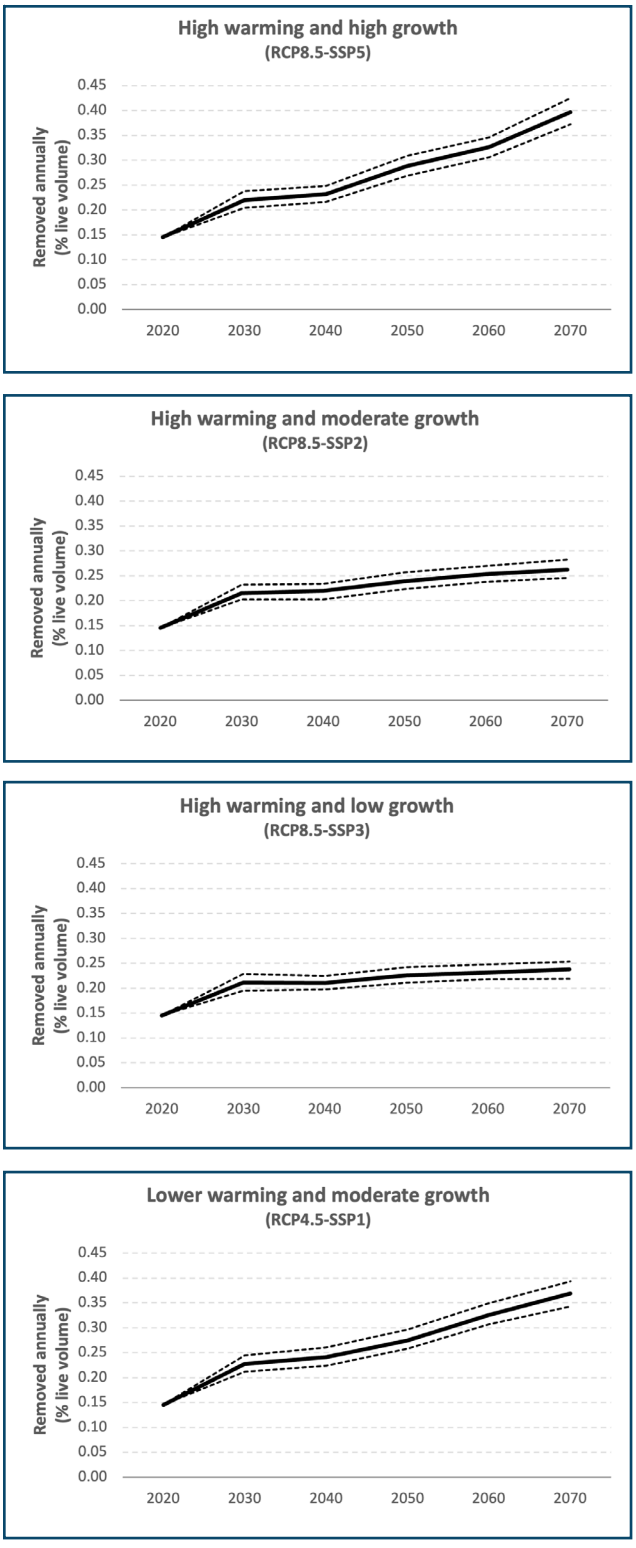
| Forest Type Group | Mature Area Estimate | Mature 95% CI | Mature Percent | Old-Growth Area Estimate | Old-Growth 95% CI | Old-Growth Percent |
|---|---|---|---|---|---|---|
| Douglas-fir | -63.1 | 70.7 | -0.7 | 23.7 | 38.6 | 0.7 |
| Lodgepole pine | -60.7 | 61.6 | -0.8 | 0.5 | 0.9 | 0 |
| Fir/spruce/mountain hemlock | -49.7 | 44.6 | -0.4 | -2.1 | 10.3 | 0 |
| Ponderosa pine | -45.2 | 73.3 | -0.7 | 20.7 | 35.3 | 1.5 |
| Hemlock/Sitka spruce | -4.6 | 11.3 | -0.8 | -44.3 | 48.7 | -1.1 |

experienced cutting, of more than 3,000 acres during the remeasurement period was a nonsignificant loss in the hemlock/Sitka spruce group, with increases of old growth suggested for cutting that occurred in Douglas-fir and ponderosa pine forest types.

Closer examination of retrospective FIA plot data by region illustrates the substantial difference in outcomes for mature and old-growth forests (appendix 12). No region demonstrated a significant (at 95 percent confidence level) reduction in the extent of old-growth forest in forests that experienced tree cutting during the remeasurement period. This likely reflects the influence of LMP components on old-growth forest management and the significant reduction in old-growth forest harvest in Alaska over the recent decade (and to a greater extent, since the 1990s). In contrast, every Forest Service region except the Intermountain, Pacific Southwest, and Alaska Regions registered a significant decline (at 95-percent confidence level) in mature forest extent during the remeasurement period in forests experiencing at least one level of tree cutting intensity. This pattern reflects the influence of forest development (forests grew and aged during the remeasurement period), and, in some cases, stewardship approaches using tree cutting intensities that fail to change forest status to a younger development stage.

As outlined above, retrospective analysis of FIA plot data provided insights on recent influence of tree cutting on mature and old-growth forests. Our analysis also examined potential future trends. The national mature and old-growth inventory (USDA and USDI 2023) combined with 2020 RPA Assessment methods for projecting future conditions, provides insight into potential changes in the extent of mature and old-growth forest resulting from tree cutting during the next 50 years (appendix 8). Projections for tree harvest reflect relationships between forest conditions, prices, and national/global demand for wood (figure 19). Relationships are modeled separately by RPA region and ownership to incorporate regional patterns (appendix 8). Regional projections demonstrate substantial variation in projected tree cutting of mature forest but very low or no old-growth forest harvest across all regions (appendix 8). Tree cutting of mature forest increases most substantially in the Pacific Coast and South RPA regions.

National projections suggest the proportion of mature and old-growth forest removed annually by tree cutting will increase steadily for all scenarios, but at a substantially lower rate than removal by wildfires (figure 19, figure 4). Removal by tree cutting is projected to increase by less than 0.5 percent annually with virtually all of that coming from mature forest (figure 19; see appendix 8). The future projections of harvest in mature and old-growth forests are consistent with the 2020 RPA Assessment projections for all forest land. The RPA Assessment attributes greater removal rates under the HH and LM scenarios to higher population growth and the greater use of bioenergy in these scenarios (Coulston et al. 2023). Over all forests in the contiguous United States, harvest levels decreased substantially following the Great Recession (2007–2009) but are projected to recover to prerecession levels in the HH and LM growth scenarios. These projections of harvest in mature and old-growth forests are




consistent with those overall trends. The 2020 RPA Assessment also projects forests to age on average across RPA scenarios. Between 2020 and 2070, the average age of all forests is expected to increase by 14 years in the East and 10 years in the West during the projection period. In the East, all projections suggest an increase in proportion of forest 80 years and older and a decrease in the proportion of forest less than 80 years old by 2070. However, forest management driven by timber prices associated with the LM and HH scenarios leads to less 80-year-old forest by 2070 than the other scenarios, while very young forests (0 to 9 years old) occupy similar area to 2020. In the West, the proportion of forest 100 years and older is projected to increase, with relatively large increases in the 150-plus year age class. The projections also suggest an increase in 30- to 40-year-old forest as a result of forest management and other disturbance. Like the East, projections for the 0- to 9-year age class are slightly higher under the LM and HH scenarios.

The quantitative analysis of tree cutting using FIA plot data, both retrospective and future projections (RPA), suggest tree cutting does not necessarily result in adverse outcomes—or threat—to mature and old-growth forest. Published literature and expert synthesis provide further understanding of the interaction of tree cutting with forest conditions determining whether tree cutting leads to positive, neutral, or adverse social, cultural, economic, or ecological outcomes.

**Figure 19.**—Observed (2020) and projected (2030–2070) future trends in annual removal rates of live tree volume in older forests (mature and old growth combined) (CONUS) based on analysis for this report. Solid lines reflect the median trend line of the median GCM (out of the five GCMs). The dashed lines represent the minimum and maximum values for the interquartile ranges (the middle 50 percent of the 100 replications) of projections across the five GCMs.

Tree cutting and associated active forest stewardship, including cultural and prescribed burning, represent well-recognized approaches to reduce the vulnerability of some mature and old-growth forest to disturbances that would otherwise remove mature and old-growth forest, transitioning them to early development stages (see citations below). Literature review and expert elicitation identified forest conditions that motivate tree cutting and associated cultural burning or prescribed fire to reduce vulnerability of both eastern and western mature and old-growth forests in frequent-fire forest ecosystems. Specialists and literature indicated that wildfire in mature and old-growth forest with uncharacteristically high tree density, low horizontal diversity, and ladder fuels are vulnerable to stand-replacement fire and therefore benefit from tree cutting to reduce lower canopy and other fuels. These are generally referred to as frequent-fire ecosystems (for example, Schmidt and McDonald 1995, Noel et al. 1998, Jain et al. 2004, Fiedler and Arno 2015, Smith and Arno 1999, Abella et al. 2007, Johnston et al. 2021, Fei and Steiner 2009, Roche et al. 2012, Beckmann et al. 2021, Devine and Harrington 2013, Reynolds et al. 2013, Hanberry et al. 2018, Kush et al. 2004, Rother et al. 2020, Palik et al. 2021). Tree cutting in frequent fire mature and old-growth forests produces a wide range of positive outcomes in addition to reducing fire severity and therefore increasing durability (see glossary). For example, stewardship that addresses uncharacteristic tree density and homogeneity can stabilize carbon in large trees and reduce mortality from endemic insects (for example, Martinson et al. 2013, Reinhardt et al. 2008).

One regionwide example stems from active forest restoration, including tree cutting, focused on longleaf pine forest ecosystems (Brockway et al. 2005). The Southern Region adopted a regionwide goal to increase representation of longleaf mature and old-growth forests while reducing vulnerability to fire and insects. Regional specialists indicate mature forests with potential to develop into old-growth longleaf pine can benefit from appropriate tree cutting and burning (Kush et al. 2004, Noel et al. 1998, Hanberry et al. 2018, Brockway et al. 2005). Effective stewardship of mature and old-growth longleaf pine provides a broad array of social, cultural, and economic benefits in addition to retaining old-growth conditions (Brockway et al. 2005).

The forest development dynamics of oak-pine, oak-hickory, and other mast producing, frequent-fire forests represent a rich example of positive social, cultural, economic, and ecological outcomes that can occur through careful tree cutting in these diverse forests that have been used by humans for millennia (for example, Nowacki and Abrams 2008, Swanston et al. 2018, Abrams 2005, Abrams et al. 2021, Fei and Steiner 2009, Hanberry and Abrams 2018, Roche et al. 2012). In the absence of disturbance, the dominant mast producing species (oak, hickory, walnut, and formerly chestnut) decline in abundance and productivity while more shade-tolerant species (for example, maple) increase in abundance, ultimately transitioning the forest from its fire-maintained hardwood dominated old-growth condition to one vulnerable to severe fire or uncharacteristic insects. In the absence of disturbance, key characteristics of the mature and old-growth mast-producing forests are lost

resulting in an adverse outcome. The adverse outcome is apparent through a cultural lens as culturally important mast foods decline, and as important wildlife decline; through a social lens as a prized open-forest structure changes; through an economic lens as recreational or subsistence hunting (mast and meat) declines, along with associated community revenue; and through an ecological lens with the loss of biodiversity as the old-growth condition fades. Regional experts and literature outline the forest characteristics before and after stewardship that together result in a positive outcome (for example, Arthur et al. 2012, Dey 2014, Oak et al. 2016, Goebel and Hix 1996, Duan et al. 2023, Hanberry et al 2018, Clark and Schweitzer 2016).

Tree cutting has been identified as a positive stewardship tool in some mature and old-growth forests that do not experience frequent, low-intensity disturbances (previous examples were all frequent-disturbance forests). Regional specialists in eastern, western, and Alaska regions indicated young, infrequent-disturbance forests with high tree density or with low horizontal heterogeneity may benefit from tree harvest to develop durable old-growth forest characteristics more rapidly (for example, Bauhus et al. 2009, for different perspective see Vizcarra et al. 2022). Similarly, southeastern specialists noted that, following heavy Fraser fir mortality from the non-native balsam woolly adelgid, limited tree cutting in mature forest may stimulate areas of spruce/fir forest to develop more complexity and more characteristic species composition and therefore old-growth characteristics more rapidly (Fassnacht et al. 2015, Busing and Garman 2002). Forests experiencing non-native insects and disease represent additional cases where infrequent-disturbance forest types may benefit from careful stewardship focused on long-term tree diversity and heterogeneity. In each of these cases, limited tree cutting would leave a mature forest condition with higher horizontal diversity and more rapid tree growth as the stand develops toward old-growth forest.

While tree cutting is identified as an effective tool to reduce vulnerability of certain forest types under specific forest conditions, tree cutting is a threat to some mature and a very limited extent of old-growth forests (see FIA retrospective analysis, figure 18). Based on current LMPs, tree cutting is more likely to occur in mature forest to a much greater extent than old-growth forest; LMP multiple use objectives and criteria identify forest conditions for commercial harvest, some of which is regeneration harvest. As described earlier, LMPs across most of the Nation restrict tree cutting in old-growth forest to conditions where tree cutting benefits the durability of the old-growth through stewardship that maintains old-growth characteristics (figure 18).

Tree harvest represents a potential threat for mature forest ecosystems most frequently in forest types that are most appropriately harvested using even-aged silviculture systems (for example, aspen, lodgepole pine, birch/poplar, Jack pine). Mature forest types typically regenerated with stand removal occur in both the eastern and western United States. When tree cutting of mature, infrequent-disturbance forests occurs, it is generally compatible with current LMPs and prescribed to meet plan desired conditions or objectives.

Tree cutting (harvest, thinning, or otherwise), is rarely recognized as a restoration prescription to reduce vulnerability for infrequent-disturbance old-growth forest ecosystems. Infrequent disturbance ecosystems in the Forest Service Southern and Eastern Regions generally face few threats that operate at sufficient spatial scale and severity to reduce large areas of mature and old-growth forest to nonmature or old-growth forest. However, as noted above, nonnative insects and diseases represent a substantial long-term threat to a range of mature and old-growth forest types. Careful stewardship specifically focused toward retaining diversity and heterogeneity may increase long-term durability in certain infrequent-disturbance forests. Tree cutting of mature infrequent-disturbance forest in the East therefore represents a potential threat, though it is compatible with current LMPs to meet multiple goals in mature forest. LMPs generally include components limiting the threat of tree cutting in old-growth forest while often allowing actions to reduce vulnerability.

Birch, aspen, and Jack pine forests in the upper Midwest and Northeast provide a useful example of the complex interaction of tree cutting and the array of associated social, cultural, economic, and ecological values. Many Indigenous people use aspen and birch for a wide range of cultural and social objects. Some of these cultural uses require exceptional trees. Local economies in some areas depend on harvest and manufacture of commercial wood products from mature aspen and birch forests. Recreation and Tribal food procurement practices (Emery et al. 2014) including fishing, hunting, hiking, and boating thrive on the character of birch and aspen stands. Tree cutting interacts with each of these uses differently. For instance, tree cutting is necessary to achieve many of the cultural benefits; often, the character of the forest is not changed by tree cutting that takes individual trees for specific cultural wood. In contrast, tree cutting for commercial products generally uses regeneration harvest in these forest types. Very different outcomes in the same forest types occurred because of different human values. Finally, the disturbance dynamics of these forests suggest that the older forest character of many Midwest and Northeastern Jack pine, birch, or aspen types will also decline in the absence of disturbance, and old-growth characteristics are unlikely to develop (Moser et al. 2015, Krasnow and Stephens 2015, Frelich and Reich 1995, Frelich 2002).

## Roads

Roads can fragment and disrupt the continuity of ecosystems with numerous impacts to wildlife and ecosystem processes, most of which are adverse (Forman and Alexander 1998). They can provide conduits that increase the risk of fire starts (Miller et al. 1996, Forman et al. 2003) and the introduction and spread of invasive species (Clifford 1959, Gelbard and Belnap 2003, Watkins et al. 2003). They also can detract from characteristics perceived as important to mature and old-growth conditions, such as solitude. Conversely, roads can be viewed positively from social and economic perspectives as they provide access for recreation, fire suppression activities, and restoration work.

The following results are based on the remeasured FIA plot analysis, where changes in mature and old-growth

forest area were analyzed based on the distance from the plot to the nearest improved road maintained for travel by normal passenger vehicles. The area of mature and old-growth forest was not significantly different and did not decrease between plot measurement within a half-mile of an improved road (figure 20). Net losses were observed at distances greater than this, for mature forests, but not for old-growth forests, which showed net gains (figure 20). Gains in old growth can occur when mature forests transition into old-growth forests.

Currently, about 55 percent of mature and 67 percent of old-growth forests are greater than 0.5 mile from a maintained road. Regardless of distance, there was no record of forest disturbance in about 70 percent of mature and old-growth forests during the average 9-year remeasurement period between 2000 and 2020. The percentage of forest that was disturbed over this period varied little with distance from road, ranging between 31 to 37 percent for mature and 24 to 34 percent for old growth (figure 21). Disturbance type did tend to change with distance from road, with cutting and cutting/fire declining with increasing distance from road for both mature and old growth, and fire and insect/disease increasing with increasing distance from road for mature but not old-growth forest (figure 21).

Based on the MOGCA analysis, greater road density (assessed as miles of road per square mile in project areas containing federally owned forested land) equated to poorer ecological condition (appendix 5). Roads are an indicator in MOGCA that has impacts dispersed around the country, indicated

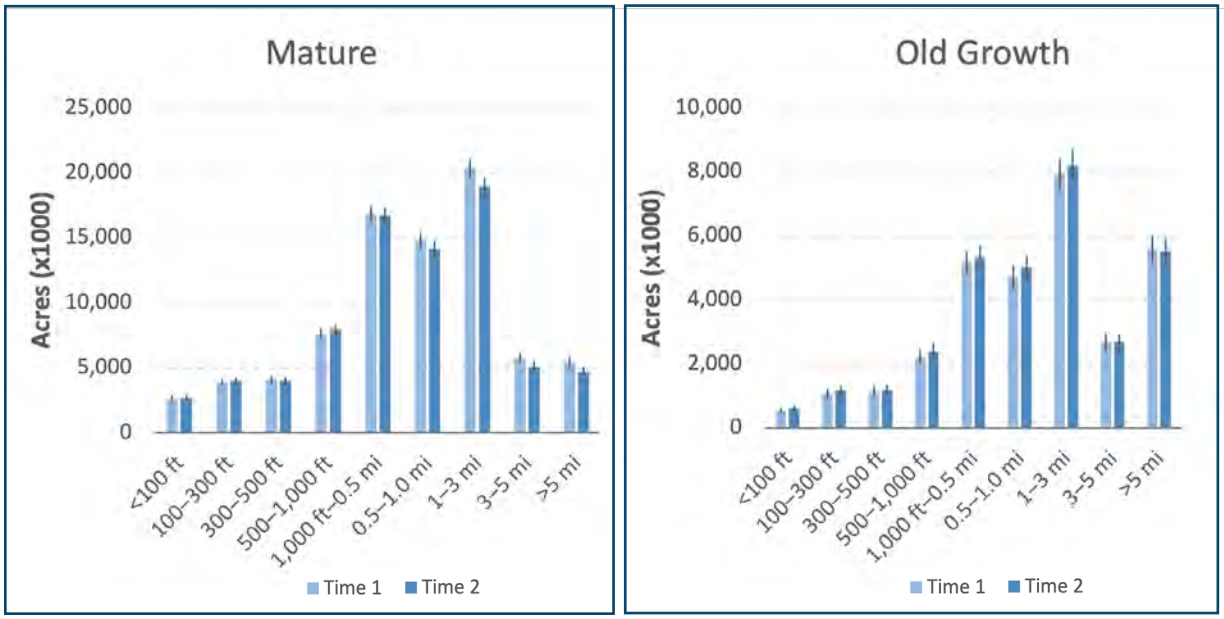



**Figure 20.**—Net area changes in (acres) of mature and old-growth forest by distance classes from roads. Time 1 represents first plot measurement and time 2 the second measurement. See appendix 4 for information on FIA plot measurement periods. Error bars are 95-percent confidence limits.

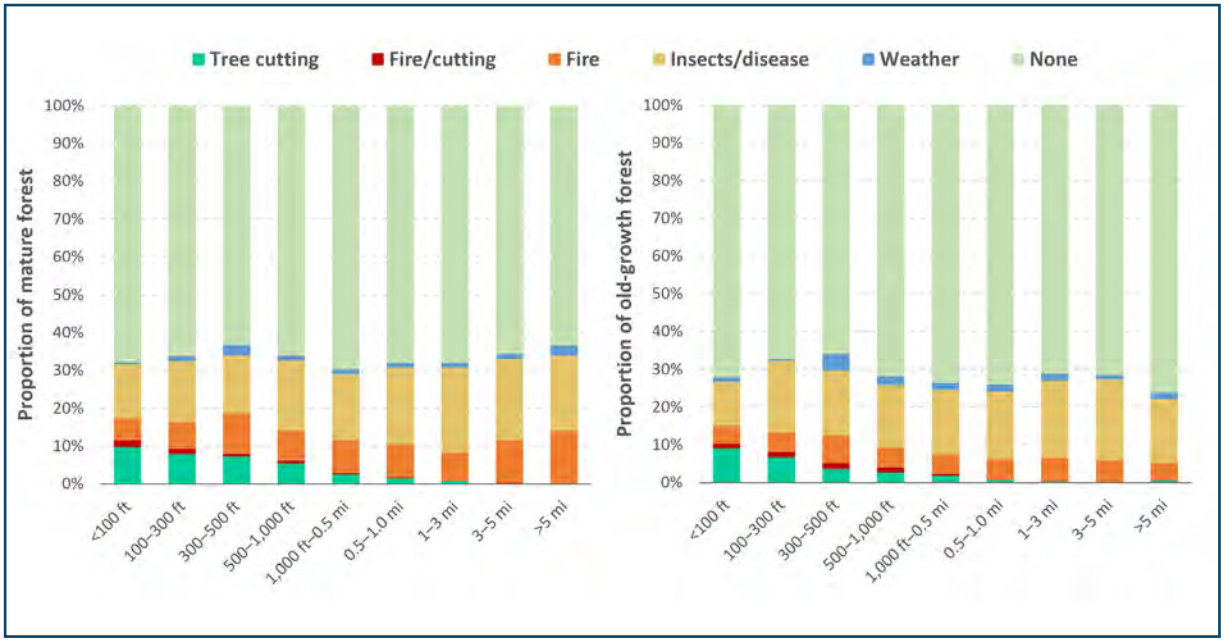



**Figure 21.**—Forest disturbances in mature (left) and old-growth forests (right) varied by distance to maintained roads.

by very poor ecological conditions occurring across most forest types. Different thresholds were used across road types to recognize the greater size, traffic, and ecological impacts caused by larger, paved compared to narrower, unimproved roads. Forest types with particularly high road densities include the loblolly-shortleaf pine, longleaf-slash pine, and oak-hickory forest types which are common across the eastern United States (appendix 5). Across the country, approximately 26 percent of areas with mature forest have road densities high enough to be classed as poor or very poor ecological conditions, with only 15 percent of areas with old growth meeting the same thresholds (figure 22).

Challenges associated with assessing the influence of roads on forests take multiple forms. On one hand, there is the sense that general development and human encroachment leads to direct damage and negative outcomes for mature and old-growth forests. Roads facilitate access for activities that are perceived as threats. On the other hand, roads provide positive outcomes when viewed from the angle of other conditions and through other lenses. Public access provides recreational opportunities in mature and old-growth forests which are both associated with a range of social values and can contribute to local economies. Finally, while many wildfires occur near roads, they usually account for smaller areas burned compared to areas burned by lightning-ignited wildfires in roadless areas (Narayanaraj and Wimberly 2012).

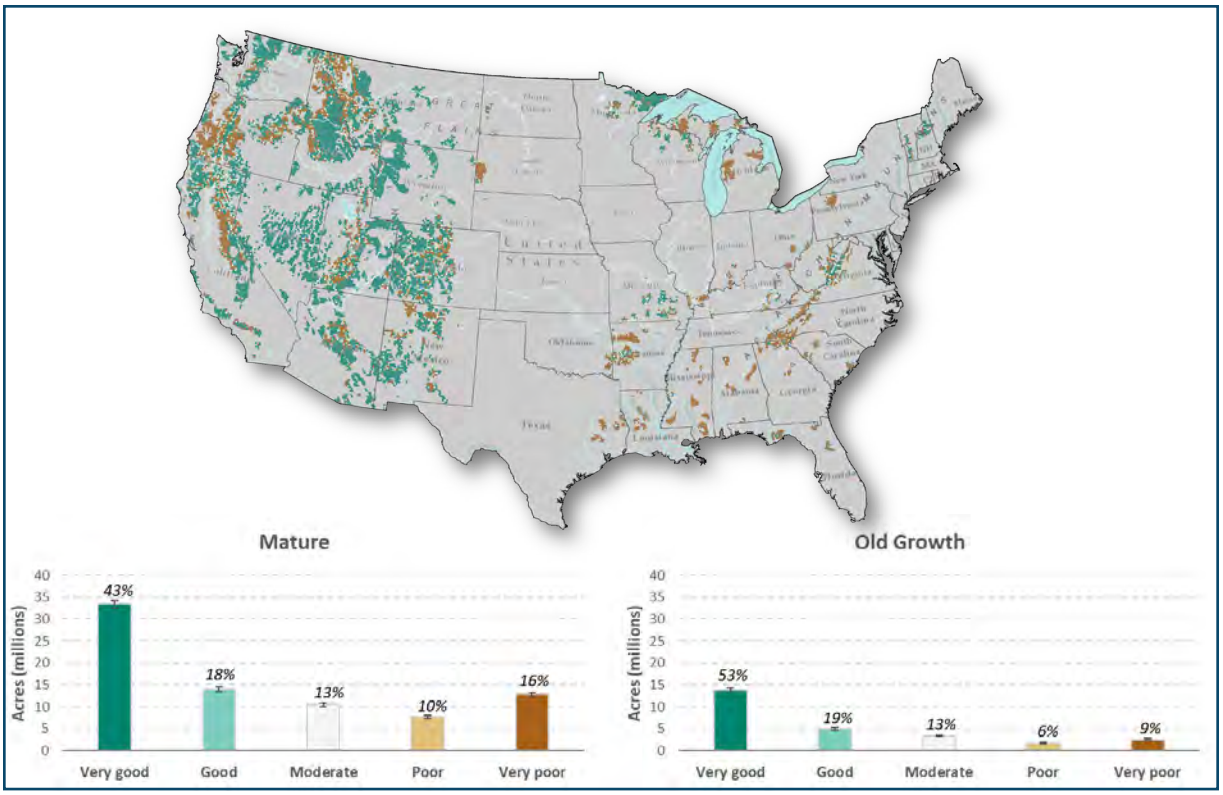



**Figure 22.**—Spatial patterns at the project area scale and area estimates (with 95-percent confidence intervals) of inventoried mature and old-growth forest current condition related to road density.

# Mature and Old Growth Condition Assessment

A total of 22 metrics representing six condition indicators and three metrics for threat indicators were used in the Mature and Old Growth Condition Assessment (MOGCA) (appendix 5). The mature and old-growth forest condition modified by threat indicators determines the current ecological integrity (figure 23). Nearly 80 percent of all project areas (from the Fireshed Registry) were in very good or good condition. Recent tree mortality from insects and disease outbreaks and the area burned by uncharacteristically severe wildfires coincides with the areas with poorer current conditions.

More project areas (representing over 28 million acres of federally forested lands) experienced uncharacteristically severe wildfires than significant tree mortality from insects and disease. Over 60 percent of the project areas with the largest proportion of uncharacteristically severe burned areas were dominated by the California mixed conifer, Douglas-fir, ponderosa pine, and western oak forest type groups.

For current climatic conditions, MOGCA examined seasonal temperature, seasonal precipitation, and drought. Poor conditions for drought and temperature (meaning the last 5 years were significantly departed from the historical record) are concentrated in the southwestern United States in analysis units dominated by California mixed

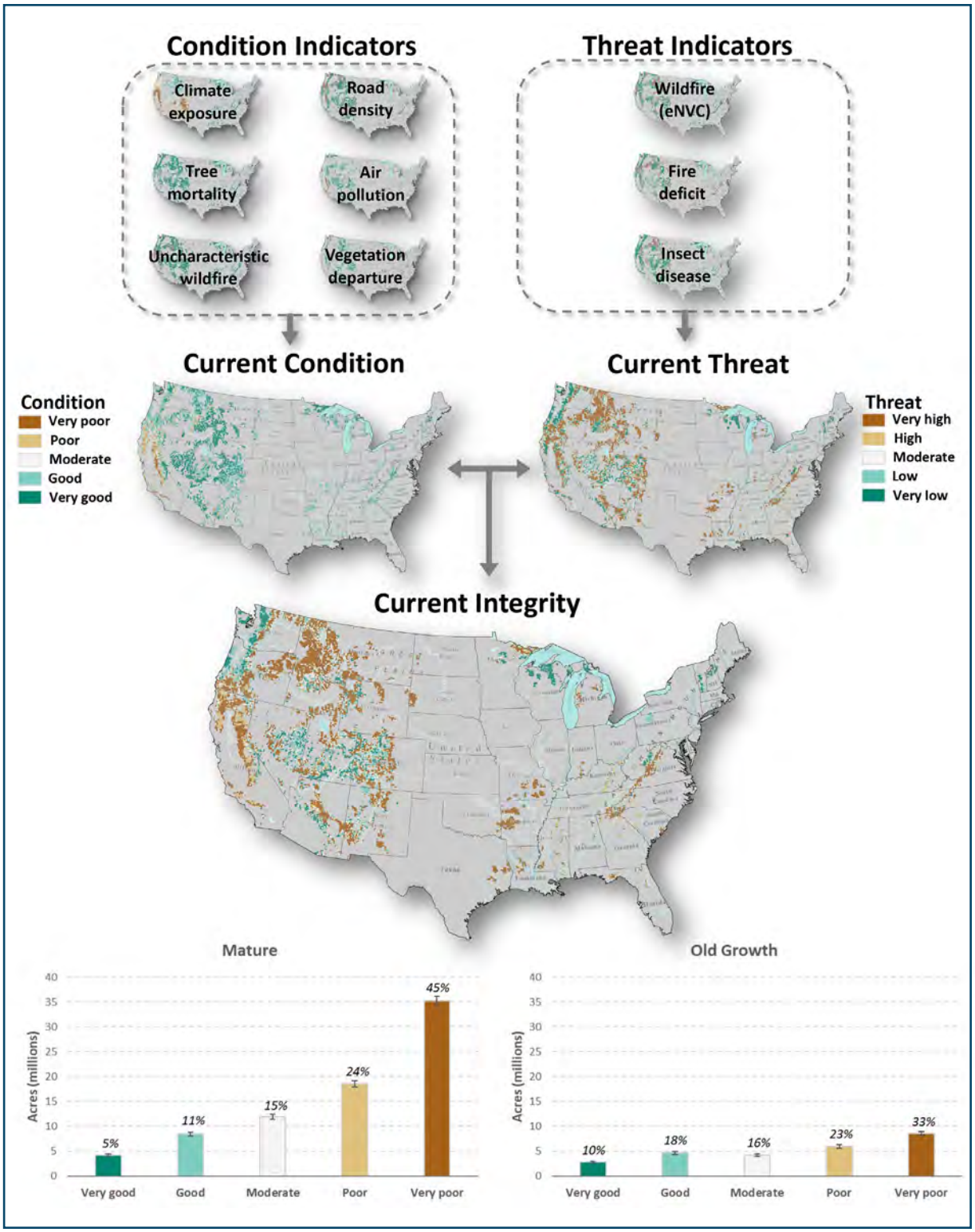



**Figure 23.**—Flow diagram (using project area maps) of the mature and old growth condition assessment (MOGCA). The bottom graph shows area (acres) of inventoried mature forest (left) and old-growth forest (right) in each ecological integrity class (from very good to very poor integrity). The percentages above the bars indicate the percentage of each forest type in the integrity class. This figure does not contain all of the individual metrics used (see appendix 5 for the full list).

conifer, piñon/juniper, tanoak-laurel, and western oak forest type groups. Summer temperature and precipitation have much more area in very poor conditions than the other seasons and are predominantly in the western United States. Overall, seasonal precipitation measures that indicate poorer conditions are more prevalent in the West compared to the East.

Vegetation departure was determined by relating to the deviation of the distribution of successional classes from expected distributions (LANDFIRE, Blankenship et al. 2021), and higher levels of deviation indicated poor to very poor conditions. However, with this approach, it is not discernable if that condition is due to over-representation of early, mid, or late seral stages.

Most areas of the country have air pollution conditions that are less than very good, indicating some level of nitrogen deposition above historical background rates to the point of having a likely impact on the ecosystem.

An estimated 66 percent of mature forest and 51 percent of old-growth forest are currently at high to very high exposure to the potential threats examined in MOGCA. Over half of all project areas dominated by fir/spruce/mountain hemlock, ponderosa pine, oak/hickory, loblolly/shortleaf, lodgepole, and oak/gum/cypress forest type groups are rated as having very high threats. Nearly 2,500 project areas (44 million acres) have a very high wildfire threat to late seral forests as represented by the expected net value change (eNVC), which used areas determined to be late-seral as a proxy for mature and old-growth conditions because of the need for finer spatial resolution to conduct the analysis. The eNVC indicates the overall predicted change to mature and old-growth forest if a wildfire were to occur, weighted by a burn probability (adapted from Thompson et al. 2013). The highest threats from wildfire were in western oak, fir/spruce/mountain hemlock, Douglas-fir, piñon/juniper, lodgepole pine, and California mixed conifer. High and very high insect and disease hazard conditions were found in 2,712 project areas representing nearly 24.5 million acres or 25.3 percent of federally forested lands in the contiguous United States. This is mostly in the Douglas-fir, fir/spruce/mountain hemlock, piñon/juniper, and ponderosa pine forest type groups.

The MOGCA model found the overall mature and old-growth forest integrity (as determined by the combination of current conditions and potential threats) was driven more by potential threats than by current condition (see appendix 5). Assessing both current conditions and current potential threats to mature and old-growth forests reveal that threats place more areas in poor and very poor conditions which correspond to high and very high threat. Based on this integration, the majority of mature forests (69 percent) and old growth (56 percent) have poor to very poor integrity based on high exposure to a current potential threat and/or conditions that could degrade ecosystems containing mature and old-growth forests (figure 23). But the outcome from that exposure to threats, in some cases, depends largely on the current characteristics of the forest which can be changed before a threat comes to pass.

# Discussion

Mature and old-growth forests have high exposure to a variety of threats. Projects of future climate and disturbance projections show this exposure will likely increase. Currently, wildfire, exacerbated by climate change and fire exclusion, is the leading threat to mature and old-growth forests followed by insects and disease. Tree cutting (any removal of trees) is currently a relatively minor threat, despite having been a major disturbance historically. The MOGCA analysis also found that two thirds of mature forests and just over half of old-growth forests are vulnerable to current threats. Climate change has increased the level of these threats and is likely altering where, and what types of mature and old-growth forests can persist. Over the next five decades, the growth of younger and mature forests is projected to result in an increase of mature and old-growth forests despite increasing disturbance—however, at a decreasing rate over time.

Since 2000, forests affected by wildfire experienced a decrease of an estimated 2.57 million acres of mature and 712,000 acres of old-growth forests on land managed by the Forest Service and BLM (figure 24). Forests affected by insects and disease experienced a decrease of 1.86 million acres of mature forest and 182,000 acres of old-growth forest. Forests affected by tree cutting by the Forest Service and BLM experienced a decrease of 214,000 acres of mature forests and 9,000 acres of old-growth forests. Forests affected by weather and cutting/fire disturbances experienced both net loss and gains, but those losses and gains were not statistically significant. Where no forest disturbances were recorded, mature forests increased by 2.21 million acres and old-growth forests by 1.20 million acres. Combined, there has been a 2.51-million-acre net decline of mature forests, with about a tenth of this becoming old growth (a 0.28-million-acre net increase in old growth). These patterns of change vary by region and forest type (appendix 13).

Historically, tree cutting associated with timber harvesting was focused on mature and old-growth forest with merchantable sawlogs. This accounted for significant losses of mature and old-growth forests,

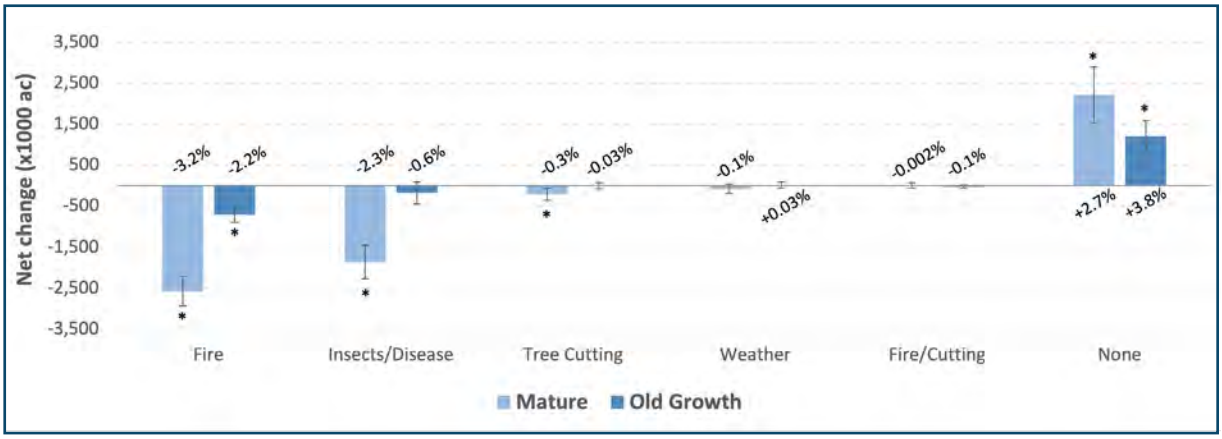



**Figure 24.**—National-scale results of net changes (with 95% confidence intervals) from disturbances to mature and old-growth forests recorded in remeasured FIA plots, ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.

setting the stage for current old growth conditions across the contiguous United States, especially in eastern forests. Beginning in the 1990s, the Forest Service and BLM started adapting to this condition (and social pressures) with decreased rates of harvesting on Federal forestlands. The type of harvesting method also changed—from one of even-aged regeneration to uneven-aged timber stand improvement and tending (figure 17). The latter methods are less adverse to the mature and old-growth condition, as reflected in the remeasured FIA analysis results (figure 25).

The FIA remeasurement analysis of forest disturbances suggests that disturbances may not always result in adverse outcomes (threats) to mature and old-growth forest. Disturbances of lower severities did not result in net area losses, in many cases. Of all disturbances, fire proportionally had higher severities, followed by fire/cutting, tree cutting, insects and disease, and weather. Insects and disease, while mostly of lower severities, ranked as the second leading disturbance experiencing loss of mature and old-growth forests. This is likely owing to the slow accumulation of annual loss over the remeasurement period (figure 25).

Spatial analyses of historical, current, and future climatic conditions and exposure showed noticeable changes between historical and current conditions consistent with the findings in regional climate change vulnerability assessments, national reports, and syntheses (USDA Forest Service 2023, USGCRP 2023, appendix 14). The story varies across the country but has

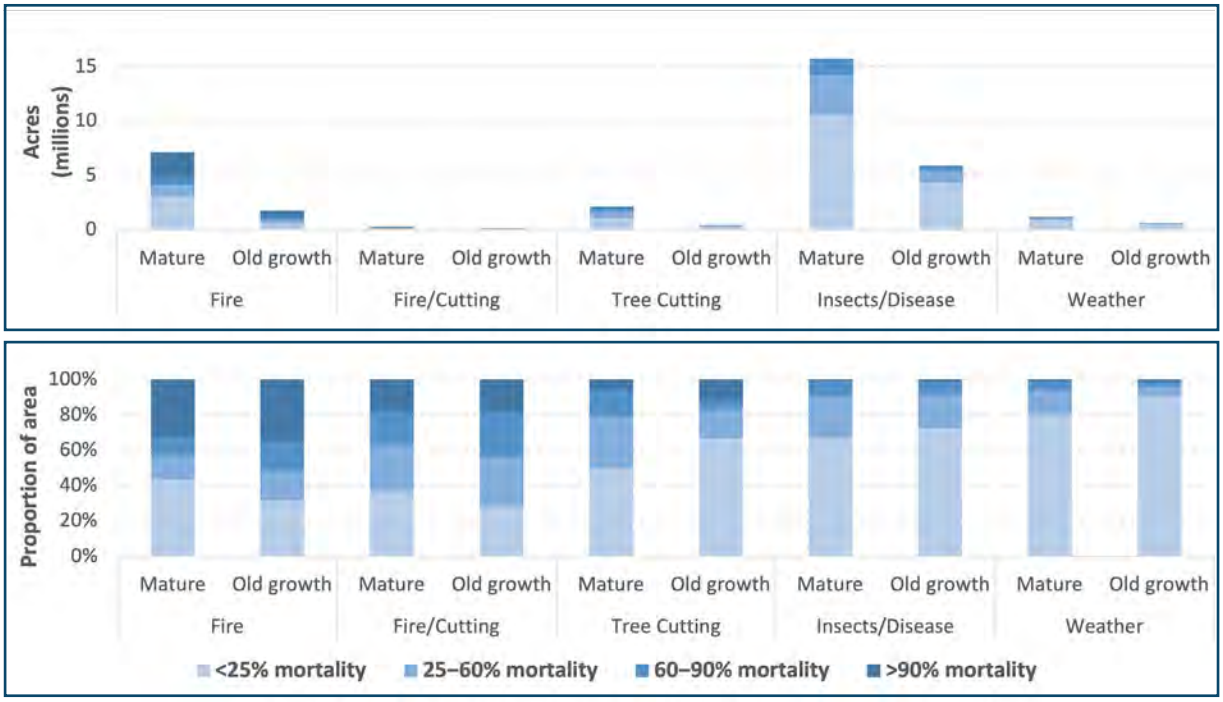



**Figure 25.**—Forest disturbances from remeasured FIA plots at the national scale. Disturbances are ordered (from left to right) by proportion of total area disturbed by moderately severe (ModSev) to severe disturbances (>60 percent live tree basal area mortality).

consistent threads. In the northeastern portion of the Eastern Region, mean annual temperature has increased by 2.4 °Fahrenheit, a slight increase in precipitation, but a substantial increase in extreme precipitation events over the historical record from 1901 through 2011. Global circulation model data projected an increased temperature of 3 to 8 °Fahrenheit and fall and winter precipitation by the end of this century. Effects of projected climatic condition changes on future tree distributions is expected to range from adverse to beneficial. Montane spruce/fir, low-elevation spruce/fir, and lowland mixed conifer forests were determined to be the most vulnerable and hardwoods and pitch pine/scrub oak forests were less vulnerable (Janowiak et al. 2018).

In the Pacific Northwest Region, southwestern Washington State GCMs project warming will continue throughout the 21st century (Hudec et al. 2019). Compared to observed historical temperature (1950–1979), average warming is projected to increase by 7.7 to 11.5 °Fahrenheit (RCP8.5). Seasonally, the largest increase is projected for the summer (10.3 to 12.2 °Fahrenheit). Mean summer precipitation is projected to decrease from 162 mm historically to 87 to 21 mm by the end of the century, while extreme precipitation events are likely to increase. Higher air temperature, through its influence on soil moisture, is expected to cause gradual changes in the abundance and distribution of vegetation species, with drought-tolerant species being more competitive. Increased occurrence of wildfire, insect outbreaks, and disease will drive forest landscape change. More frequent fires would favor fire-adapted tree species, such as lodgepole pine, but adversely affect fire-sensitive species, such as western hemlock (Hudec et al. 2019). In southwestern Oregon, average warming is projected to increase 4.3 to 10.1 °Fahrenheit by the end of the 21st century (RCP8.5). Climatic water deficit will double, suggesting substantial increases in drought stress for plants. Climate and fire refugia will facilitate tree species persistence with climate change (Hoyer 2022). In the North Cascades, the current warming trend is expected to continue, with average warming increasing by 3.8 °Fahrenheit by the 2040s and 6.8 °Fahrenheit by the 2080s; precipitation may vary. Higher temperatures will increase stress and lower the growth and productivity of lower elevation forests but increase it for high-elevation forests. Forest distributions are expected to change over the long term, and increased disturbance (wildfire, insects, and invasive species) will cause rapid changes in ecosystem structure and function across broad landscapes (Raymond et al. 2014). In the Blue Mountains of Oregon, GCMs project that the current warming trend will continue throughout the 21st century, with average warming increasing by 5.8 to 11.3 °Fahrenheit by 2100, depending on greenhouse gas emissions. Frequency of extreme climate events (drought, low snowpack) and associated effects on ecological disturbance (streamflow, wildfire, insect outbreaks) is expected to increase (Halofsky and Peterson 2017).

In the northern Rocky Mountain Region, average warming is projected to be about 4 to 5 °Fahrenheit higher than historical temperatures by 2050, and climatic extremes will probably be more common (Halofsky et al. 2018a). And in the Intermountain Region, higher temperatures and drought are expected to increase the frequency and magnitude of wildfires, insect outbreaks (both native

and nonnative), and reduce the area of mature forest (Halofsky et al. 2018b). Increased temperatures are expected to cause a gradual change in the geography of forest types with extreme heat events likely to become more common and exposure projected to be more pronounced at lower elevations (Rice et al. 2018).

Alaska has warmed twice as rapidly as the global average during the first decade of this century with statewide average temperatures for 2014–2016 notably warmer as compared to the last few decades (Markon et al. 2018). The State is expected to become even warmer by the middle of this century, with earlier springs, later falls, longer growing seasons, and shorter/less-severe winters (Hayward et al. 2017). Most climate models predict that high latitudes will experience a much larger rise in temperature than the rest of the globe through the remainder of the 21st century. Reduced snowpack is contributing to rangewide mortality increases for yellow-cedar (Hennon et al. 2012).

In the Southern Region, sea level rise, hurricanes, extreme heat, and decreased water availability are the major stressors. The number of days with temperatures above 95 °Fahrenheit is expected to increase by as much as 50 days per year. Summer precipitation is expected to fluctuate, with both increases and decreases in precipitation varying across the region. Extreme weather events increased by 22 percent during the 20th century and hurricane-related damage has increased markedly this century (McNulty et al. 2015).

Forests in the contiguous United States are experiencing increasing annual amounts of forest disturbance, in particular slow/chronic disturbances associated with climate-related stress as well as secondary stressors such as insect and disease that occur over a prolonged period of time (years) (Cohen et al. 2016). Landscape Change Monitoring System (LCMS) data[7] of slow disturbances illustrate this phenomenon when summarized by regional cumulative firesheds (figure 26). As noted by Cohen et al. (2016), this forest decline appears to be associated with diminishing forest health (or increasing stress) leading to tree canopy cover loss and increases in tree mortality above historical background levels.

Temporal and spatial patterns in slow/chronic forest disturbance coincide with recent insect and disease maps and are consistent with findings in several climate change vulnerability assessments (appendix 14). Chronic disturbance began increasing above background levels earliest (early- to mid-1990s) in the Rocky Mountain, Southwest, and Intermountain Regions which occur in the dry ecosystem domain.[8] This coincided with a mountain pine beetle outbreak on three national forests in the Rocky Mountain Region that began in 1996, and by 2010 it had spread to about 4 million acres (USDA Forest Service 2011) and continues to increase. Surrounding this area are the Northern, Pacific Southwest, and Pacific Northwest Regions, where chronic disturbance began increasing above background levels this century, beginning in the dry domain (Northern Region) and later in the humid ecosystem domain (Pacific

7 https://data.fs.usda.gov/geodata/rastergateway/LCMS/

8 https://www.fs.usda.gov/land/ecosysmgmt/colorimagemap/ecoreg1_domains.html

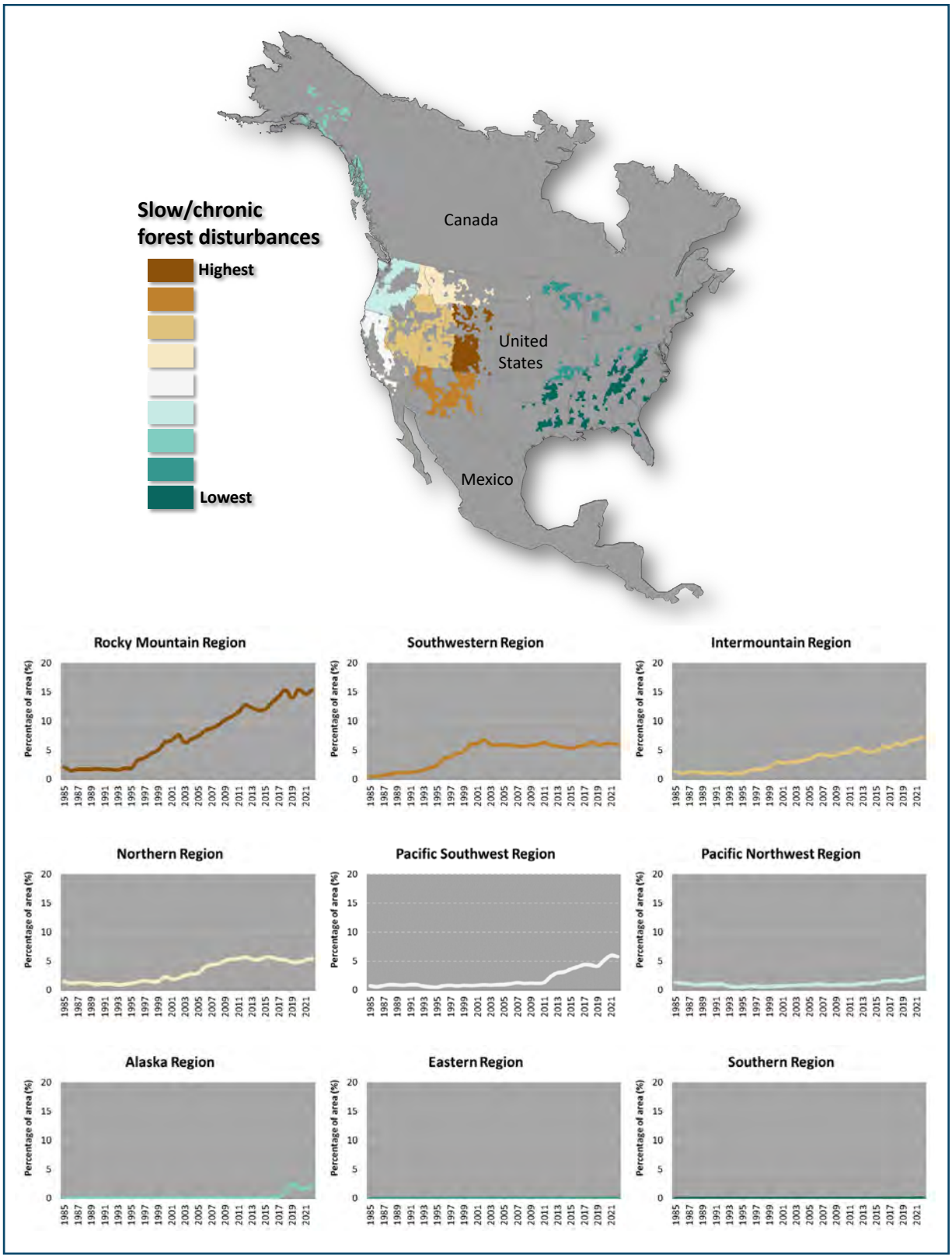



**Figure 26.**—Long-term trends in slow/chronic forest disturbance as loss of live tree canopy cover and tree mortality above historical background levels. Data from the Landscape Change Monitoring System Program Data Explorer (https://apps.fs.usda.gov/lcms-viewer/).

Southwest and Northwest Regions). Western pine beetle outbreaks contributed to mortality of 129 million trees in California from 2010 to 2017 (Vose et al. 2018). Departure from background levels only recently began around 2015 in Alaska and have not, as of yet, increased in the humid Eastern Region, which is largely expected to undergo gradual change, punctuated by rapid changes (Vose et al. 2018). The humid Southern Region experienced no detectable slow/chronic changes (lowest of all regions) but has a high amount of annual prescribed fire that may, in some part, account for this.

Despite the changes that have already occurred, current mature and old-growth forest conditions are mostly good. However, the integrity of mature and old-growth forests is mostly low because of the potential threats, which are high to very high for over half of the inventoried mature and old-growth forests. Although drivers of slow/chronic and fast (such as tree cutting and wildfires) forest loss are expected to increase, projections on Forest Service and BLM forestlands over the next 50 years show increases in mature and old-growth forests areas, based on modelling conducted under the RPA Assessment scenarios (figure 27). However, the estimated annual rate of change decreases at every time step (decade) for all scenarios and becomes negative for two scenarios (HH and LM) by 2070. The projected increase in mature and old-growth forest area is mostly attributable to projected increases in old-growth forest over time (appendix 8). Younger forest decreases for all scenarios. Younger, mature, and old-growth trends from these projections were consistent with the overall forest succession and aging trends projected for all forests in the contiguous United States in the 2020 RPA Assessment (Coulston et al. 2023). Regional differences are shown in appendix 8.

Climate change is already underway, resulting in higher temperatures, more frequent drought, and increased forest disturbances. It is expected that it will decrease the ability of many forest ecosystems to provide important ecosystem services to society (Vose et al. 2021).

The results of this analysis and the input received from public and other interested parties corroborate the potential threats to mature and old-growth forests identified in E.O. 14072 (with some nuances) and are consistent with existing science and climate change vulnerability assessments (appendix 14). As described in this analysis, outcomes of exposure to threats will depend on forest conditions that mitigate some threats, reducing vulnerability. The results also reflect values placed on mature and old-growth forests that are complex, reflect the interests of diverse cultures, economic constituencies, geographic context, and oftentimes represent contested terrain. Conflict is exacerbated by significant stressors in the form of climate change and the political environment, each of which carries instability, uncertainty, and extremes. For example, the political controversy over climate change causality plays strongly in the discourse regarding threats to mature and old-growth forests. Such factors are important considerations for evaluating this analysis.

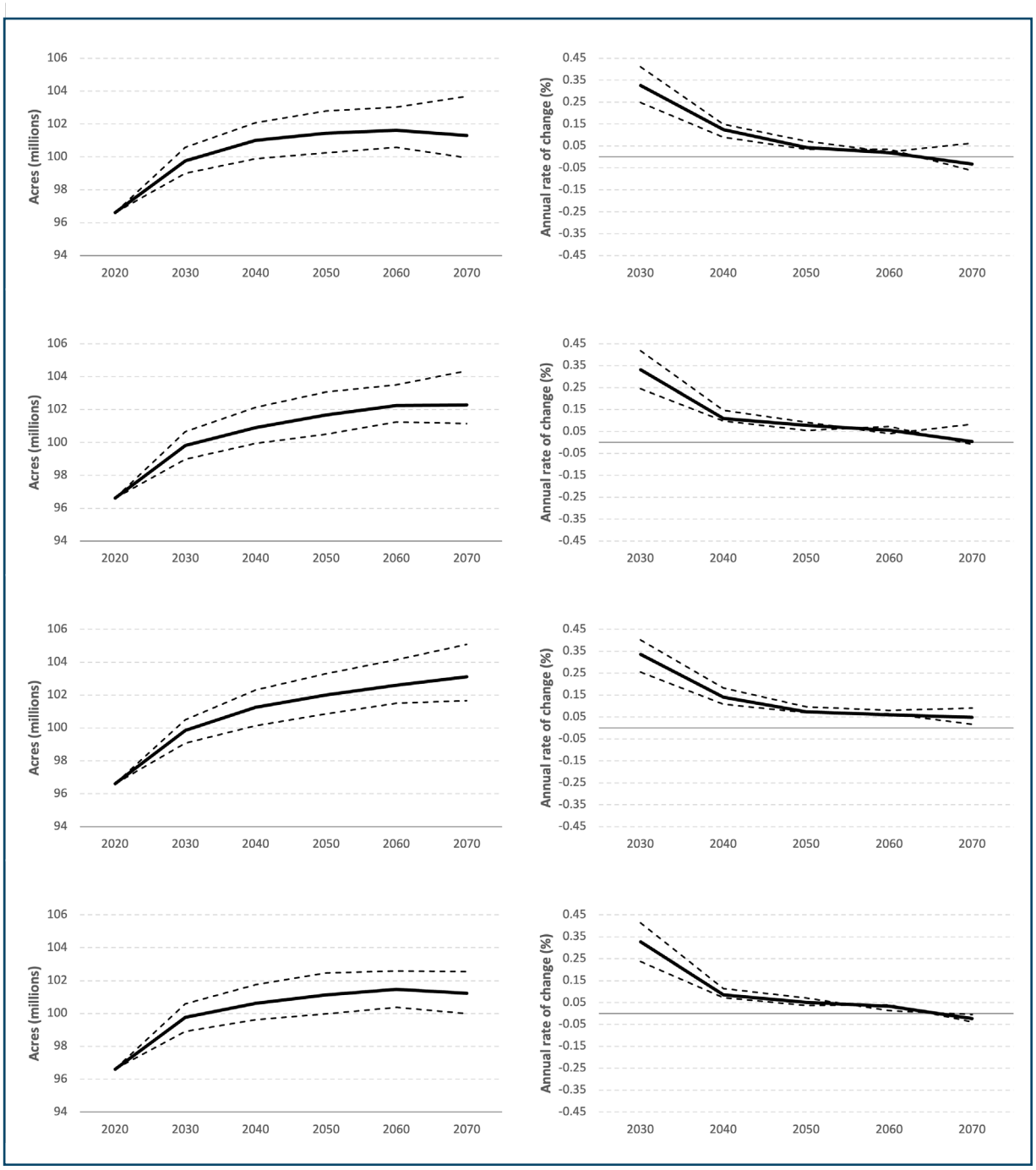



**Figure 27.**—Observed (2020) and projected (2030–2070) trends in mature and old-growth forests (mature and old growth combined) (CONUS). Solid lines reflect the median trend line of the median GCM (out of the five GCMs). The dashed lines represent the minimum and maximum values for the interquartile ranges (the middle 50 percent of the 100 replications) of projections across the five GCMs.

# Management Considerations and Challenges

Changes in mature and old-growth forests managed by the Forest Service and BLM were examined by land use designations. Plots in designated and candidate Wilderness Areas, Inventoried Roadless Areas, and National Monuments were identified and contrasted with all other administrative categories. The patterns of change were so similar between wilderness and roadless areas, and the area in national monuments so small, that these areas were combined and are referred to as "reserved." There was a 10-percent decline in mature forest in reserved areas over an average 9-year period, primarily due to impacts from fire and insects and disease (figure 28). Old-growth forests in reserved areas declined by a (nonstatistically significant) 0.4 percent, with increases in undisturbed forests almost balancing decreases in areas impacted by fire and insects and disease. Similarly, mature forest outside of reserved areas declined by a nonstatistically significant 0.4 percent, with increases in undisturbed forests almost balancing decreases in areas impacted by tree cutting, fire, and insects and disease. However, old growth outside of reserved areas increased by 7.8 percent, with minor impacts from disturbances outweighed by the increases. These results suggest that strictly reserving mature and old-growth forests may not always ensure that they are protected from future losses.

Understanding the distribution of mature and old-growth forests within national and regional priority landscapes is an important consideration. In response to the Bipartisan Infrastructure Law (January 2022)[9] the Forest Service launched a robust, 10-year strategy-

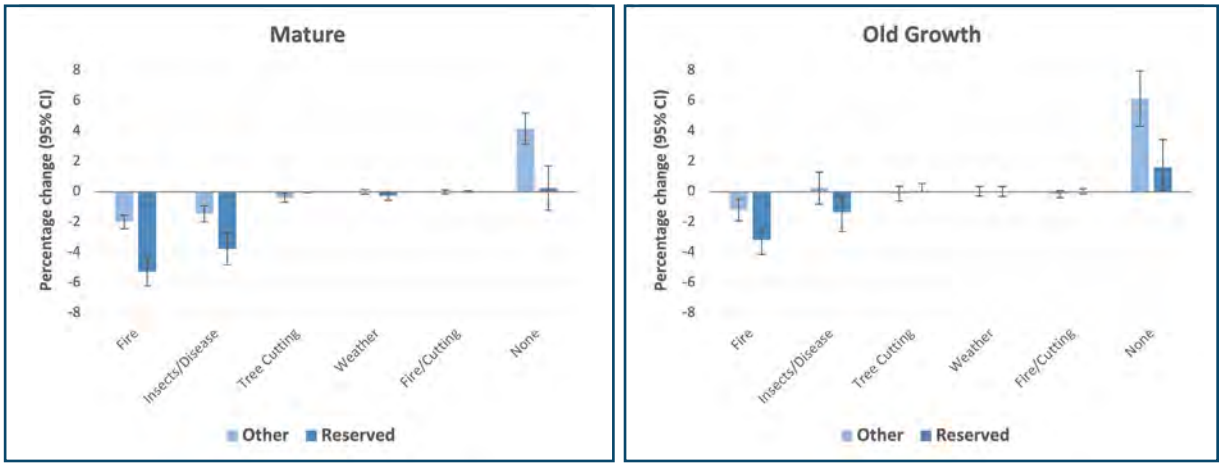



**Figure 28.**—Net percentage area changes in mature and old-growth forest (and 95-percent confidence intervals) since the first measurement (time 1) over an average of 9 years within and outside of reserved areas, from remeasured FIA plots.

9 https://www.whitehouse.gov/build/guidebook/

to address the wildfire crisis in places where wildfire poses the most immediate threats to communities. The strategy, Confronting the Wildfire Crisis: A Strategy for Protecting Communities and Improving Resilience in America's Forests, combines a historic investment of congressional funding with years of scientific research and planning into a national effort to dramatically increase the scale and pace of active forest stewardship over the next decade. With this strategy, the agency will work with States, Tribes, and partners to address wildfire risks to critical infrastructure, protect communities, and make forests more resilient.

In April 2022, in coordination with partners, the Forest Service announced that 10 of the highest priority western landscapes would receive an initial investment of $131 million in FY 2022 under the Bipartisan Infrastructure Law. The selected landscapes contain 68 high-risk firesheds and about 13 million acres to apply the funds for active forest treatment projects. The selected landscapes overlap with identified lands managed by the Forest Service in the West that require some level of immediate treatment. In early 2023, the Forest Service added 11 additional landscapes for a total of 21 identified landscapes. Estimates show that 16 percent of all estimated mature forest and 13 percent of all estimated old-growth forests on lands managed by the Forest Service are found within Wildfire Crisis Strategy Landscapes (table 10).

A Notice of Intent (NOI) to amend the Northwest Forest Plan (NWFP) was published on December 18, 2023.[10] The NOI acknowledges substantial new and relevant information including E.O. 14072. The Forest Service is proposing, "to amend NWFP direction, addressing changed conditions and new information, to improve resistance and resilience to fire where needed across the NWFP landscape, support adaptation to and mitigation of climate change in the NWFP landscape, address management needs of mature and old-growth forests with related ecosystem

**Table 10**.—Estimates of mature and old growth forest contained within Wildfire Crisis Strategy priority firesheds.

| Agency & Land Use Allocation | Younger Forest | | Mature | | Old Growth | |
|---|---|---|---|---|---|---|
| | *acres* | *SE%* | *acres* | *SE%* | *acres* | *SE%* |
| **Forest Service Total** | **51,452,872** | **1** | **68,136,957** | **1** | **24,738,364** | **1** |
| WCS Landscapes | 8,732,550 | 2 | 11,210,296 | 2 | 3,261,365 | 4 |
| Non-WCS Landscapes | 42,720,322 | 1 | 56,926,662 | 1 | 21,476,999 | 1 |
| **BLM Total** | **13,218,861** | **2** | **12,619,046** | **2** | **8,331,991** | **3** |
| WCS Landscapes | 378,360 | 12 | 404,462 | 12 | 79,862 | 27 |
| Non-WCS Landscapes | 12,840,500 | 2 | 12,214,584 | 2 | 8,252,129 | 3 |

10 https://www.federalregister.gov/documents/2023/12/18/2023-27742/region-5-and-region-6-california-oregon-and-washington-forest-plan-amendment-for-planning-and

habitat improvement, and contribute predictable supplies of timber and nontimber products to support economic sustainability in communities affected by forest management in the NWFP landscape, including addressing environmental justice concerns and ensuring Tribal inclusion in developing and implementing plan direction in the NWFP." The proposed amendment includes actions that support the Wildfire Crisis Strategy and strengthen relationships with Tribal Nations and Indigenous peoples. Both efforts are consistent with E.O. 14072 (Section 1), which describes developing policy that consults with State, local, Tribal, and territorial governments, as well as the private sector, nonprofit organizations, labor unions, and the scientific community, to pursue science-based, sustainable forest and land management to conserve America's mature and old-growth forests on Federal lands.

In addition to the considerations above, managing the mature and old-growth forest threats identified in this analysis will be challenged by existing mill infrastructure and timber processors. The geography of the current milling infrastructure is a legacy of historical logging patterns and proximity to transportation systems. The density and size (processing capacity) of mills also corresponds to geographies where landownership is diverse, with privately managed timberlands and industrial forest ground nearby. Changes in raw material supply and fluctuations in timber availability from various land ownership have also impacted the milling infrastructure across the landscape. Mills vary a great deal by size, overall log volume they can process, and the size of material they can handle—therefore the potential interaction with surrounding forests can also vary widely. The majority (81 percent) of mature and old-growth forest are in firesheds with very low or low timber processing capacity, while 8 percent are in firesheds with very high or high capacity. Mill capacity was highest in the Pacific Northwest and Southeast Regions of the country (figure 29). This situation, along with evidence presented in the current analysis, demonstrates that most mature and old-growth forest is under a low level of threat from loss due to commercial harvest. However, lack of mills presents barriers for conducting management activities aimed at reducing risk from fire, insects, and diseases in an economically viable way. About half of inventoried mature and old-growth forests occur in firesheds where wood processing capacity is low, but current threats are high (figure 29), suggesting these areas may struggle to practice active management to reduce forest vulnerability.

In addition to milling capacity, a timber harvesting workforce is needed, and may not exist in places where mill infrastructure is limited or absent. The firesheds designated as very low milling capacity are dominated by piñon/juniper forests (such as in the Intermountain and Southwest Regions). Piñon/juniper forests are not as economically viable from a classic timber production standpoint but are also not reliant on mill infrastructure for management activities intended to promote resilience. Further, much of the woody material that needs to be removed to reduce risk from the discussed threats is not logs and is more challenging to remove when infrastructure does not exist to turn that material into forest products. The Public Lands Act of 2009 included an innovative policy that established

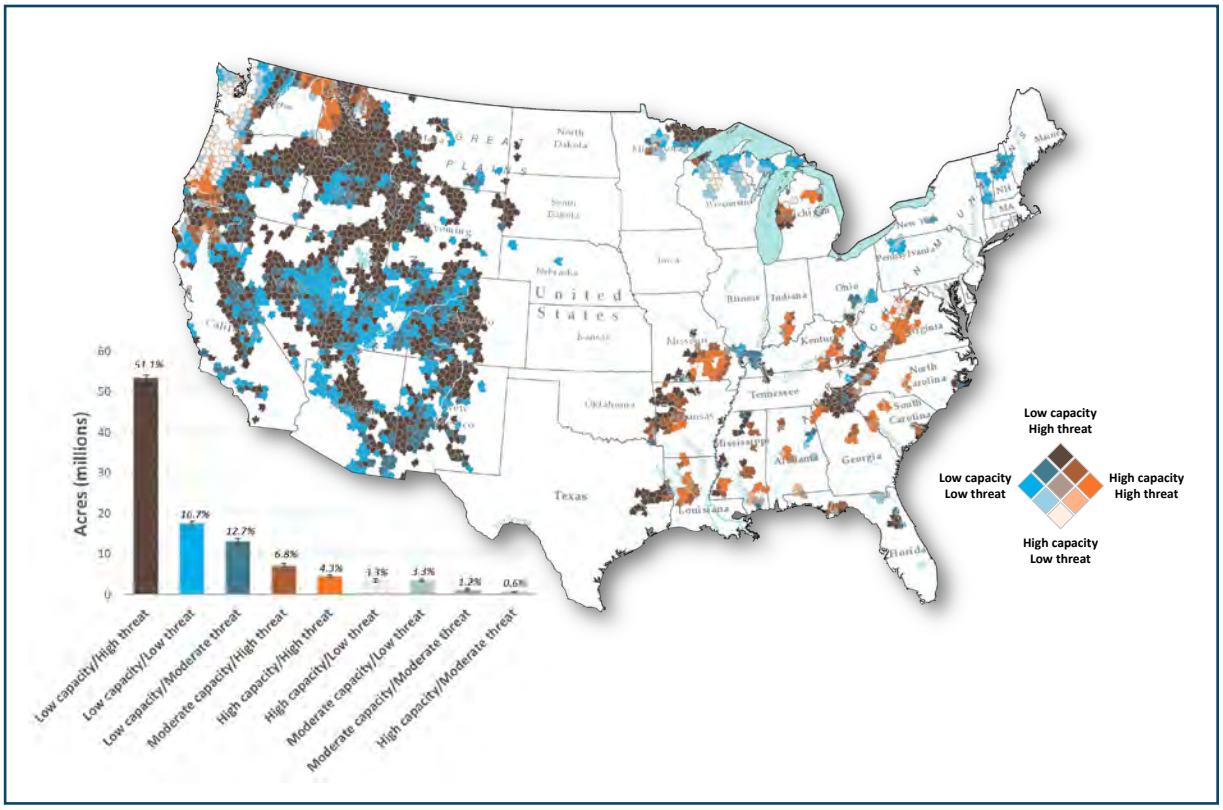



**Figure 29.**—Mill processing capacity overlayed with potential threats from fire deficit, fire threat, and insect/disease at the fireshed level for firesheds containing mature and old-growth forest managed by the Forest Service and BLM. Mill capacity was a sum of total volume within the fireshed, plus a 50km buffer. Very low= 0–6, 250 MCF (1,000 cubic feet); low= 6,251–18,000 MCF; moderate= 18,001–33,750 MCF; high= 33,751–61,750 MCF; very high= 61,751–111,625 MCF.

Collaborative Forest Landscape Restoration Programs (CFLRP[11]) that encouraged investment in new types of wood-processing infrastructure. This includes wood-processing mills that are adapting to nontraditional sources (for example, small diameter wood) and producing non-traditional products such as wood pellets.

Another consideration and challenge are the juxtaposition of human infrastructure, mature and old-growth forests, and potential forest threats. The wildland-urban interface is where housing meets or intermingles with wildland vegetation, such as forests (Radeloff et al. 2018). Following a 2001 definition in the Federal Register, scientists have mapped the wildland-urban interface consistently each decade from 1990 to 2020, combining census data on housing and remotely sensed land cover data for the conterminous United States (Radeloff et al. 2022). From 1990 to 2020, the interface footprint expanded by 31 percent (Radeloff et al. 2018). The relationship between fire deficit and the wildland-urban interface demonstrates both challenges and opportunities. The close proximity of humans and housing to the wildland can limit opportunities for

11 https://www.fs.usda.gov/restoration/CFLRP/

prescribed fire use and increase the risk of wildfire ignitions (Kobziar et al. 2015), which in turn increases the risk of higher severity fires. Alternatively increased investment through, for example, Community Wildfire Defense Grants, could provide the opportunity for more targeted maintenance and restoration efforts with positive desired effects to mature and old-growth forests. From 1990 to 2020, although firesheds containing Federal mature and old-growth forests only had a low percentage of growth in areas classified as wildland-urban (2 percent, compared to 31 percent growth in the wildland-urban interface area nationally), housing units within those same firesheds increased by a much greater proportion (43 percent, compared to 37 percent growth in housing units nationally). This trend suggests significant growth in housing near mature and old-growth forests (figure 30).

Because the wildland-urban interface creates challenges for implementing fuels treatments using planned ignitions, we further examined where high threat from fire deficit condition and moderate- to high-growth in housing units coincide near old-growth forests on federally managed land. Firesheds with high population growth and high threat from fire deficits are found across the country, with concentrations in the intermountain west and southeast areas. The West contains a diversity of combined Conditions of high population growth and high fire deficits are present while less variation is seen in the East. These conditions are present in 25 percent of mature forest acres and 17 percent of old-growth forest acres.

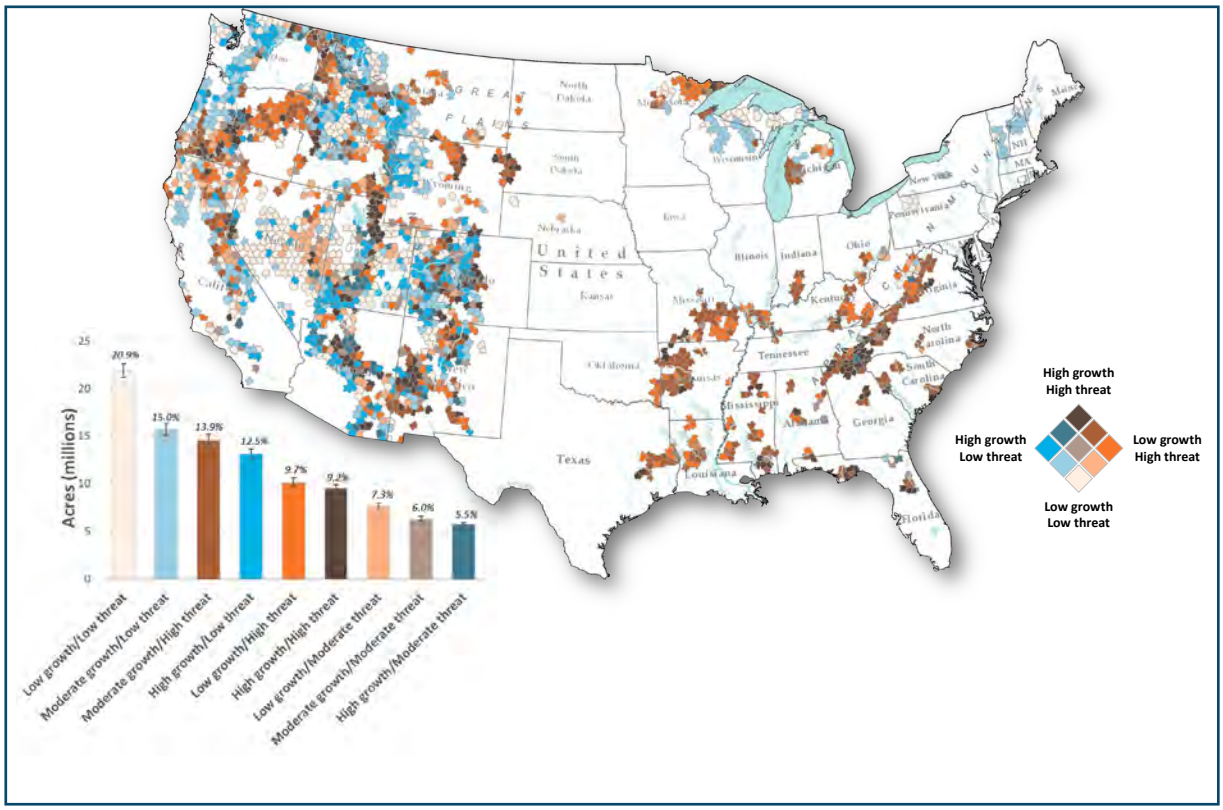



**Figure 30.**—Overlay analysis of housing unit change from 1990–2020 summarized to firesheds and fire deficit condition for Federal mature and old-growth forest firesheds.

# Conclusion

This report is a rapid analysis on the influence of various disturbances and the conditions under which those drivers and stressors become potential threats to mature and old-growth forests. Some of the threats analyzed were mentioned in E.O. 14072, and some not. The analysis validated the conception that uncharacteristically severe fires are indeed threats. It also showed that climate change poses threats and has already increased the exposure of inventoried mature and old-growth forests to some of these threats. Climate change is projected to continue increasing threat exposure into the future. This trend begins to decrease under some socio-economic/climate change scenarios by mid-century, and climate change projections beyond this point—and to the end of this century—paint a concerning picture.

While timber harvesting is recognized as the historical cause for loss of much of the Nation's mature and old-growth forests, current data show that the leading cause for losses on forestlands managed by the Forest Service and BLM is from wildfires. Second to wildfire is the loss of mature and old-growth forests from insects and disease. Nationally, recent losses from tree cutting are third, accounting for less than one percent of net losses (mostly in mature forest) this century.

As recognized in E.O. 14072 (Section 1), the world's mature and old-growth forests are quickly disappearing and only a small fraction of what existed historically remains. Given the recognized importance of this natural resource to ecosystem integrity that supports economic, social, and cultural values, it is important to understand potential threats. This latest effort to understand the threats builds on previous evaluations. The fate of the Nation's mature and old-growth forests has been of concern for over a century (Greeley 1925; figures 31 and 32, box 3). The future of mature and old-growth forests that remained on federally managed lands has been of concern since the 1980s (USDA Forest Service 1989). Conservation of older forests has largely been a Federal land management issue because, by some estimates, Federal lands are where much of it remains or is concentrated (Thomas et al. 1988, Gordon et al. 2008, Barnett et al. 2023, DellaSala et al. 2022). As stated by Thomas et al. (1988), how much is needed depends on *"For what purpose is maintenance of old growth being considered* and *… must be predicated on the relatively small amount of unevenly distributed remaining old growth."* Thomas, who later became the 13th Chief of the Forest Service, concluded that *"…the best probability of success is to preserve all remaining old growth and, if possible, produce more."* This assumed that all the remaining old growth of the time was the "right type" of old growth and part of a resilient ecosystem. However, the history and the effects of over a century of fire exclusion on fire-prone and fire-adapted forest types are now better understood. The definitions used in the inventory were based on FIA plot data that reflect current conditions and past management. In forests where fire was historically less frequent, they likely represent the forest conditions appropriate for the environment and disturbance regime. But, in areas where fire was historically frequent and has been suppressed, these data do not reflect ecologically appropriate conditions—they reflect altered conditions (Spies et al. 2018).

The presence of older (often larger) trees is an important characteristic of old growth, but if the area has experienced significant fire exclusion, those stands of mature and old-growth forests may not be in a condition conducive to their longevity. Closed canopy, structurally complex old growth normally occurs in moister/cooler conditions that can support this dense growth. The trees in these areas tend to be fire-sensitive or least resistant to surviving fire. Where the environment is warmer and drier, the forests are normally less dense and more open-canopied, consisting of tree species that have adapted to the frequent occurrence of fires. These are general observations, but there is a growing body of evidence that some of the current mature and old-growth forest inventory includes "fire-excluded" mature and old-growth forest, forests that have expanded from fire refugium (see figure 6, figure 8, table 3, table 4, table 5, and table 6), and forest that have developed stand structure and species compositions uncharacteristic of the historical fire regime.

This initial analysis suggests the Forest Service and BLM still have an opportunity to manage mature and old-growth forests on their respective lands to be adaptive and resilient to future threats. Opportunity comes from a combination of the fact that Federal lands contain much of the mature and old-growth forests and the area of mature and old-growth forests is expected to increase (at least in the next few decades). However, the threats are also expected to increase in the future with climate change. Moving forward, projections of increasing mature and old-growth forests are tempered by the reality that American forests are entering uncharted territory with climate change. As our understanding of the implications of climate change evolves, so will understanding the places and methods to best steward and conserve our Nation's older forests for the longest time and for the greatest good.



**Old-growth ponderosa pine forest stand on the Fremont-Winema National Forest, Oregon. USDA Forest Service photo.**

When Europeans began colonizing the conterminous United States, they encountered immense and diverse forested landscapes. Tree species composition, stand structure, and landscape patterns were shaped by and evolved with the climate and underlying disturbance regimes, especially fire. Many of these forests were also shaped by thousands of years of human use and fires set by the Indigenous populations that lived in or near them. Three centuries later, concerns were raised about the future of these forests as they related to the Nation's timber supply. This compelled the third Chief of the Forest Service (William Greeley) to publish a paper about the relationship between geography and the timber supply. In it, he wrote the following:

*"The course of these nations in satisfying their requirements for forest-grown materials has usually run through three different stages. At first, they have cut freely from their own virgin forests as long as the supply lasted. Then they have cast about for what they might barter from their neighbors. And finally, they have settled down to the systematic growing of wood on all the land that could be spared for the purpose." (Greeley 1925)*

He illustrated this change in a series of hand-drawn maps (transcribed to firesheds in the following plates) and concluded that:

*"The United States is still in the first of these three stages. By far the greater part of the wood we use is still obtained from our own virgin forests. But the end of this supply is plainly in sight."*

Concern in the 1920s was focused on the Nation's timber supply. Today there is a much broader array of social, economic, and cultural values, as outlined in Executive Order 14072. The focus now extends to the myriad of ecosystem services, especially those uniquely provided by older forests, including carbon sequestration and storage, climate change mitigation, and biodiversity.

The concern is heightened because of increasing signs and symptoms of a changing climate. Wildfires are increasing in frequency and extent. Droughts are lasting longer and are more intense, stressing the health of forests and making them more susceptible to adverse impacts from insects, diseases, and other stressors. And record-breaking heatwaves are more commonplace, with records broken annually. How do we conserve and restore mature and old-growth forests that remain into the future?

**Box 3.**—Historical context of mature and old-growth forest management.

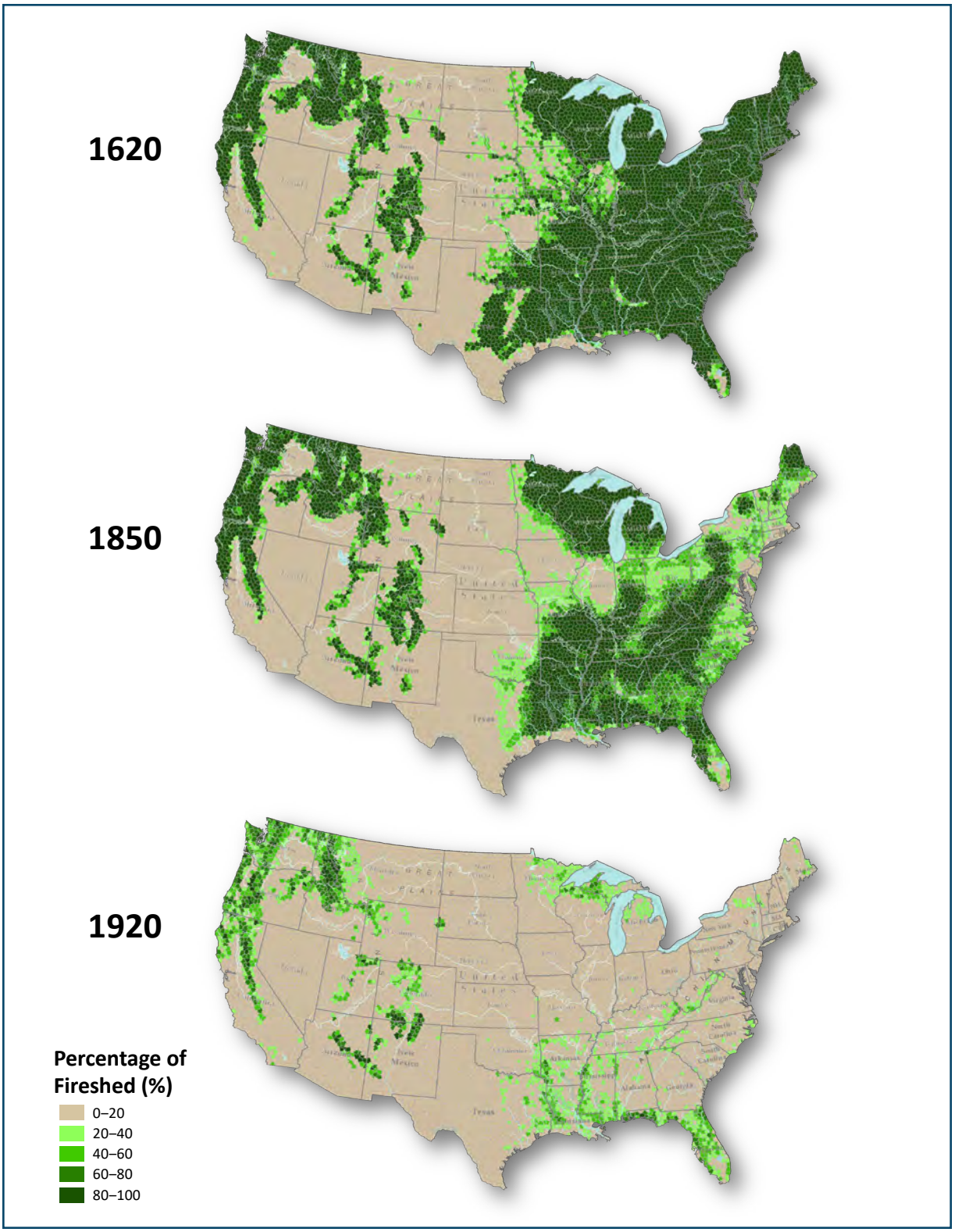



**Figure 31.**—"It was inevitable that our timber resources should shrink rapidly before this terrific onslaught. The story is told in the maps showing the approximate extent of the virgin forests in 1620, 1850, and 1920." (Greeley 1925). Maps from Greeley (1925) were transcribed onto firesheds as percentage of fireshed and represent all land ownerships.

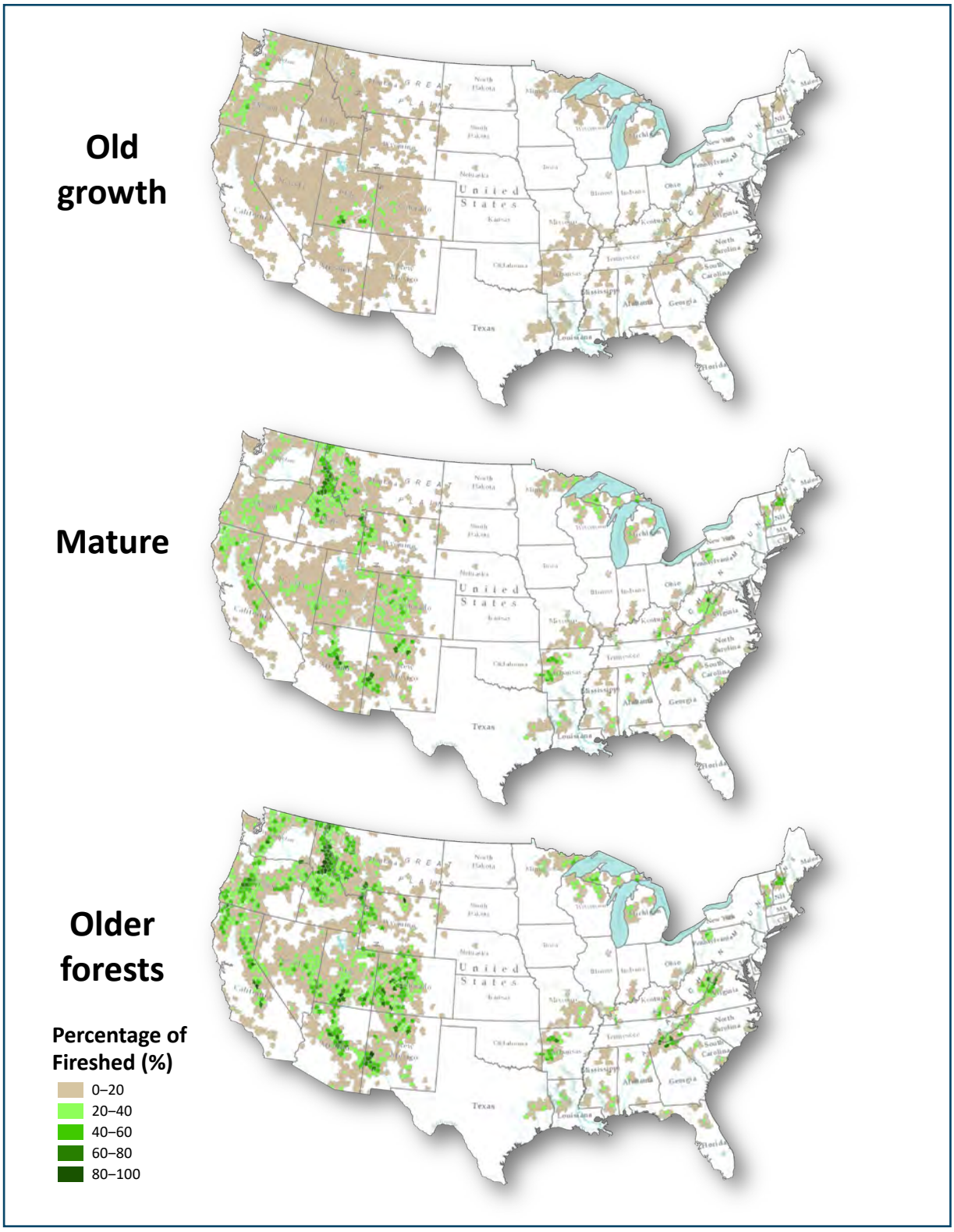



**Figure 32.**—Fireshed maps of mature and old-growth forests on Forest Service and BLM lands. Old growth (top), mature (middle), and combined (bottom).

# Appropriate Use of Data

The contents of this report do not change existing Forest Service and BLM management direction. This rapid analysis was in response to E.O. 14072, is national in scale, and results should not be used at finer spatial scales than recommended in the meta-data of the various analysis products (such as firesheds, project areas). In preparing this report, published scientific and technical literature was reviewed and scientists were consulted about their findings, methods, and/or products. In some instances, they provided advice and technical assistance. The specific results in this report have not been through formal scientific peer reviews, given the time allotted. However, some of the work in this report will be expanded upon and manuscripts prepared for eventual publication in peer-reviewed science journals. The national FIA sample was designed to provide national- and regional-scale estimates. Application of FIA estimates for small areas, with few sample plots, can result in substantial uncertainty. Nationally rare forest conditions, such as old-growth forests in the eastern United States; redwood, riparian forests in arid environments; exotic softwoods; and tropical hardwoods, were not evaluated in this report because there were few or no FIA plots.

# Refinements and Opportunities for Future Research

As with the initial mature and old-growth forest inventory report (USDA and USDI 2023), there is ample room for refining the approaches used in this report or to develop new ones. Concurrent with the writing of this report, the Forest Service sent out a request for proposals to a range of research and management agencies and organizations for potential investments to address key knowledge, tool, or technique gaps, or innovation opportunities (with respect to mature and old-growth forest management). Emphasis was placed on:

- Benefits to mature and old-growth forest conservation efforts
- Collaboration between multiple smaller efforts
- Support for monitoring required under the 2012 Planning Rule

Related to methods used in this report, the modified Terrestrial Condition Assessment (MOGCA) can be refined to include Alaska, Hawaii, and the Territories. In addition, development of MOGCA components for future conditions would improve its utility. Research on refugia (climate and fire) are needed to help managers identify the best places to maintain and restore mature and old-growth forests into the future.

# Next Steps

The results of this initial mature and old-growth threat analysis, along with the initial mature and old-growth forest inventory report (USDA and USDI 2023), represent the first nationwide assessment of Forest Service and BLM mature and old-growth forests and comprise supporting information for E.O. 14072's requirement to "develop policies, with robust opportunity for public comment, to institutionalize climate-smart management and conservation strategies that address threats to mature and old-growth forests on Federal lands" (Section 2(c).iii). In addition to supporting policy development, the inventory and threat analysis form the foundation for robust, cost-effective broadscale forest monitoring and adaptive management, and inform further Tribal and stakeholder engagement. Steps will be taken to monitor mature and old-growth forests that are not well-represented by FIA plots, such as using remote-sensing. Monitoring will provide context for understanding how local application of management strategies in coordination with Tribes and partners cumulatively contributes to overall persistence and distribution of mature and old-growth, other forest age classes, and the benefits they provide. As the tools and approaches developed for the initial mature and old-growth forest inventory report and threat analysis are refined and improved with additional information, results will become more timely, cost-effective, and aligned with management needs across scales.



**Forest stand managed for public recreation on the Flathead National Forest, Montana. USDA Forest Service photo by Elisa Stamm.**

# Glossary

**Climate change**—Changes in average weather conditions (including temperature, precipitation, and risk of certain types of severe weather events) that persist over multiple decades or longer, and that result from both natural factors and human activities, such as increased emissions of greenhouse gases. (source: U.S. Global Change Research Program 2017)

**Climatic water deficit**—Evaporative demand exceeding available soil moisture computed as the amount of evaporation and plant transpiration that would occur if sufficient water was available minus actual evapotranspiration.

**Condition**—Current status or state of the characteristic, process, or ecosystem of interest.

**Disturbance**—Any relatively discrete event in time that disrupts ecosystem, watershed, community, or species population structure and/or function and changes resources, substrate availability, or the physical environment. (source: 36 CFR Part 219.19)

**Disturbance regime**—A description of the characteristic types of disturbance on a given landscape; the frequency, severity, and size distribution of these characteristic disturbance types; and their interactions. (source: 36 CFR Part 219.19)

**Driver**—Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem.

**Drought**—A period of abnormally dry weather long enough to cause a serious hydrological imbalance. (source: U.S. Global Change Research Program 2017)

**Ecological integrity**—An ecosystem has integrity when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influences. (source: 36 CFR Part 219.19)

**Existence value**—When people value something even when they do not intend to use or experience it. (source: Krieger 2001)

**Exposure**—The magnitude or degree of change in climate or other factors a species or system is likely to experience.

**Extent**—The space or area affected, covered, or described.

**Fireshed**—A large (approximately 250,000 acre) area where social and ecological concerns about wildfire combine and intertwine. Firesheds are part of a national tessellation of the United States that divide the landscape into similar shaped and sized units. They can serve as analytical units for the assessment of other natural resource management priorities and trends. (source: Ager et al. 2021) https://data.nal.usda.gov/dataset/fireshed-registry-fireshed-and-project-area-boundaries

**Forest land**—Land at least 10 percent occupied by forest trees of any size or formerly having had such tree cover and not currently developed for nonforest uses. Lands developed for nonforest use include areas for crops, improved pasture, residential or administrative areas, improved roads of any width and adjoining road clearing, and power line clearings of any width. (source: 36 CFR Part 219.19)

**Forest type group**—Aggregations of forest types into logical ecological groupings (source: Eyre 1980).

**Landscape**—A defined area irrespective of ownership or other artificial boundaries, such as a spatial mosaic of terrestrial and aquatic ecosystems, landforms, and plant communities, repeated in similar form throughout such a defined area. (source: 36 CFR Part 219.19)

**Mature forest**— Mature forests are delineated ecologically as the stage of forest development immediately before old growth. Mature forests exhibit structural characteristics that are lacking in earlier stages of forest development and may contain some but not all the structural attributes in old-growth forests. The mature stage of stand development generally begins when a forest stand moves beyond self-thinning, starts to diversify in height and structure, and/or the understory begins to reinitiate. Structural characteristics that mark the transition from an immature to mature forest are unique to each forest type. Characteristics may include but are not limited to abundance of large trees, large tree stem diameter, stem diameter diversity, horizontal canopy openings or patchiness, aboveground biomass accumulation, stand height, presence of standing and/or downed boles, vertical canopy layers, or a combination of these attributes. (source: USDA and USDI 2023)

**Mesic**—An environment containing a moderate amount of moisture, where soil moisture is available to plants throughout the growing season.

**Mesophication**—A term used to describe the escalation of mesic microenvironmental conditions accompanied by ever-diminishing prospects for fire and fire-adapted, sun-loving tree species. By altering environmental conditions, shade-tolerant species deter fire through dense shading that promotes moist, cool microclimates and the production of fuels that are not conducive to burning (flaccid, moisture-holding leaf drop; moist, rapidly decaying woody debris). This phenomenon is reinforced and amplified by feedback loops, whereby conditions continually improve for shade-tolerant mesophytic species and further deteriorate for shade-intolerant, fire-adapted species. (source: Nowacki and Abrams 2008)

**Old-growth forest**—Old-growth forests are dynamic systems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics, which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function. (source: USDA and USDI 2023)

**Project areas**—Smaller landscape areas (approximately 25,000-acre) of similar shape and size that are nested within firesheds. (source: Ager et al. 2021) https://data.nal.usda.gov/dataset/fireshed-registry-fireshed-and-project-area-boundaries

**Stand**—A contiguous group of trees sufficiently uniform in age class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable unit, such as mixed, pure, even-aged, and uneven-aged stands. A stand is the fundamental unit of silviculture reporting and record-keeping. (source: USDA Forest Service [N.d.]) https://www.fs.usda.gov/about-agency/regulations-policies/manual/2470-silvicultural-practices

**Stakeholder**—Any Federal, State, interstate, Tribal, or local agency, any affected nongovernmental organization, affected landowner, or interested person. (source: 18 CFR § 50.1)

**Stressor**—Factors that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological process in a manner that may impair its ecological integrity, such as an invasive species, loss of connectivity, or the disruption of a natural disturbance regime. (source: 36 CFR 219.19)

**Tessellation**—An arrangement of shapes closely fitted together, especially of polygons in a repeated pattern without gaps or overlapping.

**Threat**—A current or projected disturbance or stressor that may contribute to the enduring loss or degradation of the characteristic conditions, functions, or values of existing mature and old-growth forests.

**Timber harvesting**—The physical cutting and removal of trees or parts of trees from a given forested site. (source: Riddle 2022)

**Vulnerability**—A function of the sensitivity of a resource or system to exposure, or changes in exposure, to a driver or stressor, and its capacity to adapt to or cope with changes.

**Wildfire Crisis Priority Landscape**—Firesheds where expanded efforts to reduce wildfire risk will directly benefit at-risk communities and critical infrastructure across 21 landscapes in Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Washington. https://www.fs.usda.gov/sites/default/files/2023-01/wcs-landscapes2-graphics4.jpg

**Wildland-urban interface (WUI)**—The area where houses meet forests or intermingle with undeveloped wildland vegetation. (source: USDA and USDI 2001)

# Literature Cited


Abella, S.R.; Covington, W.W.; Fulé, P.Z.; Lentile, L.B.; Meador, A.J.S.; Morgan, P. 2007. Past, present, and future old growth in frequent-fire conifer forests of the western United States. Ecology and Society. 12(2): 16. https://doi.org/10.5751/ES-02171-120216.

Abrams, M.D. 2005. Prescribing fire in eastern oak forests: is time running out? Northern Journal of Applied Forestry. 22(3): 190–196. https://doi.org/10.1093/njaf/22.3.190.

Abrams, M.D.; Nowacki, G.J. 2015. Exploring the early Anthropocene burning hypothesis and climate-fire anomalies for the Eastern U.S. Journal of Sustainable Forestry. 34(1–2): 30–48. https://doi.org/10.1080/10549811.2014.973605.

Abrams, M.D.; Nowacki, G.J. 2020. Native American imprint in palaeoecology. Nature Sustainability. 3(11): 896–897. https://doi.org/10.1038/s41893-020-0578-6.

Abrams, M.D.; Nowacki, G.J.; Hanberry, B.B. 2021. Oak forests and woodlands as Indigenous landscapes in the Eastern United States. The Journal of the Torrey Botanical Society. 149(2): 101–121. https://doi.org/10.3159/TORREY-D-21-00024.1.

Ager, A.A.; Day, M.A.; Ringo, C.; Evers, C.R.; Alcasena, F.J.; Houtman, R.M.; Scanlon, M.; Ellersick, T. 2021. Development and application of the fireshed registry. Gen. Tech. Rep. RMRS-425. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 47 p. https://doi.org/10.2737/RMRS-GTR-425.

Anderegg, W.R.; Chegwidden, O.S.; Badgley, G.; Trugman, A.T.; Cullenward, D.; Abatzoglou, J.T.; Hicke, J.A.; Freeman, J.; Hamman, J.J. 2022. Future climate risks from stress, insects and fire across US forests. Ecology Letters. 25(6): 1510–1520. https://doi.org/10.1111/ele.14018.

Anderson, N.; Ford, R.M.; Bennett, L.T.; Nitschke, C.; Williams, K.J. 2018. Core values underpin the attributes of forests that matter to people. Forestry: An International Journal of Forest Research. 91(5): 629–640. https://doi.org/10.1093/forestry/cpy022.

Anderson, S.M.; Heath, L.S.; Emery, M.R.; Hicke, J.A.; Littell, J.S.; Lucier, A.; Masek, J.G.; Peterson, D.L.; Pouyat, R.; Potter, K.M.; Robertson, G.; Sperry, J. 2021. Developing a set of indicators to identify, monitor, and track impacts and change in forests of the United States. Climatic Change. 165(1–2): 11770. https://doi.org/10.1007/s10584-021-02993-6.

Arthur, M.A.; Alexander, H.D.; Dey, D.C.; Schweitzer, C.J.; Loftis, D.L. 2012. Refining the oak-fire hypothesis for management of oak-dominated forests of the Eastern United States. Journal of Forestry. 110(5): 257–266. https://doi.org/10.5849/jof.11-080.

Baker, W.L.; Hanson, C.T.; Williams, M.A.; DellaSala, D.A. 2023. Countering omitted evidence of variable historical forests and fire regime in Western USA dry forests: the low-severity-fire model rejected. Fire. 6(4): 146. https://doi.org/10.3390/fire6040146.

Barnett, K.; Aplet, G.H.; Belote, R.T. 2023. Classifying, inventorying, and mapping mature and old-growth forests in the United States. Frontiers in Forests and Global Change. 5: 1070372. https://doi.org/10.3389/ffgc.2022.1070372.

Bauhus, J.; Puettmann, K.; Messier, C. 2009. Silviculture for old-growth attributes. Forest Ecology and Management. 258(4): 525–537. https://doi.org/10.1016/j.foreco.2009.01.053.

Bauman, D.; Fortunel, C.; Delhaye, G.; Malhi, Y.; Cernusak, L.A.; Bentley, L.P.; Rifai, S.W.; Aguirre-Gutiérrez, J.; Menor, I.O.; Phillips, O.L.; McNellis, B.E. 2022. Tropical tree mortality has increased with rising atmospheric water stress. Nature. 608(7923): 528–533. https://doi.org/10.1038/s41586-022-04737-7.

Bechtold, W.A.; Patterson, P.L. 2005. The enhanced Forest Inventory and Analysis Program–national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p. https://doi.org/10.2737/SRS-GTR-80.

Beckmann, J.J.; Sherriff, R.L.; Kerhoulas, L.P.; Kane, J.M. 2021. Douglas-fir encroachment reduces drought resistance in Oregon white oak of northern California. Forest Ecology and Management. 498: 119543. https://doi.org/10.1016/j.foreco.2021.119543.

Bengston, D.N. 2020. Shifting forest values as a driver of change. In: Dockry, M.J.; Bengston, D.N.; Westphal, L.M., comps. Drivers of change in US forests and forestry over the next 20 years. Gen. Tech. Rep. NRS-P-197. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station: 68–75.

Blankenship, K.; Swaty, R.; Hall, K.R.; Hagen, S.; Pohl, K.; Shlisky Hunt, A.; Patton, J.; Frid, L.; Smith, J. 2021. Vegetation dynamics models: a comprehensive set for natural resource assessment and planning in the United States. Ecosphere. 12(4): e03484. https://doi.org/10.1002/ecs2.3484.

Brockway, D.G.; Outcalt, K.W.; Tomczak, D.J.; Johnson, E.E. 2005. Restoration of longleaf pine ecosystems. Gen. Tech. Rep. SRS-83. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 34 p. https://doi.org/10.2737/SRS-GTR-83.

Brodie, E.G.; Knapp, E.E.; Latimer, A.M.; Safford, H.D.; Vossmer, M.; Bisbing, S.M. 2023. The century-long shadow of fire exclusion: historical data reveal early and lasting effects of fire regime change on contemporary forest composition. Forest Ecology and Management. 539: 121011. https://doi.org/10.1016/j.foreco.2023.121011.

Brown, P.; Noyes, P.D.; Casey, W.M.; Dix, D.J. 2017. Application of adverse outcome pathways to U.S. EPA's endocrine disruptor screening program. Environmental Health Perspectives. 125(9): 096001. https://doi.org/10.1289/EHP1304.

Burrill, E.A.; Christensen, G.; Conkling, B.L.; DiTommaso, A.M.; Lepine, L.; Perry, C.J.; Pugh, S.A.; Turner, J.A.; Walker, D.; Williams, M.A. 2023. The Forest Inventory and Analysis Database: database description and user guide for Phase 2 (version 9.1). https://usfs-public.app.box.com/v/FIA-FIADB-UserGuides/folder/250175063714. [Date accessed: June 4, 2024].

Busing, R.T.; Garman, S.L. 2002. Promoting old-growth characteristics and long-term wood production in Douglas-fir forests. Forest Ecology and Management. 160(1–3): 161–175. https://doi.org/10.1016/S0378-1127(01)00443-1.

Charnley, S.A.; Fisher, P.; Jones, E.T. 2008. Traditional and local ecological knowledge about forest biodiversity in the Pacific Northwest. Gen. Tech. Rep. PNW-751. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 52 p. https://doi.org/10.2737/PNW-GTR-751.

Clark, S.L.; Schweitzer, C.J. 2016. Stand dynamics of an oak woodland forest and effects of a restoration treatment on forest health. Forest Ecology and Management. 381: 258–267. https://doi.org/10.1016/j.foreco.2016.09.026.

Cleland, D.; Reynolds, K.; Vaughan, R.; Schrader, B.; Li, H.; Laing, L. 2017. Terrestrial condition assessment for national forests of the USDA Forest Service in the continental US. Sustainability. 9(11): 2144. https://doi.org/10.3390/su9112144.

Clifford, H.T. 1959. Seed dispersal by motor vehicles. Journal of Ecology. 47(2): 311–315. https://doi.org/10.2307/2257368.

Cohen, W.B.; Yang, Z.; Stehman, S.V.; Schroeder, T.A.; Bell, D.M.; Masek, J.G.; Huang, C.; Meigs, G.W. 2016. Forest disturbance across the conterminous United States from 1985–2012: the emerging dominance of forest decline. Forest Ecology and Management. 360: 242–252. https://doi.org/10.1016/j.foreco.2015.10.042.

Conners, T. 2002. Products made from wood. Department of Forestry Fact Sheet FORFS 15-02. Lexington, KY: University of Kentucky, College of Agriculture, Cooperative Extension Service. 13 p.

Corfidi, S.F.; Weiss, S.J.; Kain, J.S.; Corfidi, S.J.; Rabin, R.M.; Levit, J.J. 2010. Revisiting the 3–4 April 1974 super outbreak of tornadoes. Weather and Forecasting. 25(2): 465–510. https://doi.org/10.1175/2009WAF2222297.1.

Costanza, J.K.; Koch, F.H.; Reeves, M.; Potter, K.M.; Schleeweis, K.; Riitters, K.; Anderson, S.M.; Brooks, E.B.; Coulston, J.W.; Joyce, L.A.; Nepal, P.; Poulter, B.; Prestemon, J.P.; Varner, J.M.; Walker, D.M. 2023. Disturbances to forests and rangelands. In: U.S. Department of Agriculture, Forest Service. Future of America's forest and rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: 5-1–5-55. Ch. 5. https://doi.org/10.2737/WO-GTR-102-Chap5.

Coulston, J.W.; Brooks, E.B.; Butler, B.J.; Costanza, J.K.; Walker, D.M.; Domke, G.M.; Caputo, J.; Markowski-Lindsay, M.; Sass, E.M.; Walters, B.F.; Guo, J. 2023. Forest resources. In: U.S. Department of Agriculture, Forest Service. Future of America's forest and rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: 6-1–6-38. Ch. 6. https://doi.org/10.2737/WO-GTR-102-Chap6.

Delcourt, H.R.; Delcourt, P.A. 1997. Pre-Columbian Native American use of fire on southern Appalachian landscapes. Conservation Biology. 11(4): 1010–1014. https://doi.org/10.1046/j.1523-1739.1997.96338.x.

DellaSala, D.A.; Mackey, B.; Norman, P.; Campbell, C.; Comer, P.J.; Kormos, C.F.; Keith, H.; Rogers, B. 2022. Mature and old-growth forests contribute to large-scale conservation targets in the conterminous United States. Frontiers in Forests and Global Change. 5: 979528. https://doi.org/10.3389/ffgc.2022.979528.

DeMeo, T.; Cleland, D.T.; Davis, C.; Ferwerda, M.; Gallegos, A.J.; Haglund, J.; Howes, S.; Keys, J.; Laing, L.; Robertson, G.T.; Robbie, W.A. 2001. Towards national land type association data standards. In: Smith, M.L., ed. Land type associations conference: development and use in natural resources management, planning and research. Gen. Tech. Rep. NE-294. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station: 3–10.

Devine, W.D.; Harrington, C.A. 2013. Restoration release of overtopped Oregon white oak increases 10-year growth and acorn production. Forest Ecology and Management. 291(1): 87–95. https://doi.org/10.1016/j.foreco.2012.10.053.

Dey, D.C. 2014. Sustaining oak forests in Eastern North America: regeneration and recruitment, the pillars of sustainability. Forest Science. 60(5): 926–942. https://doi.org/10.5849/forsci.13-114.

Dockry, M.J.; Hoagland, S.J. 2017. A special issue of the Journal of Forestry—tribal forest management: innovations for sustainable forest management. Journal of Forestry. 115(5): 339–340. https://doi.org/10.5849/JOF-2017-040.

Domke, G.M.; Fettig, C.J.; Marsh, A.S.; Baumflek, M.; Gould, W.A.; Halofsky, J.E.; Joyce, L.A.; LeDuc, S.D.; Levinson, D.H.; Littell, J.S.; Miniat, C.F.; Mockrin, M.H.; Peterson, D.L.; Prestemon, J.; Sleeter, B.M.; Swanston, C. 2023: Forests. In: Crimmins, A.R.; Avery, C.W.; Easterling, D.R.; Kunkel, K.E.; Stewart, B.C.; Maycock, T.K., eds. Fifth National Climate Assessment. Washington, DC: U.S. Global Change Research Program. Ch. 7. https://doi.org/10.7930/NCA5.2023.CH7.

Duan, S.; He, H.S.; Knapp, L.S.P.; Bonnot, T.W.; Fraser, J.S. 2023. Current management in national and state forests has important but limited impacts on sustaining oaks in temperate forests of the eastern U.S. Forest Ecology and Management. 546(5): 121331. https://doi.org/10.1016/j.foreco.2023.121331.

Eidenshink, J.; Schwind, B.; Brewer, K.; Zhu, Z.L.; Quayle, B.; Howard, S. 2007. A project for monitoring trends in burn severity. Fire Ecology. 3(1): 3–21. https://doi.org/10.4996/fireecology.0301003.

Emery, M.R.; Wrobel, A.; Hansen, M.H.; Dockry, M.; Moser, W.K.; Stark, K.J.; Gilbert, J.H. 2014. Using traditional ecological knowledge as a basis for targeted forest inventories: paper birch (Betula papyrifera) in the U.S. Great Lakes region. Journal of Forestry. 112(2): 207–214. https://doi.org/10.5849/jof.13-023.

EPA. 2017. Multi-model framework for quantitative sectoral impacts analysis: a technical report for the fourth national climate assessment. EPA 430-R-17-001. Washington, DC: U.S. Environmental Protection Agency. 271 p.

Eyre, F.H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p.

Fassnacht, K.S.; Bronson, D.R.; Palik, B.; D'Amato, A.W.; Lorimer, C.G.; Martin, K.J. 2015. Accelerating the development of old-growth characteristics in second-growth northern hardwoods. Gen. Tech. Rep. NRS-144. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 33 p. https://doi.org/10.2737/NRS-GTR-144.

Fei, S.; Steiner, K.C. 2009. Rapid capture of growing space by red maple. Canadian Journal of Forest Research. 39(8): 1444–1452. https://doi.org/10.1139/X09-065.

Fiedler, C.E.; Arno, S.F. 2015. Ponderosa: people, fire, and the West's most iconic tree. Missoula, MT: Mountain Press Publishing Company. 272 p.

Forman, R.T.; Alexander, L.E. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics. 29(1): 207–231. https://doi.org/10.1146/annurev.ecolsys.29.1.207.

Forman, R.T.T.; Sperling, D.; Bissonette, J.A.; Clevenger, A.P.; Cutshall, C.D.; Dale, V.H.; Fahrig, L.; France, R.; Goldman, C.R.; Heanue, K.; Jones, J.A.; Swanson, F.J.; Turrentine, T.; Winter, T.C. 2003. Road ecology: science and solutions. Washington, DC: Island Press. 481 p.

Frelich, L.E. 2002. Forest dynamics and disturbance regimes: studies from temperate evergreen-deciduous forests. New York: Cambridge University Press. 266 p. https://doi.org/10.1017/CBO9780511542046.

Frelich, L.E.; Reich, P.B. 1995. Spatial patterns and succession in a Minnesota southern-boreal forest. Ecological Monographs. 65: 325–346. https://doi.org/10.2307/2937063.

Gelbard, J.L.; Belnap, J. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology. 17(2): 420–432. https://doi.org/10.1046/j.1523-1739.2003.01408.x.

Gidmark, D. 1995. Birchbark canoes of the Algonquin. American Indian Art Magazine. 20(3): 54–63.

Gilhen-Baker, M.; Roviello, V.; Beresford-Kroeger, D.; Roviello, G.N. 2022. Old growth forests and large old trees as critical organisms connecting ecosystems and human health. A review. Environmental Chemistry Letters. 20(2): 1529–1538. https://doi.org/10.1007/s10311-021-01372-y.

Goebel, P.C.; Hix, D.M. 1996. Development of mixed-oak forests in southeastern Ohio: a comparison of second-growth and old-growth forests. Forest Ecology and Management. 84(1): 1–21. https://doi.org/10.1016/0378-1127(96)03772-3.

Gordon, J.M.; Lansford, H.; Hagan, J.A.; Langston, N.; Mitchell, R.J.; Spies, T.A.; Covington, W.W. 2008. Beyond old growth: older forests in a changing world: a synthesis of five regional workshops. Washington, DC: National Commission on Science for Sustainable Forestry. 40 p.

Gray, A.N.; Pelz, K.; Hayward, G.D.; Schuler, T.; Salverson, W.; Palmer, M.; Schumacher, C.; Woodall, C.W. 2023. Perspectives: the wicked problem of defining and inventorying mature and old-growth forests. Forest Ecology and Management. 546: 121350. https://doi.org/10.1016/j.foreco.2023.121350.

Greeley, W.B. 1925. The relation of geography to timber supply. Economic Geography. 1: 1–14. https://doi.org/10.2307/140095.

Hagmann, R.K.; Hessburg, P.F.; Prichard, S.J.; Povak, N.A.; Brown, P.M.; Fulé, P.Z.; Keane, R.E.; Knapp, E.E.; Lydersen, J.M.; Metlen, K.L.; Reilly, M.J. 2021. Evidence for widespread changes in the structure, composition, and fire regimes of western North American forests. Ecological Applications. 31(8): e02431. https://doi.org/10.1002/eap.2431.

Halofsky, J.E.; Peterson, D.L., eds. 2017. Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-939. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 331 p. https://doi.org/10.2737/PNW-GTR-939.

Halofsky, J.E.; Peterson, D.L.; Dante-Wood, S.K.; Hoang, L.; Ho, J.J.; Joyce, L.A., eds. 2018a. Climate change vulnerability and adaptation in the Northern Rocky Mountains [part 1]. Gen. Tech. Rep. RMRS-374. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 1–273. https://doi.org/10.2737/RMRS-GTR-374PART1.

Halofsky, J.E.; Peterson, D.L.; Ho, J.J.; Little, N.J.; Joyce, L.A., eds. 2018b. Climate change vulnerability and adaptation in the Intermountain Region [part 1]. Gen. Tech. Rep. RMRS-375. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 1–197. https://doi.org/10.2737/RMRS-GTR-375PART1.

Halpern, A.A.; Sousa, W.P.; Lake, F.K.; Carlson, T.J.; Paddock, W. 2022. Prescribed fire reduces insect infestation in Karuk and Yurok acorn resource systems. Forest Ecology and Management. 505: 119768. https://doi.org/10.1016/j.foreco.2021.119768.

Hanberry, B.B.; Abrams, M.D. 2018. Recognizing loss of open forest ecosystems by tree densification and land use intensification in the Midwestern USA. Regional Environmental Change. 18: 1731–1740. https://doi.org/10.1007/s10113-018-1299-5.

Hanberry, B.B.; Abrams, M.D.; Arthur, M.A.; Varner, J.M. 2020. Reviewing fire, climate, deer, and foundation species as drivers of historically open oak and pine forests and transition to closed forests. Frontiers in Forests and Global Change. 3: 56. https://doi.org/10.3389/ffgc.2020.00056.

Hanberry, B.B.; Brzuszek, R.F.; Foster, H.T., II; Schauwecker, T.J. 2018. Recalling open old growth forests in the Southeastern Mixed Forest province of the United States. Ecoscience. 26(1): 11–22. https://doi.org/10.1080/11956860.2018.1499282.

Hanberry, B.B.; Coursey, K.; Kush, J.S. 2018. Structure and composition of historical longleaf pine ecosystems in Mississippi, USA. Human Ecology. 46(2): 241–248. https://doi.org/10.1007/s10745-018-9982-1.

Hayward, G.H.; Colt, S.; McTeague, M.L.; Hollingsworth, T.N., eds. 2017. Climate change vulnerability assessment for the Chugach National Forest and the Kenai Peninsula. Gen. Tech. Rep. PNW-950. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 340 p. https://doi.org/10.2737/PNW-GTR-950.

Helmer, E.H.; Kay, S.; Marcano-Vega, H.; Powers, J.S.; Wood, T.E.; Zhu, X.; Gwenzi, D.; Ruzycki, T.S. 2023. Multiscale predictors of small tree survival across a heterogeneous tropical landscape. PLOS ONE. 18(3): e0280322. https://doi.org/10.1371/journal.pone.0280322.

Hennon, P.E.; D'Amore, D.V.; Schaberg, P.G.; Wittwer, D.T.; Shanley, C.S. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow-cedar in the North Pacific coastal rainforest. BioScience. 62: 147–158. https://doi.org/10.1525/bio.2012.62.2.8.

Herrera, D.; Ault, T. 2017. Insights from a new high-resolution drought atlas for the Caribbean spanning 1950–2016. Journal of Climate. 30(19): 7801–7825. https://doi.org/10.1175/JCLI-D-16-0838.1.

Hoyer, R., comp. 2022. Climate change vulnerability and adaptation in southwest Oregon: executive summary. Gen. Tech. Rep. PNW-1013. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 8 p. https://doi.org/10.2737/PNW-GTR-1013.

Hudec, J.L.; Halofsky, J.E.; Peterson, D.L.; Ho, J.J., eds. 2019. Climate change vulnerability and adaptation in southwest Washington. Gen. Tech. Rep. PNW-977. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 249 p. https://doi.org/10.2737/PNW-GTR-977.

Hulme, P.E. 2009. Trade, transport and trouble: managing invasive species pathways in an era of globalization. Journal of Applied Ecology. 46(1): 10–18. https://doi.org/10.1111/j.1365-2664.2008.01600.x.

Jain, T.B.; Graham, R.T.; Morgan, P. 2004. Western white pine growth relative to forest openings. Canadian Journal of Forest Research. 34(11): 2187–2198. https://doi.org/10.1139/x04-094.

Janowiak, M.K.; D'Amato, A.; Swanston, C.W.; Iverson, L.R.; Thompson, F.R.; Dijak, W.D.; Matthews, S.; Peters, M.P.; Prasad, A.; Fraser, J.S.; Brandt, L.A. 2018. New England and northern New York forest ecosystem vulnerability assessment and synthesis: a report from the New England climate change response framework project (No. NRS-173). Gen. Tech. Rep. NRS-173. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 234 p. https://doi.org/10.2737/NRS-GTR-173.

Johnson, K.N.; Franklin, J.F.; Reeves, G.H. 2023. The making of the Northwest Forest Plan: the wild science of saving old growth ecosystems. Corvallis, OR: Oregon State University Press. 457 p.

Johnston, J.D.; Greenler, S.M.; Miller, B.A.; Reilly, M.J.; Lindsay, A.A.; Dunn, C.J. 2021. Diameter limits impede restoration of historical conditions in dry mixed-conifer forests of eastern Oregon, USA. Ecosphere. 12(3): e03394. https://doi.org/10.1002/ecs2.3394.

Joyce, L.A.; Coulson, D.P. 2020. Climate scenarios and projections: a technical document supporting the USDA Forest Service 2020 RPA Assessment. Gen. Tech. Rep. RMRS-413. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 85 p. https://doi.org/10.2737/RMRS-GTR-413.

Karppinen, H. 1998. Values and objectives of non-industrial private forest owners in Finland. Silva Fennica. 32(1): 699. https://doi.org/10.14214/sf.699.

Keellings, D.; Hernández Ayala, J.J. 2019. Extreme rainfall associated with Hurricane Maria over Puerto Rico and its connections to climate variability and change. Geophysical Research Letters. 46(5): 2964–2973. https://doi.org/10.1029/2019GL082077.

Klein, T.; Torres-Ruiz, J.M.; Albers, J.J. 2022. Conifer desiccation in the 2021 NW heatwave confirms the role of hydraulic damage. Tree Physiology. 42(4): 722–726. https://doi.org/10.1093/treephys/tpac007.

Kobziar, L.N.; Godwin, D.; Taylor, L.; Watts, A.C. 2015. Perspectives on trends, effectiveness, and impediments to prescribed burning in the Southern U.S. Forests. 6(3): 561–580. https://doi.org/10.3390/f6030561.

Koch, F.H.; Coulston, J.W.; Smith, W.D. 2012. Mapping drought conditions using multi-year windows. In: Potter, K.M.; Conkling, B.L., eds. 2012. Forest health monitoring: 2009 national technical report. Gen. Tech. Rep. SRS-167. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 163–179.

Kramer, M.G.; Hansen, A.J.; Taper, M.L.; Kissinger, E.J. 2001. Abiotic controls on long-term windthrow disturbance and temperate rain forest dynamics in Southeast Alaska. Ecology. 82: 2749–2768. https://doi.org/10.1890/0012-9658(2001)082[2749:ACOLTW]2.0.CO;2.

Krasnow, K.D.; Stephens, S.L. 2015. Evolving paradigms of aspen ecology and management: impacts of stand condition and fire severity on vegetation dynamics. Ecosphere. 6(1): 1–16. https://doi.org/10.1890/ES14-00354.1.

Krieger, D.J. 2001. Economic value of forest ecosystem services: a review. Washington, DC: The Wilderness Society. 31 p.

Kush, J.S.; Meldahl, R.S.; Avery, C. 2004. A restoration success: longleaf pine seedings established in fire-suppressed, old-growth stand. Ecological Restoration. 22: 6–10. https://doi.org/10.3368/er.22.1.6.

Lidestav, G.; Bergstén, S.; Keskitalo, E.C.H.; Linck, L. 2020. Forest social values: the case of Dalasjö, Sweden. Scandinavian Journal of Forest Research. 35(3–4): 177–185. https://doi.org/10.1080/02827581.2020.1754454.

Long, J.W.; Lake, F.K.; Goode, R.W., 2021. The importance of Indigenous cultural burning in forested regions of the Pacific West, USA. Forest Ecology and Management. 500: 119597. https://doi.org/10.1016/j.foreco.2021.119597.

Markon, C.; Gray, S.; Berman, M.; Eerkes-Medrano, L.; Hennessy, T.; Huntington, H.; Littell, J.; McCammon, M.; Thoman, R.; Trainor, S. 2018: Alaska. In: Reidmiller, D.R.; Avery, C.W.; Easterling, D.R.; Kunkel, K.E.; Lewis, K.L.M.; Maycock, T.K.; Stewart, B.C., eds. Impacts, risks, and adaptation in the United States: Fourth National Climate Assessment, volume II. Washington, DC: U.S. Global Change Research Program: 1185–1241. https://doi.org/10.7930/NCA4.2018.CH26.

Martinson, E.J.; Omi, P.N. 2013. Fuel treatments and fire severity: a meta-analysis. Res. Pap. RMRS-103WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 38 p. https://doi.org/10.2737/RMRS-RP-103.

Marvel, K.; Su, W.; Delgado, R.; Aarons, S.; Chatterjee, A.; Garcia, M.E.; Hausfather, Z.; Hayhoe, K.; Hence, D.A.; Jewett, E.B.; Robel, A.; Singh, D.; Tripati, A.; Vose, R.S. 2023. Climate trends. In: Crimmins, A.R.; Avery, C.W.; Easterling, D.R.; Kunkel, K.E.; Stewart, B.C.; Maycock, T.K., eds. Fifth National Climate Assessment. Washington, DC: U.S. Global Change Research Program. Ch. 2. https://doi.org/10.7930/NCA5.2023.CH2.

Mather, A.S. 2001. Forests of consumption: postproductivism, postmaterialism, and the postindustrial forest. Environment and Planning C: Government and Policy. 19(2): 249–268. https://doi.org/10.1068/c9914j.

Matlack, G.R. 2013. Reassessment of the use of fire as a management tool in deciduous forests of eastern North America. Conservation Biology. 5: 916–926. https://doi.org/10.1111/cobi.12121.

McElwee, P.D.; Carter, S.L.; Hyde, K.J.W.; West, J.M.; Akamani, K.; Babson, A.L.; Bowser, G.; Bradford, J.B.; Costanza, J.K.; Crimmins, T.M.; Goslee, S.C.; Hamilton, S.K.; Helmuth, B.; Hoagland, S.; Hoover, F.-A.E.; Hunsicker, M.E.; Kashuba, R.; Moore, S.A.; Muñoz, R.C.; Shrestha, G.; Uriarte, M.; Wilkening, J.L. 2023. Ecosystems, ecosystem services, and biodiversity. In: Crimmins, A.R.; Avery, C.W.; Easterling, D.R.; Kunkel, K.E.; Stewart, B.C.; Maycock, T.K., eds. Fifth National Climate Assessment. Washington, DC: U.S. Global Change Research Program. Ch. 8. https://doi.org/10.7930/NCA5.2023.CH8.

McNulty, S.; Wiener, S.; Treasure, E.; Moore Myers, J.; Farahani, H.; Fouladbash, L.; Marshall, D.; Steele, R.; Hickman, D.; Porter, J.; Hestvik, S.; Dantzler, R.; Hall, W.; Cole, M.; Bochicchio, J.; Meriwether, D.; Klepzig, K. 2015. Anderson, T, ed. Southeast Regional Climate Hub assessment of climate change vulnerability and adaptation and mitigation strategies. Raleigh, NC: U.S. Department of Agriculture. 61 p. https://doi.org/10.32747/2015.7279978.ch.

Miller, J.R.; Joyce, L.A.; Knight, R.L.; King, R.M. 1996. Forest roads and landscape structure in the southern Rocky Mountains. Landscape Ecology. 11: 115–127. https://doi.org/10.1007/BF02093743.

Moser, W.K.; Hansen, M.H.; Gormanson, D.; Gilbert, J.; Wrobel, A.; Emery, M.R.; Dockry, M.J. 2015. Paper birch (Wiigwaas) of the Lake States, 1980–2010. Gen. Tech. Rep. NRS-149. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 37 p. https://doi.org/10.2737/NRS-GTR-149.

Moyer, J.M.; Owen, R.J.; Duinker, P.N. 2008. Forest values: a framework for old-growth forest with implications for other forest conditions. The Open Forest Science Journal. 1(1): 27–36. https://doi.org/10.2174/1874398600801010027.

Narayanaraj, G.; Wimberly, M.C. 2012. Influences of forest roads on the spatial patterns of human-and lightning-caused wildfire ignitions. Applied Geography. 32(2): 878–888. https://doi.org/10.1016/j.apgeog.2011.09.004.

National Forest System Land and Resource Management Planning: Final Rule and Record of Decision. 2012. 77 FR 21162. Federal Register. 77: 21161–21276. https://federalregister.gov/a/2012-7502. [Date accessed: June 5, 2024].

Nelson, M.L.; Brewer, C.K.; Solem, S.J.; Spencer, L.A.; Manning, M.E.; Coles-Richie, M.;Tart, D.; DeMeo, T.; Goetz, W.; Lister, A.J., 2015. Existing vegetation classification, mapping, and inventory technical guide. Version 2.0. Gen. Tech. Rep. WO–90. Washington, DC, US Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff.

Noel, J.M.; Platt, W.J.; Moser, E.B. 1998. Structural characteristics of old- and second-growth stands of longleaf pine (Pinus palustris) in the gulf coastal region of the USA. Conservation Biology. 12(3): 533–548. https://doi.org/10.1046/j.1523-1739.1998.96124.x.

Nowacki, G.J.; Abrams, M.D. 2008. The demise of fire and “mesophication” of forests in the eastern United States. BioScience. 58(2): 123–138. https://doi.org/10.1641/B580207.

Nyholm, E. 1981. The use of birch bark by the Ojibwa Indians. Washington, DC: Smithsonian Institution. 9 p.

Oak, S.W.; Spetich, M.A.; Morin, R.S. 2016. Oak decline in central hardwood forests: frequency, spatial extent, and scale. In: Greenberg, C.H.; Collins, B.S., eds. Natural disturbances and historic range of variation: type, frequency, severity, and post-disturbance structure in central hardwood forests USA. Cham, Switzerland: Springer International Publishing: 49–71. https://doi.org/10.1007/978-3-319-21527-3_3.

O’Dea, C.B.; Langner, L.L.; Joyce, L.A.; Prestemon, J.P.; Wear, D.N. 2023. Future scenarios. In: U.S. Department of Agriculture, Forest Service. Future of America’s forest and rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: 3-1–3-13. Ch. 3. https://doi.org/10.2737/WO-GTR-102-Chap3.

Ortiz, B.R. 2008. Contemporary California Indians, oaks and sudden oak death (Phytophthora ramorum). In: Merenlender, A.; McCreary, D.; Purcell, K.L., tech. eds. 2008. Proceedings of the sixth California oak symposium: today's challenges, tomorrow's opportunities. Gen. Tech. Rep. PSW-217. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 39–56.

Oswald, W.W.; Foster, D.R.; Shuman, B.N.; Chilton, E.S.; Doucette, D.L.; Duranleau, D.L. 2020. Conservation implications of limited Native American impacts in pre-contact New England. Nature Sustainability. 3(3): 241–246. https://doi.org/10.1038/s41893-019-0466-0.

Oswalt, S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A., coords. 2019. Forest resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA Assessment. Gen. Tech. Rep. WO-97. Washington, D.C.: U.S. Department of Agriculture, Forest Service, Washington Office. 223 p. https://doi.org/10.2737/WO-GTR-97.

Paletto, A.; De Meo, I.; Cantiani, M.G.; Maino, F. 2013. Social perceptions and forest management strategies in an Italian Alpine community. Mountain Research and Development. 33(2): 152–160. https://doi.org/10.1659/MRD-JOURNAL-D-12-00115.1.

Palik, B.J.; D'Amato, A.W.; Franklin, J.F.; Norman Johnson, K. 2021. Ecological silviculture: foundations and applications. Long Grove, IL: Waveland Press. 343 p.

Pelz, K.A.; Hayward, G.; Gray, A.N.; Berryman, E.M.; Woodall, C.W.; Nathanson, A. 2023. Quantifying old-growth forest based on United States Forest Service National Forest System definitions. Forest Ecology and Management. https://doi.org/10.2139/ssrn.4480118.

Perry, C.H.; Finco, M.V.; Wilson, B.T., eds. 2022. Forest atlas of the United States. FS-1172. Washington, DC: U.S. Department of Agriculture, Forest Service. 54 p.

Pierce, D.W.; Cayan, D.R.; Feldman, D.R.; Risser, M.D. 2023. Future increases in North American extreme precipitation in CMIP6 downscaled with LOCA. Journal of Hydrometeorology. 24(5): 951–975. https://doi.org/10.1175/JHM-D-22-0194.1.

Pierce, D.W.; Cayan, D.R.; Thrasher, B.L. 2014. Statistical downscaling using Localized Constructed Analogs (LOCA). Journal of Hydrometeorology. 15: 2558–2585. https://doi.org/10.1175/JHM-D-14-0082.1.

Pyne, S.J. 1997. Fire in America. A cultural history of wildland and rural fire. Seattle, WA: University of Washington Press. 680 p.

Radeloff, V.C.; Helmers, D.P.; Kramer, H.A.; Mockrin, M.H.; Alexandre, P.M.; Bar-Massada, A.; Butsic, V.; Hawbaker, T.J.; Martinuzzi, S.; Syphard, A.D.; Stewart, S.I. 2018. Rapid growth of the US wildland-urban interface raises wildfire risk. Proceedings of the National Academy of Sciences. 115: 3314–3319. https://doi.org/10.1073/pnas.1718850115.

Radeloff, V.C.; Helmers, D.P.; Mockrin, M.H.; Carlson, A.R.; Hawbaker, T.J.; Martinuzzi, S. 2022. The 1990–2020 wildland-urban interface of the conterminous United States-geospatial data. Geospatial Data. 4th ed. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2015-0012-4.

Raymond, C.L.; Peterson, D.L.; Rochefort, R.M., eds. 2014. Climate change vulnerability and adaptation in the North Cascades region, Washington. Gen. Tech. Rep. PNW-892. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 279 p. https://doi.org/10.2737/PNW-GTR-892.

Reilly, M.J.; Halofsky, J.E.; Krawchuk, M.A.; Donato, D.C.; Hessburg, P.F.; Johnston, J.D.; Merschel, A.G.; Swanson, M.E.; Halofsky, J.S.; Spies, T.A. 2021. Fire ecology and management in Pacific Northwest forests. In: Greenberg, C.H.; Collins, B., eds. Fire ecology and management: past, present, and future of U.S. forested ecosystems. Cham, Switzerland: Springer: 393–435. https://doi.org/10.1007/978-3-030-73267-7_10.

Reinhardt, E.D.; Keane, R.E.; Calkin, D.E.; Cohen, J.D. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest Ecology and Management. 256: 1997–2006. https://doi.org/10.1016/j.foreco.2008.09.016.

Reynolds, K.M.; Hessburg, P.F. 2014. An overview of the ecosystem management decision-support system. In: Reynolds, K.M.; Hessburg, P.F.; Bourgeron, P.S., eds. Making transparent environmental management decisions: applications of the ecosystem management decision support system. Heidelberg, Germany: Springer Berlin: 3–22. https://doi.org/10.1007/978-3-642-32000-2_1.

Reynolds, R.T.; Sánchez Meador, A.J.; Youtz, J.A.; Nicolet, T.; Matonis, M.S.; Jackson, P.L.; DeLorenzo, D.G.; Graves, A.D. 2013. Restoring composition and structure in southwestern frequent-fire forests: a science-based framework for improving ecosystem resiliency. Gen. Tech. Rep. RMRS-310. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 76 p. https://doi.org/10.2737/RMRS-GTR-310.

Rice, J.R.; Joyce, L.A.; Regan, C.; Winters, D.; Truex, R. 2018. Climate change vulnerability assessment of aquatic and terrestrial ecosystems in the U.S. Forest Service Rocky Mountain Region. Gen. Tech. Rep. RMRS-376. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 216 p. https://doi.org/10.2737/RMRS-GTR-376.

Riddle, A.A. 2022. Timber harvesting on federal lands. CRS Report R45688. Washington, DC: Congressional Research Service. 20 p. https://crsreports.congress.gov/product/pdf/R/R45688. [Date accessed: June 5, 2024].

Roche, L.M.; Rice, K.J.; Tate, K.W. 2012. Oak conservation maintains native grass stands in an oak woodland-annual grassland system. Biodiversity and Conservation. 21: 2555–2568. https://doi.org/10.1007/s10531-012-0317-z.

Rondeau, R.; Anderson, D.; Handwerk, J.; Spector, T. 2022. Post-fire effects on the globally imperiled Chapin Mesa milkvetch (Astragalus schmolliae), 2001–2019. Natural Areas Journal. 42(1): 4–17. https://doi.org/10.3375/21-14.

Rother, M.T.; Huffman, J.M.; Guiterman, C.H.; Robertson, K.M.; Jones, N. 2020. A history of recurrent, low-severity fire without fire exclusion in southeastern pine savannas, USA. Forest Ecology and Management. 475: 118406. https://doi.org/10.1016/j.foreco.2020.118406.

Sargent, C.S. 1884. Report on the forests of North America (exclusive of Mexico). Vol. 9. Washington, DC: U.S. Government Printing Office. 612 p. https://doi.org/10.5962/bhl.title.45220.

Schmidt, W.C.; McDonald, K. 1995. Ecology and management of Larix forests: a look ahead – proceedings of an international symposium. Gen. Tech. Rep. INT-319. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 521 p. https://doi.org/10.5962/bhl.title.109332.

Secretary's Memorandum 1077-004. 2022. Climate resilience and carbon stewardship of America's national forests and grasslands. https://www.usda.gov/directives/sm-1077-004. [Date accessed: June 5, 2024].

Smith, H.Y.; Arno, S.F. 1999. Eighty-eight years of change in a managed ponderosa pine forest. Gen. Tech. Rep. RMRS-23. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 55 p. https://doi.org/10.2737/RMRS-GTR-23.

Spies, T.A.; Stine, P.A.; Gravenmier, R.; Long, J.W.; Reilly, M.J.; Mazza, R. 2018. Synthesis of science to inform land management within the Northwest Forest Plan area: executive summary. Gen. Tech. Rep. PNW-970. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 186 p. https://doi.org/10.2737/PNW-GTR-970.

Stephenson, N. 1998. Actual evapotranspiration and deficit: biologically meaningful correlates of vegetation distribution across spatial scales. Journal of Biogeography. 25(5): 855–870. https://doi.org/10.1046/j.1365-2699.1998.00233.x.

Still, C.J.; Sibley, A.; DePinte, D.; Busby, P.E.; Harrington, C.A.; Schulze, M.; Shaw, D.R.; Woodruff, D.; Rupp, D.E.; Daly, C.; Hammond, W.M. 2023. Causes of widespread foliar damage from the June 2021 Pacific Northwest heat dome: more heat than drought. Tree Physiology. 43(2): 203–209. https://doi.org/10.1093/treephys/tpac143.

Stryd, A.H.; Feddema, V. 1998. Sacred cedar: the cultural and archaeological significance of cultural modified trees. A report of the Pacific Salmon Forests Project. Vancouver: David Suzuki Foundation. 24 p.

Swanston, C.; Brandt, L.A.; Janowiak, M.K.; Handler, S.D.; Butler-Leopold, P.; Iverson, L.; Thompson, F.R., III; Ontl, T.A.; Shannon, P.D. 2018. Vulnerability of forests of the Midwest and Northeast United States to climate change. Climatic Change. 146: 103–116. https://doi.org/10.1007/s10584-017-2065-2.

Thomas, J.W.; Ruggiero, L.F.; Mannan, R.W.; Schoen, J.W.; Lancia, R.A. 1988. Management and conservation of old-growth forests in the United States. Wildlife Society Bulletin. 16(3): 252–262.

Thompson, M.P.; Scott, J.; Helmbrecht, D.; Calkin, D.E. 2013. Integrated wildfire risk assessment: framework development and application on the Lewis and Clark National Forest in Montana, USA. Integrated Environmental Assessment and Management. 9(2): 329–342. https://doi.org/10.1002/ieam.1365.

Timmons, R.S.; deBano, L.; Ryan, K.C. 2012. Implications of fire management on cultural resources. In: Ryan, K.C.; Jones, A.T.; Koerner, C.L.; Lee, K.M., tech. eds. Wildland fire in ecosystems: effects of fire on cultural resources and archaeology. Gen. Tech. Rep. RMRS-42-vol. 3. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 171–191.

Triepke, F.J.; Muldavin, E.H.; Wahlberg, M.M. 2019. Using climate projections to assess ecosystem vulnerability at scales relevant to managers. Ecosphere. 10(9): e02854. https://doi.org/10.1002/ecs2.2854.

Tulowiecki, S.J.; Hanberry, B.B.; Abrams, M.D. 2023. Native American geography shaped historical fire frequency in forests of eighteenth-century Pennsylvania, USA. Scientific Reports. 13: 18598. https://doi.org/10.1038/s41598-023-44692-5.

Turner, N.J.; Deur, D.; Mellott, C.R. 2011. "Up on the mountain": ethnobotanical importance of montane sites in Pacific coastal North America. Journal of Ethnobiology. 31(1): 4–43. https://doi.org/10.2993/0278-0771-31.1.4.

U.S. Department of Agriculture, Forest Service. [USDA Forest Service]. [No date]. Forest Service manual and handbooks. Washington, DC. https://www.fs.usda.gov/about-agency/regulations-policies/national-directives. [Date accessed: June 5, 2024].

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1989. Chief Dale Robertson letter to regional foresters, station directors, and WO staff regarding national forest old-growth values and the generic definition and description of old-growth forests. Dated October 11, 1989.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2011. Review of the Forest Service response: the bark beetle outbreak in northern Colorado and southern Wyoming. A report by USDA Forest Service Rocky Mountain Region and Rocky Mountain Research Station at the request of Senator Mark Udall. 45 p.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2018. U.S. climate by forest (adaptation of climate resilience toolkit climate explorer). https://climate-by-forest.nemac.org. [Date accessed: June 5, 2024].

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2023. Future of America's forests and rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC. 348 p. https://doi.org/10.2737/WO-GTR-102.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2024. Forest inventory and analysis national core field guide for the nationwide forest inventory, version 9.3. 539 p. https://www.fs.usda.gov/research/understory/nationwide-forest-inventory-field-guide [Date accessed: June 6, 2024].

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior [USDA and USDI]. 2001. Urban wildland interface communities within vicinity of Federal lands that are at high risk from wildfire. 66 FR 751. Federal Register. 66: 751–777.

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management [USDA and USDI]. 2023. Mature and old-growth forests: definition, identification, and initial inventory on lands managed by the Forest Service and Bureau of Land Management. Washington, DC. 68 p.

U.S. Global Change Research Program [USGCRP]. 2016. Our changing planet: the U.S. Global Change Research Program for fiscal year 2017. Washington, DC. https://downloads.globalchange.gov/ocp/ocp2017/Our-Changing-Planet_FY2017_full.pdf. [Date accessed: June 5, 2024].

U.S. Global Change Research Program [USGCRP]. 2023. Our changing planet: the U.S. Global Change Research Program for fiscal year 2023. Washington, DC. https://downloads.globalchange.gov/ocp/ocp2023/Our-Changing-Planet_FY2023.pdf. [Date accessed: June 5, 2024].

Vargas-Gutierrez, G.; Marcano, H.; Ruzycki, T.; Wood, T.; Anderegg, W.; Powers, J.; Helmer, E. 2023. Aridity and forest age mediate landscape scale patterns of tropical forest resistance to cyclonic storms. Authorea Preprints. 1–30. https://doi.org/10.22541/au.169651630.06248226/v1.

Velasco-Muñoz, J.F.; Aznar-Sánchez, J.A.; Schoenemann, M.; López-Felices, B. 2022. An analysis of the worldwide research on the socio-cultural valuation of forest ecosystem services. Sustainability. 14(4): 2089. https://doi.org/10.3390/su14042089.

Vizcarra, N.; Johnson, A.D.; Cerveny, L. 2022. Old-growth wood for cultural uses: sustaining native lifeways in southeast Alaska. Science Findings 252. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 5 p.

Voggesser, G.; Lynn, K.; Daigle, J.; Lake, F.K.; Ranco, D. 2013. Cultural impacts to tribes from climate change influences on forests. In: Koppel Maldonado, J.; Colombi, B.; Pandya, R., eds. Climate change and indigenous peoples in the United States: impacts, experiences and actions. Cham: Springer International Publishing: 107–118. https://doi.org/10.1007/978-3-319-05266-3_9.

Vose, J.M.; Clark, J.S.; Luce, C.H.; Patel-Weynand, T., eds. 2016. Effects of drought on forests and rangelands in the United States: a comprehensive science synthesis. Gen. Tech. Rep. WO-93b. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 289 p. https://doi.org/10.2737/WO-GTR-93b.

Vose, J.M.; Peterson, D.L.; Domke, G.M.; Fettig, C.J.; Joyce, L.A.; Keane, R.E.; Luce, C.H.; Prestemon, J.P.; Band, L.E.; Clark, J.S.; Cooley, N.E. 2018. Forests. In: Reidmiller, D.R.; Avery, C.W.; Easterling, D.R.; Kunkel, K.E.; Lewis, K.L.M.; Maycock, T.K.; Stewart, B.C., eds. Impacts, risks, and adaptation in the United States: Fourth National Climate Assessment. Volume II. Washington, DC: U.S. Global Change Research Program: 232–267. https://doi.org/10.7930/NCA4.2018.CH6.

Vose, J.M.; Peterson, D.L.; Fettig, C.J.; Halofsky, J.E.; Hiers, J.K.; Keane, R.E.; Loehman, R.; Stambaugh, M.C. 2021. Fire and forests in the 21st century: managing resilience under changing climates and fire regimes in USA forests. In: Greenberg, C.H.; Collins, B., eds. Fire ecology and management: past, present, and future of U.S. forested ecosystems. Cham, Switzerland: Springer: 465–502. https://doi.org/10.1007/978-3-030-73267-7_12.

Watkins, R.Z.; Chen, J.; Pickens, J.; Brosofske, K.D. 2003. Effects of forest roads on understory plants in a managed hardwood landscape. Conservation Biology. 17(2): 411–419. https://doi.org/10.1046/j.1523-1739.2003.01285.x.

Weiskopf, S.R.; Rubenstein, M.A.; Crozier, L.G.; Gaichas, S.; Griffis, R.; Halofsky, J.E.; Hyde, K.J.; Morelli, T.L.; Morisette, J.T.; Muñoz, R.C.; Pershing, A.J. 2020. Climate change effects on biodiversity, ecosystems, ecosystem services, and natural resource management in the United States. Science of the Total Environment. 733: 137782. https://doi.org/10.1016/j.scitotenv.2020.137782.

The White House. 2022. Executive order 14072 on strengthening the Nation's forests, communities, and local economies. Washington, DC: White House. https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/. [Date accessed: June 5, 2024].

Winthers, E.; Fallon, D.; Haglund, J.; DeMeo, T.; Nowacki, G.; Tart, D.; Ferwerda, M.; Robertson, G.; Gallegos, A.; Rorick, A.; Cleland, D.T.; Robbie, W. 2005. Terrestrial Ecological Unit Inventory technical guide. Gen. Tech. Rep. WO-68. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office, Ecosystem Management Coordination Staff. 245 p. https://doi.org/10.2737/WO-GTR-68.

Woodall, C.; Kamoske, A.G.; Hayward, G.; Schuler, T.M.; Hiemstra, C.M.; Palmer, M.; Gray, A.N. 2023. Classifying mature federal forests in the United States: the forest inventory growth stage system. Forest Ecology and Management. 546: 121361. https://doi.org/10.1016/j.foreco.2023.121361.

Woodbridge, M.; Keyser, T.; Oswalt, C. 2022. Stand and environmental conditions drive functional shifts associated with mesophication in eastern US forests. Frontiers in Forests and Global Change. 5: 991934. https://doi.org/10.3389/ffgc.2022.991934.

Zasada, J. 2002. Birch and birch bark. St. Paul, MN: University of Minnesota Extension Service. 36 p.

# Appendixes

List of Figures and Tables ..... 2
Appendix 1 – Recent Government Actions ..... 10
Appendix 2 – Forums and Engagements ..... 14
Appendix 3 – Regional Condition-Based Evaluation Worksheets ..... 18
Appendix 4 – Forest Inventory Analysis Sample Plot Characteristics ..... 23
Appendix 5 – Mature and Old Growth Condition Assessment Description and Results ..... 25
Appendix 6 – Regional Fire Summary ..... 55
Appendix 7 – Monitoring Trends in Burn Severity Analysis ..... 59
Appendix 8 – Resources Planning Act Assessment of Future Mature and Old-Growth Forests ..... 62
Appendix 9 – Regional Insect and Disease Summary ..... 70
Appendix 10 – Regional Weather Summary ..... 74
Appendix 11 – Complex Perspectives on Tree Cutting ..... 78
Appendix 12 – Regional Tree Cutting Summary ..... 81
Appendix 13 – Regional All Disturbances Summary ..... 85
Appendix 14 – Mature and Old Growth Climate Change Vulnerability Assessment Synthesis ..... 90
Literature Cited ..... 115

# List of Figures and Tables

## Figures

***Figure A3.1.—****Example of worksheet used to document regional inputs.*

***Figure A3.2.—****Fireshed map of regions.*

***Figure A3.3.—****Fireshed map of ecological divisions.*

***Figure A3.4.—****Fireshed map of forest type groups.*

***Figure A5.1.—****Map of the results generated using the initial thresholds for Insect and Disease Hazard (50% for −1 and 10% for +1). The indicator is based on data from the National Insect and Disease Risk Map. Scores are continuous, and quantiles of the continuous scores are used to create condition classes ranging from Very High (scores >=−1 and <−0.6) to Very Low (scores =<+1.0 and >+0.6) threat.*

***Figure A5.2.—****Different thresholds were evaluated by subject matter experts to determine the most appropriate thresholds to discern levels of threat posed by insect and disease outbreaks as depicted by the National Insect and Disease Risk Map. The thresholds recommended by subject matter experts and ultimately used by MOGCA were 35% of the analysis unit area as a threshold for −1 and 5% of the analysis unit area as a threshold for +1 (A5.2a). Other thresholds were tested including thresholds of 25% for a score of −1 and 5% for a score of +1 that highlight areas threatened but discern less across different amounts of area at risk and under threat (A5.2b).*

***Figure A5.3.—****Map of the overall MOG conditions which depicts an assessment of the overall current integrity of Project Areas with MOG across Forest Service and Bureau of Land Management lands. Overall MOG Conditions are derived by the Mature and Old Growth Condition Assessment from a combination of current conditions and current threats.*

***Figure A5.4.—****The Overall Mature and Old Growth Condition from MOGCA depicted by the number of Project Areas by (A5.4a) condition class and by (A5.4b) forest type group. Nationally, 5,077 Project Areas were in Very Poor condition, 1,812 in Poor condition, 1,611 in Moderate condition, 1,923 in Good condition, and 1,356 in Very Good condition.*

***Figure A5.5.—****The Current Condition of Project Areas containing federally owned forest land from the MOGCA model. Current Condition is determined by the outcomes of Recent Disturbances and Vegetation Condition which includes various stressors and characteristics of the current forest vegetation community.*

***Figure A5.6.—****Mapped condition classes of the Tree Mortality indicator for Project Areas containing federally owned forest land from the MOGCA model. The Tree Mortality indicator is composed of two metrics looking at extent of tree mortality documented in the most recent five years (2021-2017) and the five years preceding that period (2016-2012).*

***Figure A5.7.—****The number of Project Areas by (A5.7a) condition class and by (A5.7b) forest type group for the Tree Mortality indicator. Nationally, 192 Project Areas were in Very Poor condition, 200 in Poor condition, 528 in Moderate condition, 824 in Good condition, and 10,035 in Very Good condition. Most Project Areas rated as in Poor or Very Poor conditions for this indicator occurred in the California mixed conifer forest type group.*

***Figure A5.8.—****Mapped condition classes of the Uncharacteristic Wildfire indicator for Project Areas containing federally owned forest land from the MOGCA model. The Uncharacteristic Wildfire indicator depicts where areas have burned more severely than expected based on the historical fire regime. It is composed of two metrics: one focused on areas with ecosystems characterized by low severity fire regimes that burned at higher severities and another on ecosystems characterized by moderate/mixed severity fire regimes that burned at high severities.*

***Figure A5.9.—****The number of Project Areas by (A5.9a) condition class and by (A5.9b) forest type group for the Uncharacteristic Wildfire indicator. Nationally, 1,370 Project Areas were in Very Poor condition, 239 in Poor condition, 363 in Moderate condition, 652 in Good condition, and 9,155 in Very Good condition.*

***Figure A5.10.—****Mapped condition classes of the Climate Exposure indicator for Project Areas containing federally owned forest land from the MOGCA model. The Climate Exposure indicator depicts how much recent climate conditions have deviated from the historical record. It considers metrics on seasonal temperature, seasonal precipitation, and drought.*

***Figure A5.11.—****The number of Project Areas by forest type group and condition class for the Climate Exposure indicator. Nationally, across all forest type groups, 2,247 Project Areas were in Very Poor condition, 2,081 in Poor condition, 2,336 in Moderate condition, 2,573 in Good condition, and 2,542 in Very Good condition.*

***Figure A5.12.—****Mapped condition classes of the Drought metric for Project Areas containing federally owned forest land from the MOGCA model. The Drought metric examines MDZ scores over the last three years (2021-2019) compared to the historical record. It is one of 13 metrics considered in the Climate Exposure indicator in the MOGCA model.*

***Figure A5.13.—****Mapped condition classes of the Temperature Exposure metrics for Project Areas containing federally owned forest land from the MOGCA model. Temperature Exposure is generated from four seasonal measures (Spring, Summer, Fall, and Winter) that look at average seasonal temperatures over the most recent 5 years (2021-2017) compared to the historical record.*

***Figure A5.14.—****Mapped condition classes of the Precipitation Exposure metrics for Project Areas containing federally owned forest land from the MOGCA model. Precipitation Exposure is generated from four seasonal measures (Spring, Summer, Fall, and Winter) that look at average seasonal precipitation amounts over the most recent 5 years (2021-2017) compared to the historical record.*

***Figure A5.15.—****Mapped condition classes of the Road indicator for Project Areas containing federally owned forest land from the MOGCA model. The Roads indicators is derived from three roads metrics that capture different road types that vary in their size and volume of traffic: paved roads, light duty roads, and unimproved roads. Roads negatively impact ecological conditions by fragmenting the landscape while also providing conduits for access which is necessary to enable restoration work.*

***Figure A5.16.—****The number of Project Areas by forest type group and condition class for the Road Density indicator. Nationally, 3,313 Project Areas were in Very Poor condition, 489 in Poor condition, 632 in Moderate condition, 1,024 in Good condition, and 6,321 in Very Good condition.*

***Figure A5.17.—****Mapped condition classes of the Vegetation Departure indicator for Project Areas containing federally owned forest land from the MOGCA model. Vegetation Departure depicts the departure of the distribution of observed successional classes compared to the expected distribution for that ecosystem.*

***Figure A5.18.—****Mapped condition classes of the Nitrogen Deposition metric for Project Areas containing federally owned forest land from the MOGCA model. The Nitrogen Deposition metric makes up the Air Quality indicator in the MOGCA model.*

***Figure A5.19.—****Mapped condition classes of the Current Threats measure for Project Areas containing federally owned forest land from the MOGCA model. Current Threats are derived from three different potential threats analyzed by the MOGCA model: wildfire, insects and disease, and fire exclusion.*

***Figure A5.20.—****The number of project areas by forest type group and condition class for the Current Threat measure which is determined by the scores (outcomes) of the Wildfire Threat to Late Seral Forests, Insect and Disease Hazard, and Fire Deficit indicators in the MOGCA model. Nationally, 5,324 Project Areas were in Very Poor condition, 1,379 in Poor condition, 1,310 in Moderate condition, 1,379 in Good condition, and 2,387 in Very Good condition.*

***Figure A5.21.—****Mapped condition classes of the Wildfire Threat to Late Seral Forest indicator for Project Areas containing federally owned forest land from the MOGCA model. This indicator represents the likelihood that fire could cause tree mortality to older forests defined as areas classified as late seral by LANDFIRE Successional Class data.*

***Figure A5.22.—****The number of project areas by forest type group and condition class for the Wildfire Threat to Late Seral Forests indicator. Nationally, 2,427 project areas were in Very Poor condition, 636 in Poor condition, 886 in Moderate condition, 1,438 in Good condition, and 6,106 in Very Good condition.*

***Figure A5.23.—****Mapped condition classes of the Insect and Disease hazard indicator for Project Areas containing federally owned forest land from the MOGCA model. Insect and Disease hazard leverages the National Insect and Disease Risk Map to determine areas likely to experience significant tree mortality from insects and disease in the next 15 years.*

***Figure A5.24.—****The number of Project Areas by forest type group and condition class for the Insect and Disease Hazard indicator. Nationally, 1,960 Project Areas were in Very Poor condition, 752 in Poor condition, 863 in Moderate condition, 1071 in Good condition, and 7,129 in Very Good condition.*

***Figure A5.25.—****Mapped condition classes of the Fire Deficit indicator for project areas containing federally owned forest land from the MOGCA model. Fire Deficit is identifying where ecosystems dependent on fire (based on mean fire return intervals) have not had fire at the ecologically appropriate frequency. This deficit is driven predominantly by fire exclusion.*

***Figure A5.26.—****The number of Project Areas by forest type group and condition class for Fire Deficit indicator. Nationally, 3,434 Project Areas were in Very Poor condition, 1,420 in Poor condition, 1,282 in Moderate condition, 1,054 in Good condition, and 4,589 in Very Good condition.*

***Figure A6.1. —****Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.2.—****Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.3.—****Region 3 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.4.—****Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.5.—****Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.6.—****Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity*

*was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.7.—****Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.8.—****Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.9.—****Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A6.10.—****Regional variations in fire disturbance severity (based on live tree basal area mortality) for mature and old-growth forests. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A7.1.—****A side-by-side visual comparison of the National Burn Probability map (L) with the Anderegg et al. (2022) map (R).*

***Figure A7.2.—****Fireshed analysis based on percentage of forests on NFS and BLM lands burned by large (>1,000 ac in the west and 500 ac in the east) moderate- to high-severity fire using Monitoring Trends in Burn Severity (MTBS) data.*

***Figure A8.1.—****Resources Planning Act Assessment regions within the contiguous United States.*

***Figure A8.2.—****Acres of old growth, mature, and younger forest on Forest Service and Bureau of Land Management land in the contiguous United States until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Note the difference in the scale of the y-axes. Climate models are represented by colors, and results for each scenario are shown in separate panels.*

***Figure A8.3.—****Acres of old growth, mature, and younger forest on Forest Service and Bureau of Land Management land by region until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model, for the high warming/moderate growth scenario only. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors. The other three scenarios showed similar trends. Note the difference in the scale of the y-axes on each panel.*

***Figure A8.4.—****Annual area burned (in acres) of old growth, mature, and younger forest on Forest Service and Bureau of Land Management land in the contiguous United States until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors, and results for each scenario are shown in separate panels. The secondary y-axis indicates the proportion of total Forest Service and BLM forest land in 2020 that corresponds to the given annual area burned.*

***Figure A8.5.—****Annual area burned (in acres) on old growth and mature forest on Forest Service and Bureau of Land Management land by region until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model,*

*for the high warming/moderate growth scenario only. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors. The other three scenarios showed similar trends. Note the difference in the scale of the y-axes for old growth and mature.*

***Figure A8.6.—****Annual harvested volume of trees (in cubic feet) from old growth, mature, and younger forest on Forest Service and Bureau of Land Management land in the contiguous United States until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors, and results for each scenario are shown in separate panels. The secondary y-axis indicates the proportion of total live volume on Forest Service and BLM forest land in 2020 that corresponds to the given annual removal volume.*

***Figure A8.7.—****Annual harvested volume of trees (in cubic feet) from old growth and mature forest on Forest Service and Bureau of Land Management land by region until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model, for the middle climate model (NorESM1-M) only. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. The other climate models showed similar trends.*

***Figure A9.1.—****Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.2.—****Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.3.—****Region 31 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.4.—****Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.5.—****Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.6.—****Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.7.—****Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant.*

*Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.8.—****Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.9.—****Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A9.10.—****Regional variations in insect/disease disturbance severity (basal area mortality) for mature and old-growth forests. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.1.—****Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.2.—****Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.3.—****Region 3 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.4.—****Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.5.—****Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.6.—****Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.7.—****Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.8.—****Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.9.—****Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A10.10.—****Regional variations in weather disturbance severity (basal area mortality) for mature and old-growth forests.*

***Figure A11.1.—*** *Stakeholder responses to the term 'tree cutting' illustrate the complexity of perspectives on the subject.*

***Figure A12.1.—****Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.2.—****Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.3.—****Region 3 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.4.—****Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.5.—****Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.6.—****Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.7.—****Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.8.—****Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance*

*severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.9.—****Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A12.10.—****Regional variations in tree cutting disturbance severity (basal area mortality) for mature and old-growth forests. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

***Figure A13.1.—****Region 1 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.2.—****Region 2 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.3.—****Region 3 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.4.—****Region 4 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.5.—****Region 5 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.6.—****Region 6 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.7.—****Region 8 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.8.—****Region 9 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

***Figure A13.9.—****Region 10 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

# Tables

***Table A4.1.—****Characteristics of sample plots on BLM and Forest Service lands used in the FIA plot change analysis, showing evaluations (EVALIDs), inventory years, mean plot remeasurement interval, and number of forested plots used.*

***Table A5.1.—****Parameters used in the Mature and Old Growth Condition Assessment.*

***Table A5.2.—****Indicators and metrics used in the Mature and Old Growth Condition Assessment and associated data sources.*

***Table A5.3.—****Ranges of continuous scores used to define the condition and threat classes used to characterize output scores from the Mature and Old Growth Condition Assessment (MOGCA) model. Good (poor) ecological conditions are aligned with lower (higher) threats.*

***Table A7.1.—****Map class thresholds for the continuous model outputs for the National BP and Anderegg maps.*

***Table A7.2.—****Proportion (total and averaged annually) of NFS and BLM forest burned by moderate to high-severity wildfires. Historical data for Monitoring Trends in Burn Severity only extends back to 1984.*

# Appendix 1 – Recent Government Actions

## Executive Order 14072

On April 22, 2022, **E.O. 14072 (also known as "Strengthening the Nation's Forests, Communities, and Local Economies")[1] instructed the Department of the Interior, Bureau of Land Management (BLM) and U.S. Department of Agriculture (USDA), Forest Service to implement a set of actions focused on the health of the Nation's forests.** This Executive order focuses on the role of mature and old-growth forests on Federal lands in supporting healthy, prosperous, and resilient human communities. It directs the Secretary of the Interior and the Secretary of Agriculture, to:

1. Define, identify, and complete an inventory of mature and old-growth (MOG) forests on Federal lands, accounting for regional and ecological variations, as appropriate.
2. Coordinate conservation and wildfire risk reduction activities, including consideration of climate-smart stewardship of MOG forests, with other executive departments and agencies, States, Tribal Nations, and any private landowners who volunteer to participate.
3. Analyze the threats to MOG forests on Federal lands, including from wildfires and climate change.
4. Develop policies, with robust opportunity for public comment, to institutionalize climate-smart management and conservation strategies that address threats to MOG forests on Federal lands.

Threats to MOG forests specifically mentioned in the Executive order included wildfire (specifically catastrophic), decades of fire exclusion, insect infestations, disease, and climate change.

## USDA Secretary's Memo 1077-004

On June 23, 2022, this memo titled **Climate Resilience and Carbon Stewardship of America's National Forests and Grasslands[2]** (issued by the Secretary of Agriculture) highlighted that climate impacts, in combination with a legacy of fire exclusion and other past management practices, have already caused severe disruptions in natural forest ecosystems. As an example, in fire-frequent forests, more than a century of fire exclusion has caused them to become significantly different from their natural structural/compositional conditions and more vulnerable to uncharacteristic and catastrophic wildfire. The climate crisis is exacerbating unhealthy forest conditions through widespread drought, insect and disease mortality, and an increase in extreme weather events. It stated that timber harvesting was once a primary threat to old-growth forests on national forests but is no longer a threat compared to catastrophic

[1] https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/
[2] https://www.usda.gov/directives/sm-1077-004

wildfires and other disturbances resulting from the combination of climate change and past fire exclusion as discussed above. This memo stated that *"The appropriate science-based practices that will sustain resilient forests and stabilize forest carbon are place specific,"* and it called for spatially identifying risks to ecosystem values to inform decision making. Following completion of the MOG forest inventory report in response to E.O. 14072, Section 2(b), the memo recommended measures to protect, maintain, restore, and cultivate MOG forests within the National Forest System, grounded in science, considering a range of management strategies, and recognizing complementary opportunities and tradeoffs with other ecosystem values including water, wildlife, and biodiversity and social values such as wildfire risk to communities and source-water watersheds.

## Tribal and Alaska Native Corporations Consultation

In December 2022, Government-to-Government consultation was initiated and will continue throughout the agencies' response to Section 2(b) and Sections 2(c).ii and 2(c).iii of E.O. 14072. Consultation on actions may be requested at any time and the timelines for consultation on those actions will be made available as they arise. Consultation will remain open and ongoing throughout the entire effort.

## Proposed Rule on Conservation and Landscape Health

On April 3, 2023, the BLM published a proposed rule that gave the public an opportunity to comment on proposed new regulations to ensure the health and resilience of BLM lands. The proposed Public Lands Rule focuses on protecting intact landscapes, restoring degraded habitat, and making wise management decisions based on science and data. It is designed to ensure healthy wildlife habitat, clean water, and ecosystem resilience so public lands can resist and recover from disturbances like drought and wildfire. The notice for the proposed rule stated that pursuant to E.O. 14072, the BLM is working on various aspects of ensuring that forests on BLM lands, including old and mature forests, are managed to: promote their continued health and resilience; retain and enhance carbon storage; conserve biodiversity; mitigate the risk of wildfires; enhance climate resilience; enable subsistence and cultural uses; provide outdoor recreational opportunities; and promote sustainable local economic development. Questions it posed to the public included "What additional or expanded provisions could address this issue in this rule?" and "How might the BLM use this rule to foster ecosystem resilience of old and mature forests on BLM lands?"

In response to these questions, many comments were received emphasizing the need to protect old-growth and mature forests as part of meeting the proposed rule's stated purpose of ensuring ecosystem resilience on public lands. Commenters recommended adding provisions to the rule to establish emphasis areas for old-growth and mature forests, limit or prohibit tree cutting on BLM-managed lands, facilitate designation of old-growth forests as Areas of Critical Environmental Concern (ACECs), and focus on climate sustainable logging. Commenters

highlighted the scientific and social values of old-growth and mature forests and requested explicit language in the rule to protect these valuable ecosystems consistent with E.O. 14072. BLM published the final rule on May 9, 2024, with an effective date of June 10, 2024.[3]

# The Mature and Old-Growth Forest Inventory

On April 21, 2023, the Forest Service and BLM released a technical report on the definitions, identification, and initial inventory of mature and old-growth forests on National Forest System and BLM forest lands (revised April 2024)[4] (USDA and DOI 2023—hereafter, referred to as the mature and old-growth forest inventory report). This report was the product of E.O. 14072, Section 2(b) and is the first national inventory of mature and old-growth forests on National Forest System (NFS) and BLM forest lands. It documented that these forests are generally widely distributed geographically and across Congressional designated land use allocations. A definitional framework led to detailed quantitative criteria, using measurable structural characteristics that were applied to specific regions and forest types. Applying these criteria to Forest Inventory and Analysis (FIA) field plot data, NFS and BLM forest lands collectively contain 33.1 +/- 0.4 million acres of old-growth and 80.8 +/- 0.5 million acres of mature forest, at a 68-percent confidence interval. Old-growth forest represents 19 percent and mature forest another 45 percent of all forested land managed by the two agencies. To address the Secretary's memo "place specific" direction, FIA estimates were produced for firesheds that contained NFS and BLM forest lands (see glossary). This effort produced peer reviewed scientific publications documenting the methods developed and used for this inventory (Gray et al. 2023, Pelz et al. 2023, Woodall 2023).

# Advance Notice of Proposed Rulemaking

Also in April 2023, the Forest Service published an Advance Notice of Proposed Rulemaking (ANPR). The ANPR gave the public an opportunity to explore new tools, like the Climate Risk Viewer (web link), and to provide input on how the Forest Service should respond to the climate crisis through management activities and possibly future policies. It included the following two questions specifically informing outcomes of E.O. 14072:

1. How might the Forest Service use the mature and old-growth forest inventory—together with analyzing threats and risks—to determine and prioritize when, where, and how different types of management will best enable retention and expansion of mature and old-growth forests over time?
2. Given our current understanding of the threats to the amount and distribution of mature and old-growth forest conditions, what policy, management, or practices would enhance ecosystem resilience and distribution of these conditions under a changing climate?

Based on initial analysis of the 92,000 public submissions, protections for mature and old-growth forests were the most commonly expressed statement. Recommendations included a temporary moratorium on logging until longer-term conservation and management strategies

[3] https://www.federalregister.gov/documents/2024/05/09/2024-08821/conservation-and-landscape-health
[4] https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Mature-and-Old-Growth-Forests.pdf

have been established. Other submissions indicated that MOG forests should not be actively managed and should be "chainsaw free, livestock free, connected, and fire inclusive and should be protected from logging, mining, grazing, and oil and mineral development." Several submissions recommended special designations to ensure protection of MOG forests, including designation as carbon reserves. Analysis of comments and refinement of recommendations is ongoing.

# Appendix 2 – Forums and Engagements

Throughout July 2023, the Forest Service and BLM conducted eight meetings to systematically engage more than 600 Forest Service and BLM employees and an estimated 170 members of the general public, 70 advocacy group members, 70 scientists, 60 other government employees, 60 industry members, and about 20 people from other user groups. Almost 1,000 people learned and shared their views about the MOG initiative. The sessions were an opportunity for participants to share thoughts and concerns and to ask questions.

The engagement sessions focused on the MOG threat analysis framework provided findings from the forest inventory report and information about its future refinement. Robust engagement and individual conversations with stakeholders resulted in vigorous and often competing narratives.

Based on engagement feedback, additional data layers (for example, timber mill infrastructure, adjacent land use change, source watersheds) were considered. It was also suggested that threat identification and management implementation would be helped by spatially providing MOG inventory at a finer spatial scale. Several potential partnerships in collaboration with the agencies are examining approaches that might provide greater granularity for the MOG inventory. Additionally, as outlined in the forest inventory report, Forest Service regions and districts will apply other approaches to operationalize the Forest Inventory and Analysis-based national inventory. Participant feedback illustrated that it will be important for the threat analysis report to show that a system driver or stressor can be one person's threat and another person's solution, depending on the forest ecosystem and the individual's priorities and perceptions. The following are some highlights of feedback received:

- **Timber Harvest and Active Forest Management**
    - Place a moratorium on all MOG harvesting to better retain and enhance carbon sequestration and storage.
    - Retain and enhance carbon storage, while continuing to harvest MOG.
    - Timber harvesting is the only threat to MOG that we can control, and we should stop doing it.
    - Analyze timber harvest and other forms of active forest management as a threat.
    - Harvesting is not a threat to MOG, continue to produce lumber domestically.
    - A policy would have a negative impact on rural forest-based communities.
    - A policy might impact resource use and timber output.
- **Fire**
    - Fire is a benefit to MOG conservation, not a threat.
    - Fire suppression compromises forest resiliency and MOG.
    - Fire is the biggest threat to MOG.
    - Prescribed fire and backburns are widely used without considering the impact on MOG and so consume significant acres of MOG.
- **Carbon Storage and Emissions**
    - Harvesting, and the roads required, increase carbon emissions, reduce carbon storage, and increase the likelihood of wildfires.

    - MOG sequesters and stores the most carbon.
    - Young vigorous forest store carbon more quickly.
    - Wood products play an important role in sequestering carbon.
- **Tribal and Cultural**
    - Integrate Western science and Indigenous Knowledge.
    - Inform and work with Tribes and Alaska Native Corporations.
    - Co-stewardship is important.
- **Threats**
    - Natural disturbances, policies that restrict MOG treatment pace and scale, timber harvest, anthropogenic activities (for example, logging, prescribed burns, plantation management, roads), and nonnative species encroachment are threats to MOG.
    - Activities on State and private lands adjacent to Forest Service and BLM lands are threats.
    - Expansion of the wildland-urban interface is a threat to MOG.
- **Special Designations/Protections**
    - Designations to meet 30x30 Executive Order 14008 are needed.
- **Forest Service Land Management Plans and BLM Resource Management Plans**
    - Management plan guidance conflicts with ANPR and mature and old-growth forest initiative.
    - Use the results of the initial MOG inventory during forest and project planning to support diverse ecosystems.
    - Use management plans to manage, monitor, and adapt MOG management.
    - There would be no issues if management plans were fully implemented.

Attendees at the engagement sessions were also asked to answer two questions about MOG benefits and threats. While not a random sample, asking the questions provided an additional opportunity for feedback. Nearly 200 Forest Service and BLM employees, more than 30 members of the public, and less than 20 members each from the other attendee groups provided answers. Overall, stakeholders most frequently named ecological processes, habitat, ability to store and sequester carbon, and recreation as benefits from MOG. The most commonly mentioned threats were logging, improper/lack of management, climate change, and wildfire. Generally, Forest Service and BLM employees identified wildfire, insects and disease, and climate change as the biggest threats to MOG.

Forest Service and BLM employees were asked a slightly different second question than that asked of stakeholders. Employees were asked to comment on what they see as challenges to managing MOG. Communication with the public and public perceptions as well as litigation, appeared most frequently. There were also numerous responses about shortcomings in planning tools, lack of planning clarity/agreement, restrictions on management, and mismanagement.

# Tribal and Alaska Native Corporations Forum

On July 12, 2023, the Forest Service held a Tribal and Alaska Native Corporation forum on the agency's implementation of the **Advanced Notice of Proposed Rulemaking** *Climate Resilient Forests and Grasslands*, **Secretarial Memo 1077-004** *Climate Resilience and Carbon Stewardship of America's National Forests and Grasslands*, and **Executive Order 14072** *Strengthening the Nation's Forests, Communities, and Local Economies*. Representatives from the National Forest System spent approximately 2 hours sharing information on all 3 topics followed by a discussion. The following is some of the key feedback that was received:

Several Tribal organizations, working groups, efforts, and/or initiatives focus on climate change. The agency should consider engaging with these efforts, connecting Tribal and Forest Service scientists to inform climate change approaches and policies:

- Active engagement with individual Tribes is essential to the respectful application of Indigenous Knowledge.
- Engagements should occur at the most local level possible and local relationships should be prioritized.
- Non-timber forest products (for example, food systems) are important and must be prioritized in addition to timber.
- Data sovereignty must also be addressed and incorporated as Indigenous Knowledge is incorporated into policy and climate change resilience practices.
- The Forest Service should clarify the definition being used for Indigenous Knowledge.
- Clarity is needed on how the agency will consider and account for the breadth, depth, and diversity of Indigenous Knowledges within policy.

Responses from Forest Service panelists included the following:

- The agency sponsored Tribal roundtables in winter 2023/spring 2024 for Tribal representatives to interact with each other and dialogue around appropriate application of Indigenous Knowledge—as well as commonalities and differences in Indigenous Knowledges.
- Mature forests are the 'clay' with which to sculpt old growth. The agency is seeking a deeper understanding of how to mold that clay through active engagement with Tribal leaders and people scaled to local levels. The term 'accountability to place' resonated with the agency panelists.
- Forest Service panelists agreed that early and meaningful InterTribal engagement with Tribes and community members is an important factor in relationship building, and this needs to be accounted for in policy and project development. Creating national policies, approaches, and expectations that drive interactions at the local level is a critical task.
- The Forest Service has and will continue to encourage local Native-led groups as they work to develop climate adaptation menus by making expectations clear at the national level.

- If the effort moves forward into a proposed rule and Indigenous Knowledge is included as a definition, the agency wants to ensure that Tribal perspectives are incorporated and wants to address diversity in Indigenous Knowledges.
- Addressing Tribal data sovereignty is an important part of incorporating Indigenous Knowledge and Western science. The agency must be respectful of Tribal sovereignty in data management.
- The Forest Service is recruiting Tribal youth professionals to help braid together Indigenous Knowledge and Western science.
- To help further connections, establishing a Native American Advisory Committee that includes Tribal subject matter experts at all levels of the agency, should be considered.

The Forest Service and BLM held informational engagement sessions in November 2023 that focused on work associated with analyzing threats to mature and old-growth forests to support policy development to reduce those threats and foster climate resilience. A Tribal forum to share the same information was held in December 2023.

# Appendix 3 – Regional Condition-Based Evaluation Worksheets

**Forest Service regions provided condition-based information using threat evaluation worksheets and templates:**

Instructions were to provide brief general descriptions in worksheets (fFigure A3.1) by region (Figure A3.2), ecological division (Figure A3.3), and forest type group (Figure A3.4):

- How extensive compared to other types;
- Xeric, mesic, moist;
- Most common tree species;
- Drivers critical to maintaining system;
- Environmental history (such as broad-scale clearcutting in the early 1900s) resulting in extensive, low-diversity mature forest;
- What social, cultural, and economic benefits are provided by this forest type? Benefits may not be solely dependent on forest type and are not necessarily uniformly distributed across a forest. Examples include, but are not limited to:
    - Tribal rights/practices (including hunting, fishing, gathering), cultural and spiritual sites;
    - Sustain rural ways of life and bases of income (for example, forage for domestic livestock, grazing, ranching);
    - Timber or biomass for sale;
    - Recreation and tourism, trail systems, aesthetics and scenery, existence value (valuing that the resource does and will continue to exist);
    - Passive human benefits (for example, carbon sequestration, climate regulation, filtration of fresh water provided to downstream uses);
    - Cultural sites, heritage, sense of place;
    - Opportunities for education and knowledge;
    - Public health (physical and/or mental), environmental quality, social relationships/spaces for interaction;
    - Include most important source citations (not exhaustive). Can be from expertise/observation, monitoring reports, literature, interfacing with the public, etc.
- Include most important literature citations (not exhaustive). Can be from expertise/observation, monitoring reports, literature, interfacing with the public, etc.

*Threat Evaluation*
*Record Adverse outcome criteria: change condition renders forest non-mature or non-old growth forest*

***Forest Vegetation Threat Evaluation: Region#*** ***VEGETATION TYPE***

**USER FORM**

FIA Forest Type Group:

Forest Service EcoMap Divisions:

Brief General Description of this vegetation:

| Driver/ Stressor | Narratives | Sources |
|---|---|---|
| 1st Driver/Stressor<br><br>Example: Fire (including wildfire of all intensity, cultural burning, and other forest treatments employing fire | General Description of driver/stressor<br>• Emphasis on disturbance processes (fine or broad scale) that influence mature/old-growth conditions across areas of one or more stands<br>• Frequency, Severity<br>• Primary influence on composition, structure<br>• Examples of well-documented social/cultural linkages to old-growth forest type<br>• Disturbances likely to influence non-dominant species (trees or others) and NOT result in changed status (still old-growth forest)<br>• How are the social, cultural, or economic benefits identified in the "Brief General Description" section impacted by this driver/stressor? | For example, (Jones 2010) |
| | Conditions determining negative (adverse) outcome<br>• Describe features of this disturbance agent that lead to negative outcomes<br>• Describe forest conditions that contribute to negative outcomes<br>• Describe interactions with other disturbance agents that contribute to negative outcomes<br>• Describe any social, cultural, or economic conditions that can or do contribute to negative outcomes | |
| | Conditions determining positive or neutral outcome<br>• Describe features of this disturbance agent that improve conditions for MOG or reduce vulnerability<br>• Describe forest conditions that that improve conditions for MOG or reduce vulnerability<br>• Describe interactions with other disturbance agents that contribute to positive or neutral outcomes<br>• Describe any social, cultural, or economic conditions that can or do contribute to a neutral or positive outcome | |
| | Summary of relative importance of this driver/stressor as a threat: | |
| | Summary of relative importance of this driver/stressor in restoration/transformation: | |
| Evaluator(s):<br><br>Reviewer(s): | | Date: |

Literature Cited

*Figure A3.1.—Example of worksheet used to document regional inputs.*

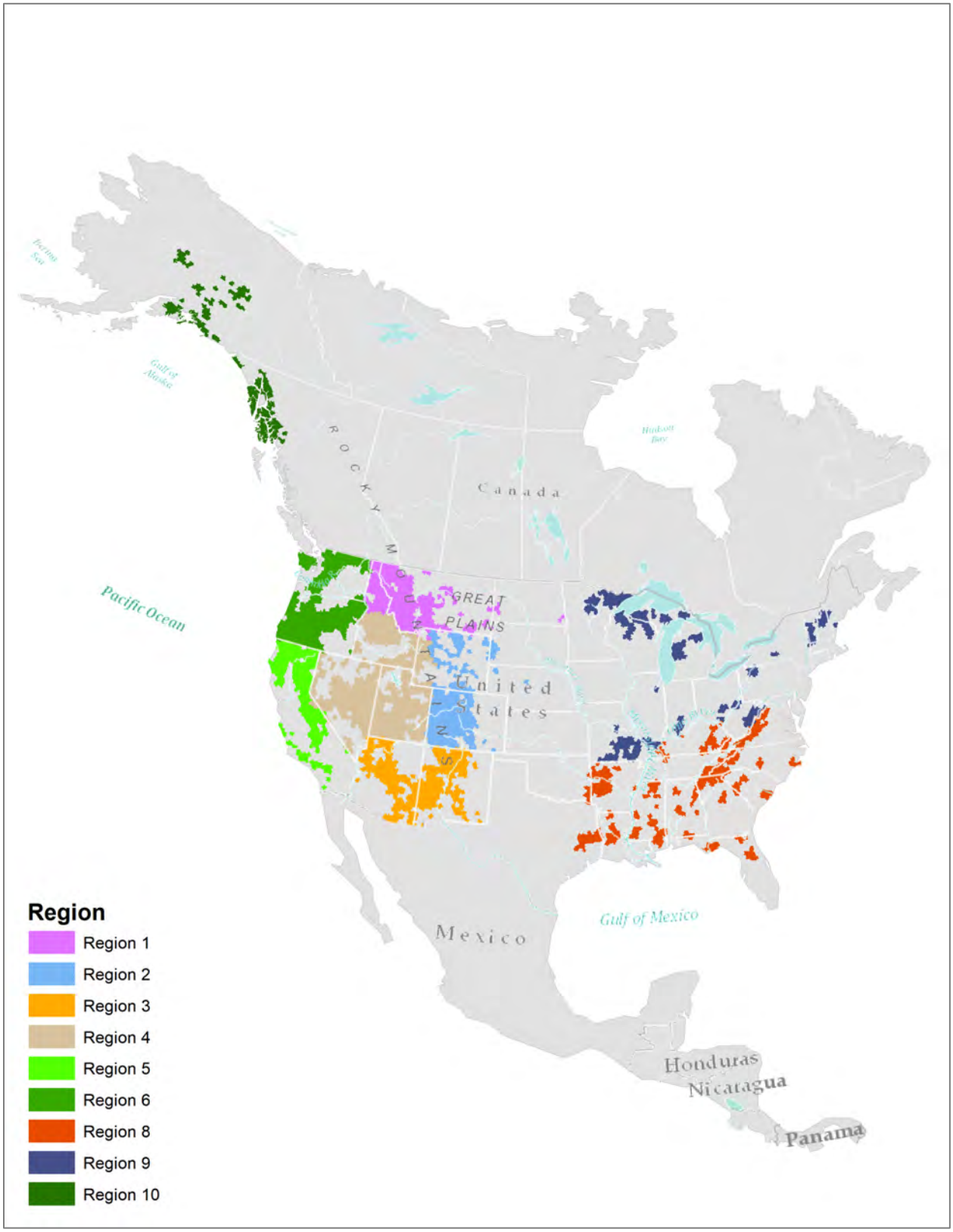



*Figure A3.2.—Fireshed map of regions.*

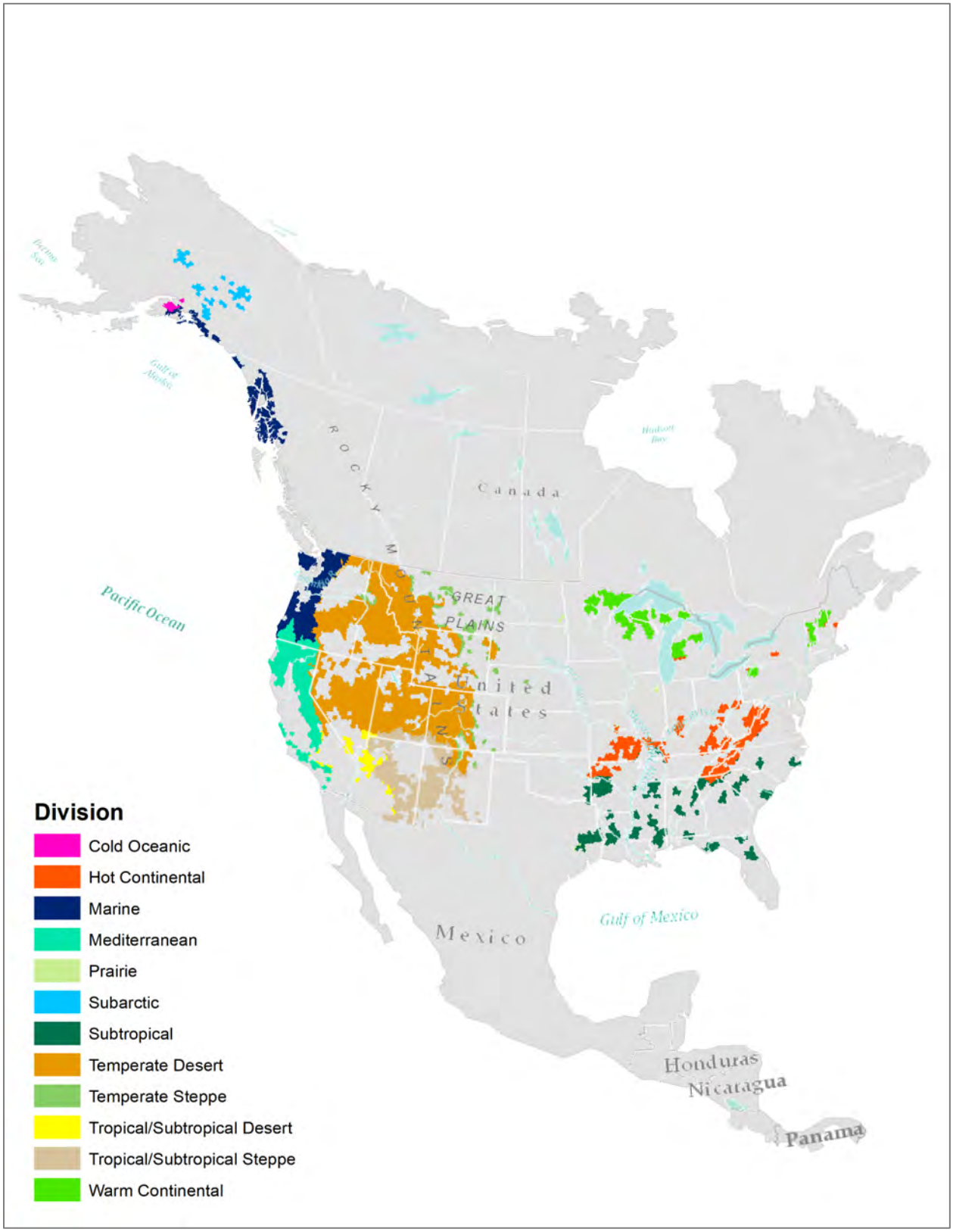



*Figure A3.3.—Fireshed map of ecological divisions.*

*Figure A3.4.—Fireshed map of forest type groups.*

# Appendix 4 – Forest Inventory Analysis Sample Plot Characteristics

Table A4.1.—Characteristics of sample plots on BLM and Forest Service lands used in the FIA plot change analysis, showing evaluations (EVALIDs), inventory years, mean plot remeasurement interval, and number of forested plots used.

| STATECD | State_name | EVALID | First measurement | Remeasurement | Mean remeasurement period (years) | N plots |
|---|---|---|---|---|---|---|
| 1 | Alabama | 12103 | 2006 - 2017 | 2014 - 2021 | 6.8 | 124 |
| 2 | Alaska (coastal) | 21903 | 2004 - 2008 | 2015 - 2019 | 11.2 | 528 |
| 4 | Arizona | 41903 | 2001 - 2009 | 2011 - 2019 | 10.1 | 1,322 |
| 5 | Arkansas | 52103 | 2012 - 2016 | 2017 - 2021 | 5.2 | 413 |
| 6 | California | 61903 | 2001 - 2009 | 2011 - 2019 | 10.0 | 2,332 |
| 8 | Colorado | 81903 | 2002 - 2009 | 2012 - 2019 | 10.0 | 1,987 |
| 9 | Connecticut | 92003 | 2009 - 2013 | 2014 - 2020 | | 0 |
| 10 | Delaware | 102003 | 2009 - 2013 | 2014 - 2020 | | 0 |
| 12 | Florida | 121903 | 2010 - 2016 | 2015 - 2019 | 6.1 | 348 |
| 13 | Georgia | 132003 | 2011 - 2017 | 2016 - 2020 | 5.5 | 373 |
| 16 | Idaho | 161903 | 2004 - 2009 | 2014 - 2019 | 9.9 | 1,647 |
| 17 | Illinois | 172103 | 2009 - 2014 | 2015 - 2021 | 6.1 | 151 |
| 18 | Indiana | 182003 | 2009 - 2013 | 2014 - 2020 | 5.9 | 82 |
| 19 | Iowa | 192103 | 2009 - 2014 | 2015 - 2021 | | 0 |
| 20 | Kansas | 202003 | 2009 - 2013 | 2014 - 2020 | | 0 |
| 21 | Kentucky | 211803 | 2005 - 2012 | 2012 - 2018 | 6.1 | 127 |
| 22 | Louisiana | 221803 | 2001 - 2012 | 2009 - 2018 | 8.3 | 111 |
| 23 | Maine | 232103 | 2012 - 2016 | 2017 - 2021 | 5.0 | 26 |
| 24 | Maryland | 241903 | 2008 - 2013 | 2013 - 2019 | | 0 |
| 25 | Massachusetts | 251903 | 2008 - 2013 | 2013 - 2019 | | 0 |
| 26 | Michigan | 261903 | 2008 - 2013 | 2013 - 2019 | 5.9 | 989 |
| 27 | Minnesota | 271903 | 2010 - 2014 | 2015 - 2019 | 5.0 | 705 |
| 28 | Mississippi | 282003 | 2009 - 2015 | 2016 - 2020 | 6.8 | 535 |
| 29 | Missouri | 292103 | 2009 - 2014 | 2015 - 2021 | 6.2 | 493 |
| 30 | Montana | 301903 | 2003 - 2009 | 2013 - 2019 | 10.0 | 1,806 |
| 31 | Nebraska | 312003 | 2009 - 2013 | 2014 - 2020 | 6.2 | 8 |
| 32 | Nevada | 321903 | 2004 - 2009 | 2014 - 2019 | 8.6 | 948 |
| 33 | New Hampshire | 332003 | 2009 - 2014 | 2014 - 2020 | 6.1 | 258 |
| 34 | New Jersey | 341903 | 2009 - 2014 | 2015 - 2019 | | 0 |
| 35 | New Mexico | 351903 | 2005 - 2009 | 2015 - 2019 | 6.8 | 819 |
| 36 | New York | 361903 | 2008 - 2013 | 2013 - 2019 | 6.2 | 5 |

| STATECD | State_name | EVALID | First measurement | Remeasurement | Mean remeasurement period (years) | N plots |
|---|---|---|---|---|---|---|
| 37 | North Carolina | 372103 | 2009 - 2015 | 2016 - 2021 | 6.6 | 210 |
| 38 | North Dakota | 382103 | 2009 - 2014 | 2015 - 2021 | 6.3 | 15 |
| 39 | Ohio | 391903 | 2008 - 2013 | 2013 - 2019 | 5.8 | 70 |
| 40 | Oklahoma | 401903 | 2009 - 2014 | 2015 - 2019 | 6.0 | 53 |
| 41 | Oregon | 411903 | 2001 - 2009 | 2011 - 2019 | 10.0 | 6,174 |
| 42 | Pennsylvania | 422003 | 2009 - 2013 | 2014 - 2020 | 6.1 | 187 |
| 44 | Rhode Island | 442003 | 2009 - 2013 | 2014 - 2020 | | 0 |
| 45 | South Carolina | 452003 | 2007 - 2016 | 2014 - 2020 | 5.4 | 279 |
| 46 | South Dakota | 462003 | 2009 - 2013 | 2014 - 2020 | 6.0 | 176 |
| 47 | Tennessee | 471803 | 2005 - 2014 | 2012 - 2018 | 6.6 | 309 |
| 48 | Texas | 481903 | 2004 - 2014 | 2014 - 2019 | 5.5 | 308 |
| 49 | Utah | 491903 | 2000 - 2009 | 2010 - 2019 | 10.0 | 2,025 |
| 50 | Vermont | 502003 | 2009 - 2013 | 2014 - 2020 | 6.1 | 154 |
| 51 | Virginia | 512003 | 2009 - 2015 | 2015 - 2020 | 5.3 | 464 |
| 53 | Washington | 531903 | 2002 - 2009 | 2012 - 2019 | 10.0 | 2,573 |
| 54 | West Virginia | 542003 | 2009 - 2013 | 2014 - 2020 | 6.0 | 342 |
| 55 | Wisconsin | 552103 | 2009 - 2014 | 2015 - 2021 | 6.2 | 528 |
| 56 | Wyoming | Custom | 2000 - 2000 | 2011 - 2019 | 15.2 | 859 |
| 72 | Puerto Rico | 721903 | 2011 - 2014 | 2016 - 2019 | 5.8 | 2 |
| 78 | Virgin Islands of the U.S. | 781403 | 2009 - 2009 | 2014 - 2014 | | 0 |
| | All | | | | 9.0 | 30,864 |

# Appendix 5 – Mature and Old Growth Condition Assessment Description and Results

## Model Description

Scientific review, public engagement, and employee dialogue identified numerous stressors and drivers that—under certain conditions—become threats to the resilience and persistence of MOG forests. While it is important to identify individual stressors and drivers along with their historical trends, current conditions, and future projections, it is also important to understand how these stressors and drivers co-occur and interact across the landscapes in which MOG is or could be located.

To better understand these stressors and drivers as interacting factors in an ecosystem, the Terrestrial Condition Assessment (TCA) was adapted to understand the ecological condition and potential threats to MOG in an integrated way. The TCA was developed by the Forest Service, and it leverages nationally consistent datasets to model ecological integrity on NFS lands at the mid-level (1:100,000) using land-type associations (LTA, units approximately 10,000 acres in size) or comparable spatial units representing ecosystems (Cleland et al. 2017, Nelson et al. 2015, Winthers et al. 2005). The TCA model is supported through the Ecosystem Management Decision Support (EMDS) logic model which provides transparency and repeatability for TCA while allowing TCA to incorporate information about the relationships between indicators and metrics of ecological integrity (Reynolds and Hessburg 2014). Since the TCA's initial development, it has been updated to better account for non-forested ecosystems on NFS lands (Anderson et al. 2020) and been leveraged to develop a key performance indicator (KPI) focused on ecological outcomes for the Forest Service (USDA Forest Service 2023).

The TCA provides one way to examine several stressors and drivers simultaneously and evaluate their collective impact. Additionally, the team that developed and maintains TCA has established processes to update the model annually to calculate and report the KPI. These methods could inform future efforts to revisit and reevaluate MOG conditions going forward. However, key differences exist between the goals and objectives of TCA and the goals and objectives laid out in E.O. 14072, Secretary's Memo 1077-004, and subsequent decisions made during the inventory of MOG:

- Time frame: The TCA models current ecological conditions. Current conditions are informed by historical trends and patterns which can identify important deviations and changes. The TCA leverages historical trends when assessing current conditions but does not make projections about future conditions. There is a distinct need to consider future conditions and future threats to MOG to identify appropriate courses of action that can mitigate potential threats.

- Spatial extent: The TCA was designed with explicit guidance to assess ecological conditions on NFS lands (Forest Service Correspondence 2012). The Executive order requires examining MOG across Federal lands which has been interpreted to define and inventory MOG for Forest Service and BLM lands.
- Analysis Scope: The TCA evaluates ecological conditions across all NFS lands which include several types of ecosystems from boreal and temperate forests to grasslands and shrublands. Physiognomic types other than forest are beyond the scope of the analysis of MOG; there is little need to examine MOG in places it does not and should not exist (e.g., grassland ecosystems).
- Analysis units: The TCA leverages LTAs where they have been mapped, and first approximations of LTAs have been modelled where LTAs are not yet available. LTAs are one level of the National Hierarchical Framework of Ecological Units (NHFEU, Winthers et al. 2005). The inventory of MOG was summarized to firesheds (which are units capturing fire risk to communities and exist outside of the NHFEU).

Based on the differences listed above, adaptations to TCA were needed to better align with the goals and objectives of the threat analysis. This led to the development of the Mature and Old-Growth Condition Assessment (MOGCA) which has key differences from the original TCA:

- Time frame: Once fully developed, MOGCA will examine both current and future conditions and threats to MOG.
- Spatial extent: The MOGCA will model ecological conditions of- and potential threats to- MOG on both NFS and BLM lands identified (at the fireshed scale) to contain MOG.
- Analysis scope: The MOGCA will focus on indicators and metrics germane to capturing potential threats to MOG and ecological conditions that could degrade MOG conditions. It will also focus only on forested areas, as defined by a forest mask layer, derived from remote sensing products.
- Analysis units: The MOGCA will be run using Project Areas which are polygons nested within firesheds. Project Areas average about 25,000 acres and range in size from approximately 9,000 to 38,000 acres, making them comparable in scale to LTAs.

The initial version of MOGCA focuses on current conditions and threats with the portion of the model devoted to future threats to be developed later. Additionally, there is potential to develop decision-support models within the EMDS framework for MOGCA to integrate information related to social, economic, and cultural values ascribed to MOG in different systems as that information becomes available.

The architecture of the model consists of a network of logic networks, in which each logic network evaluates evidence for a proposition (e.g., threat is absent) in terms of two or more logical premises or parameters (values/thresholds that define a condition, table A5.1). Each path through the logic architecture terminates in a data input that is interpreted based on the premises/parameters, and subsequently synthesized with the other data inputs for each Project Area. The model is data driven with higher level outcomes being evidence based and derived from the outcomes of the logic networks of the metrics and indicators directly tied to the data.

# Table of Parameters and Thresholds

Parameters (often referred to as thresholds) used in the MOGCA model to define scores of -1 indicating Very Poor conditions or Very High threats (depending on the indicator) and scores of +1 indicating Very Good conditions or Very Low threats (depending on indicator, table A5.1).

Table A5.1.—Parameters used in the Mature and Old Growth Condition Assessment.

| Indicator | Metrics | Parameter for −1 | Parameter for +1 | Summary Unit |
|---|---|---|---|---|
| Tree mortality | Tree mortality – most recent 5 years (2021 to 2017) | 50 | 25 | % area |
| | Tree mortality – previous 5 years (2016 to 2012) | 50 | 25 | % area |
| Uncharacteristic disturbance events | Uncharacteristically severe fire: low severity ecosystems | 20 | 0 | % area |
| | Uncharacteristically severe fire: moderate severity ecosystems | 10 | 0 | % area |
| Climate exposure | Spring temperature | 2.5 | 0 | °F changed |
| | Summer temperature | 2.5 | 0 | °F changed |
| | Fall temperature | 2.5 | 0 | °F changed |
| | Winter temperature | 2.5 | 0 | °F changed |
| | Spring precipitation (amount) | −1.0 | 0.0 | inches |
| | Summer precipitation (amount) | −1.0 | 0.0 | inches |
| | Fall precipitation (amount) | −1.0 | 0.0 | inches |
| | Winter precipitation (amount) | −1.0 | 0.0 | inches |
| | Spring precipitation (% change) | −10.0 | 0.0 | % changed |
| | Summer precipitation (% change) | −10.0 | 0.0 | % changed |
| | Fall precipitation (% change) | −10.0 | 0.0 | % changed |
| | Winter precipitation (% change) | −10.0 | 0.0 | % changed |
| | Drought | −1.5 | 0.0 | z-score difference |

| Indicator | Metrics | Parameter for −1 | Parameter for +1 | Summary Unit |
|---|---|---|---|---|
| Road density | Paved roads | 0.3 | 0.1 | Miles per square mile |
| | Light duty roads | 2.0 | 1.0 | Miles per square mile |
| | Unimproved roads | 2.5 | 1.0 | Miles per square mile |
| Vegetation successional departure | Vegetation departure index | 75 | 34 | Index value |
| Air pollution | Nitrogen (N) deposition | Ecosystem dependent | | Kilograms per hectare per year |
| Wildfire Threat to Late Seral | Cumulative expected Net Value Change (eNVC) due to wildfire | 30 | 1 | Percent of cumulative eNVC |
| Forest insect and disease hazard | Potential uncharacteristic mortality from insects and disease | 35 | 5 | % area |
| Ecological process departure | Fire deficit | 95 | 33 | % area |

The goal of MOGCA is to examine the ecological conditions and potential threats to MOG. Thus, the highest-level in the network of logic networks is Overall MOG Condition which is determined for each Project Area by making logical inferences considering:

- Current condition,
- Current threats, and
- Future threats (to be developed).

Where TCA evaluates ecological integrity (Overall Terrestrial Condition) as the absence of ecological stressors, the MOGCA model evaluates the overall MOG condition as the absence of detrimental conditions and potential threats. Along these lines, the overall MOG condition can be thought of as an inference about MOG integrity. Several stressors and drivers are relevant to understanding both ecological integrity and threats to ecosystems. Thus, the initial version of MOGCA model is leveraging indicators and metrics from the TCA because the datasets and data summaries have already been reviewed, validated, and refined at a comparable scale by subject matter experts in consultation with the TCA team (table A5.2). In the future, these different indicators will be revisited with a greater focus on mature and old growth forest to improve the alignment of metrics with factors and measures most relevant to mature and old growth conditions and functions to manage and mitigate potential loss and/or degradation. For the initial threat analysis, several metrics and supporting datasets

have been identified and incorporated into spatial overlays. Time constraints, however, did not allow for development, review, and evaluation of the parameters and model logic necessary for including these alternative metrics and data into MOGCA at this stage. The next MOGCA iteration will include these subject-matter expert identified datasets and metrics.

## Table of Model Data Sources

Indicators and metrics included in the MOGCA to assess conditions of areas with MOG which makes an assessment of the ecological integrity of these areas. All except the Wildfire Threat to Late Seral was adapted from TCA.

Table A5.2.—Indicators and metrics used in the Mature and Old Growth Condition Assessment and associated data sources.

| Indicator | Metrics | Data source |
|---|---|---|
| | **Current Conditions** | |
| Recent Disturbances | | |
| Tree mortality | Tree mortality – most recent 5 years (2021 to 2017) | FS FHAAST National Forest Pest Conditions Database |
| | Tree mortality – previous 5 years (2016 to 2012) | |
| Uncharacteristic disturbance events | Uncharacteristically severe fire: low severity ecosystems | MTBS (fire severity data) and LF BPS (expected fire severity) |
| | Uncharacteristically severe fire: moderate severity ecosystems | |
| Stressors and Characteristics of Vegetation | | |
| Climate exposure | Spring temperature | **P**arameter elevation **R**egression on **I**ndependent **S**lopes **M**odel (PRISM) Climate Group at Oregon State University |
| | Summer temperature | |
| | Fall temperature | |
| | Winter temperature | |
| | Spring precipitation (amount) | |
| | Summer precipitation (amount) | |
| | Fall precipitation (amount) | |
| | Winter precipitation (amount) | |
| | Spring precipitation (% change) | |
| | Summer precipitation (% change) | |
| | Fall precipitation (% change) | |
| | Winter precipitation (% change) | |
| | Drought | FS Office of Sustainability and Climate |
| Road density | Paved roads | USGS National Transportation Dataset |
| | Light duty roads | |
| | Unimproved roads | |

| Indicator | Metrics | Data source |
|---|---|---|
| Vegetation successional departure | Vegetation departure index | LF BPS models and succession class data using approach in Swaty et al. 2021 |
| Air pollution | Nitrogen (N) deposition | NADP TDep Measurement-Model Fusion data |
| | **Current Threats** | |
| Wildfire Threat to Late Seral* | Cumulative expected Net Value Change (eNVC) due to wildfire | Quantitative wildfire risk assessment framework using LF BPS and succession class data and response functions by FS Fire Modeling Institute |
| Forest insect and disease hazard | Potential for uncharacteristic mortality from insects and disease | NIDRM produced by FS FHAAST |
| Ecological process departure | Fire deficit | LF MFRI (expected) and historical fire records (observed) |

*FS = Forest Service; FHAAST = Forest Health Assessment and Applied Sciences Team; USGS = United States Geological Survey; NADP = National Atmospheric Deposition Program; TDep = Total Deposition Science Committee; MTBS = Monitoring Trends in Burn Severity; LF = LANDFIRE https://landfire.gov/index.php; BPS = Biophysical Settings; NIDRM = National Insect and Disease Risk Map; MFRI = Mean Fire Return Interval;*
** = Denotes layer not used in TCA*

Six indicators capturing recent disturbances and other characteristics of/stressors to forests describe the Current Condition in MOGCA:

- The ***Recent Disturbances*** (disturbance agents) logic network is composed of two indicators:
    - **Tree Mortality** describes recent tree mortality caused by various insect outbreaks and pathogens as recorded by the aerial detection surveys. Data are from the US Forest Service Forest Health Assessment and Applied Sciences Team (FHAAST) National Forest Pest Conditions Database. Two metrics characterize recent mortality events (within the last 0–5 years, 2017–2021) and mortality events that have had some time to begin recovering (i.e., occurred within 6–10 years ago, 2016–2012).
    - **Uncharacteristic Wildfire** identifies areas that experienced unnaturally severe wildfires. It leverages information from the Biophysical Settings (BpS) from LANDFIRE to determine expected burn severities depending on the type of ecosystem and compares that to observed burn severities as recorded in the Monitoring Trends in Burn Severity (MTBS) data. One metric (Low Severity) identifies areas that have been mapped with a dominant condition of low severity fire but had a moderate or high severity MTBS fire pixel in that location. Another metric (Moderate Severity) identifies areas mapped with a dominant condition of mixed-severity fire and had a high severity MTBS fire pixel in that location.

- ***Vegetation Condition*** is composed of four indicators and captures other stressors and characteristics that have the potential to degrade ecological conditions or exacerbate other stressors and disturbances:
    - **Climate** examines how much current climatic conditions (drought, temperature, and precipitation) deviate from historical norms using data from the PRISM Climate Group. For seasonal temperature and precipitation, the average of the most-recent 5 years (2021–2017) is compared to the historical record going back to 1900 (2016–1900) to understand how much warmer and drier recent climate is. Drought measures moisture deficit as a z-score over the previous 3 years (2021–2019) compared to the historical record back to 1900.
    - **Road Density** looks at the miles per square mile of three different road types with varying levels of infrastructure, development, and use: paved roads (controlled access highways, secondary highways, major connecting roads, and ramps), light duty roads (local roads and local connecting roads), and unimproved roads (four-wheel drive roads). The USGS National Transportation Datasets vector dataset of national roads is used.
    - **Vegetation Departure** is an adaptation of LANDFIRE's Vegetation Departure Index based on methods described in Swaty et al. 2021. It leverages LANDFIRE's BpS dataset to identify an expected distribution of successional classes for the analysis area of interest and compares it to the observed distribution of successional classes in that area as described in LANDFIRE's S-class dataset.
    - **Air Pollution** examines levels of nitrogen deposition from the Total Deposition product from EPA and the National Atmospheric Deposition Program (NADP). It determines where exceedances are occurring based on ecosystem-dependent critical loads documented in the National Critical Loads Database (NCLD).
    - **Terrestrial Invasive Species** are recognized as an important stressor on ecosystems that impair and deteriorate ecological conditions with the potential to degrade key characteristics of MOG. However, nationally consistent data are not available at the scale of Project Areas. Nationally consistent data are mostly available at the fireshed level; however, more time is needed to interpret this data in regard to mature and old growth forest conditions.

Recognizing when a stressor or disturbance has the potential to become a threat to mature and old growth forest is an ecosystem and location dependent determination. Certain stressors and drivers are more readily characterized in the ways that they threaten either MOG forests specifically and/or forests more broadly. Although many potential threats have been identified, three have been characterized thus far with nationally consistent data to form the basis for three indicators of current threats to MOG and/or the ecosystems in which MOG resides:

- **Wildfire Threat to Late Seral Forests** is focused on where the probability is high that wildfires would result in the loss of late seral forests. A geospatial layer was specifically developed to consider this threat using a standard quantitative wildfire risk assessment (QWRA) framework that considered both annual burn probability (BP) and

the conditional Net Value Change (cNVC) to determine the expected Net Value Change (eNVC). The cNVC leverages a series of response functions that quantify the degree of loss across six fire intensity levels based on flame lengths. LANDFIRE successional class (SClass) data were used to identify areas with late seral forests, as a proxy for MOG because it was spatially explicit at an appropriate scale for this analysis.

- **Forest Insect and Disease Hazard** identifies areas with unhealthy forest conditions based on a combination of stand and environmental characteristics making them uncharacteristically vulnerable to insect and disease outbreaks. This indicator uses the National Insect and Disease Risk Map (NIDRM) from FHAAST.
- **Fire Deficit** identifies areas burning less frequently than they did under natural disturbance regimes. Often, these missed fire cycles were due to human factors, principally fire suppression since the beginning of the 20th century. The historic mean fire return interval (MFRI) from LANDFIRE BpS is used to determine fire frequency of the natural fire regime, and it is compared to observed frequency of fire from historical fire records extending back to the 1920s.

The Future Threats component of the MOGCA model will be developed leveraging data from various scenarios and projections of future conditions identified during this initial analysis of potential threats to MOG. During this initial analysis, several groups of subject matter experts have identified different data layers regarding future conditions that inform how to understand projected trends in key climate variables (such as heat or drought) and wildfire.

Both Current Condition and Current Threat (and Future Threat, once developed) along with each indicator has its own logic network. The evaluated state of each logic network (i.e., the outcomes for each Project Area) can be displayed as a map in the EMDS application for MOG threat. The user can display as few or as many of the networks as they wish. Although EMDS output is continuous, it is easier to visualize classes, and generally the results were classified into five classes of very low (dark brown) to very high (dark green) evidence. Basing map symbology for evidence can be somewhat confusing in the MOG threat analysis context, in which we are evaluating evidence for absence of threat. This translates into very high evidence (represented by dark green) equating to very good ecological conditions and/or very low threat; conversely, very low evidence (represented by dark brown) equates to very poor ecological conditions and/or very high threat.

To better understand threats to MOG and focus the analysis, a federal forest mask was developed for summarizing datasets with finer spatial resolution (<4km). The goal was to focus on the same areas targeted in the inventory (i.e., Forest Service and BLM lands); this was identified using the basic ownership data layer filtered to areas owned by the Forest Service and BLM. Because the MOG inventory is reliable to the scale of firesheds, which are coarser than the MOGCA model (i.e., the scale of Project Areas) and many of the input datasets (raster layers with resolution as fine as 30 meters), a mask was developed to focus the analysis on areas that are forested. Based on prior work examining forest landcover layers for another application (Patterson et al. 2022), the Landscape Change Monitoring System (LCMS, Housman et al. 2022) forested land cover layer was selected with a 30-percent

probability threshold. The LCMS forested land cover layer makes use of the full LANDSAT record to identify the probability that a given pixel could be forested. The 30-percent threshold allows for areas that have had recent tree removal from human (e.g., harvest or stand improvement work) or natural (e.g., wildfire) to still be recognized as forested.

The inventory identified approximately 2,500 firesheds that contain mature and/or old growth forest. Those firesheds are composed of nearly 21,000 Project Areas, but not all those Project Areas contain forested, federally owned land. Thus, a threshold of 10 percent forested-federally owned land was implemented to identify which Project Areas to include in the analysis carried out by MOGCA model. This removed nearly 9,000 Project Areas from the analysis, reducing the number analyzed down to 11,779 Project Areas across the conterminous United States included in the modeling, which represent an area of nearly 300 million acres of land of which 76.1 percent is forested, and 55.2 percent of it is both forested and federally owned. The 165 million acres of federally forested land analyzed includes areas of young, mature, and old-growth forest.

# Future Work and Model Improvements

The Mature and Old Growth Condition Assessment (MOGCA) model is a proof of concept demonstrating the importance of considering multiple potential threats and factors that can degrade the ecological condition of MOG simultaneously. Stressors and drivers often interact with compounding effects. Examining multiple stressors and drivers simultaneously sparks questions and forces considerations that are unlikely to be made when considering factors individually. It also invites comparisons while acknowledging differences across ecosystems, forest types, and regions (both ecological and administrative).

The current version of MOGCA was developed on an extremely tight timeline. The original vision was to address both current and future conditions and potential threats and to incorporate data sources, metrics, and variables garnered from subject matter experts based on threats identified through other parts of the threat analysis and public engagement sessions. Time constraints limited progress to only identifying the key datasets and variables with subject matter experts which led to their inclusion in the spatial overlay analyses. Additional review and evaluation are necessary to determine how best to summarize these datasets to the Project Areas and to set meaningful thresholds for inclusions of these variables in the MOGCA.

Some of the datasets borrowed from the TCA are the same ones recommended by the subject matter experts consulted in the development of MOGCA. Even these datasets would benefit from further evaluation and review. Initial subject matter expert review identified key places where thresholds and result summaries could be further refined to better capture potential threats and conditions that could degrade MOG. One example of this is the thresholds used with the Insect and Disease Hazard measure which is based on the NIDRM. Initially, the data summary (percent area identified to have risk, defined as projected basal area loss greater than 25 percent caused by insects and disease over the next 15 years) was using the same thresholds as TCA (figure A5.1). Upon review with the subject matter experts, the results layer

of scores was found to be missing key areas with some remaining risk following prior insect and disease outbreaks and wildfire. With further investigation, it was clear that applying the mask of federally owned forested lands to layers removed unforested areas from the data summary unit (percent area of the Project Area) and focused the analysis on forests. The TCA is examining the whole ecosystem, including non-forested areas, which made larger thresholds more appropriate to account for areas that are not forested. In MOGCA, the masking to forested areas focuses the analysis which causes a need for lower thresholds to detect the same inputs. Refining thresholds is a process, and different objectives can favor one alternative over another. For example, recommended thresholds have been identified that help capture areas known with risk and distinguish more across areas with different levels of risk (figure A5.2a). An alternative could be to really highlight risk which could be done by setting thresholds even lower than the recommended, which causes more areas to have low scores indicating poorer ecological conditions and higher levels of potential threat (figure A5.2b).

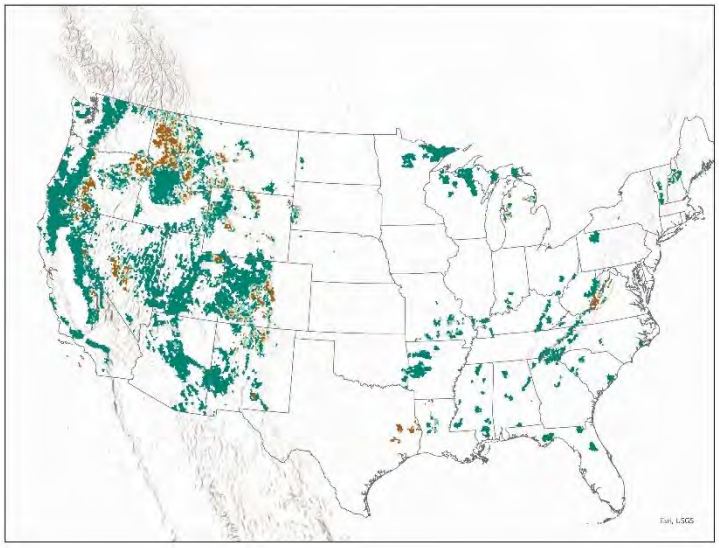
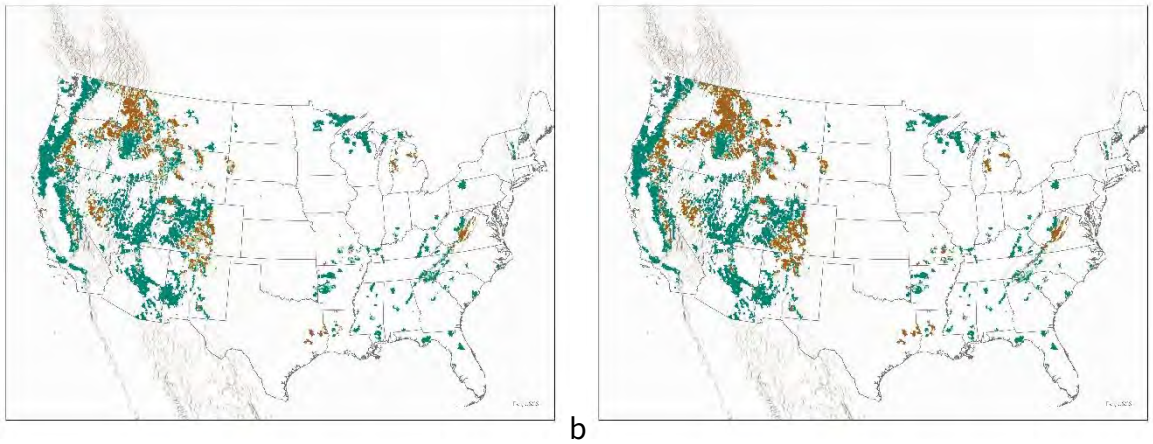


*Figure A5.1.— Map of the results generated using the initial thresholds for Insect and Disease Hazard (50% for −1 and 10% for +1). The indicator is based on data from the National Insect and Disease Risk Map. Scores are continuous, and quantiles of the continuous scores are used to create condition classes ranging from Very High (scores >=−1 and <−0.6) to Very Low (scores =<+1.0 and >+0.6) threat.*



a b

*Figure A5.2.— Different thresholds were evaluated by subject matter experts to determine the most appropriate thresholds to discern levels of threat posed by insect and disease outbreaks as depicted by the National Insect and Disease Risk Map. The thresholds recommended by subject matter experts and ultimately used by MOGCA were 35% of the analysis unit area as a threshold for −1 and 5% of the analysis unit area as a threshold for +1 (A5.2a). Other thresholds were tested including thresholds of 25% for a score of −1 and 5% for a score of +1 that highlight areas threatened but discern less across different amounts of area at risk and under threat (A5.2b).*

# Results

## Overall MOG Conditions and Potential Threats

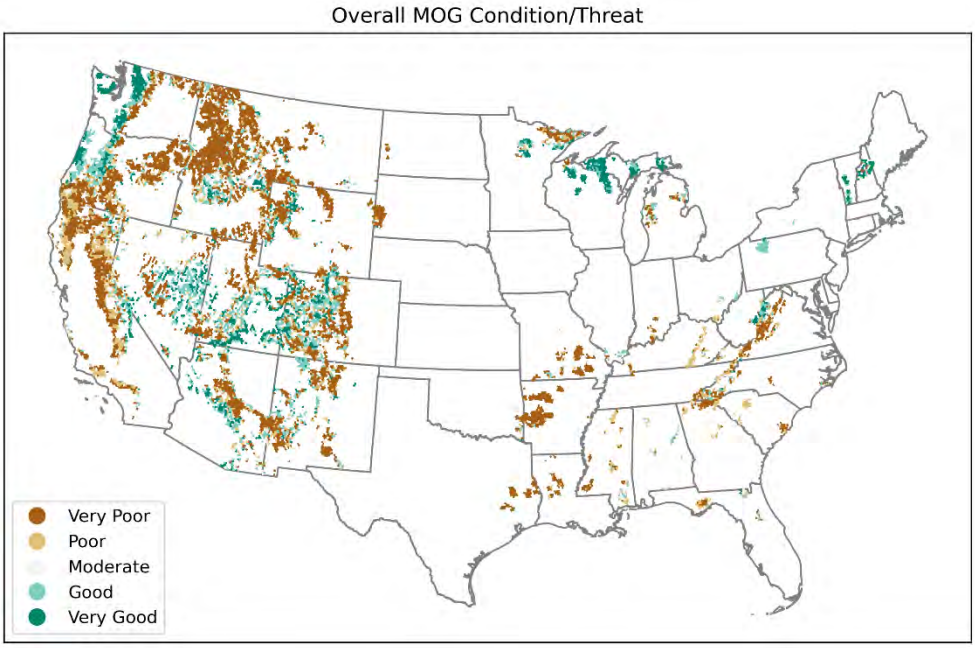



*Figure A5.3.— Map of the overall MOG conditions which depicts an assessment of the overall current integrity of Project Areas with MOG across Forest Service and Bureau of Land Management lands. Overall MOG Conditions are derived by the Mature and Old Growth Condition Assessment from a combination of current conditions and current threats.*

The overall MOG condition (current condition + current threats) varies across the country (figure A5.3). Over 5,000 Project Areas representing just under half of the federally owned forested land were rated as Very Poor for overall MOG condition (figure A5.4). The remaining

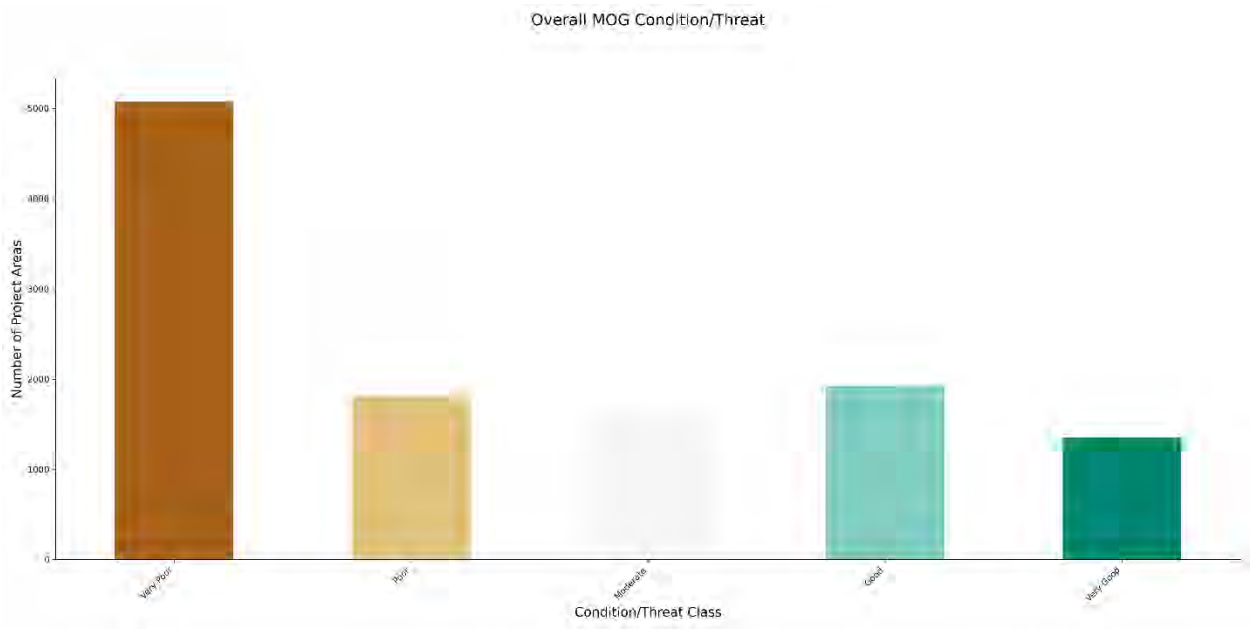
four condition classes had a relatively even distribution of Project Areas (between 1,300 and 1,900) across the remaining four condition classes. Classes represent even divisions (ranges of 0.4) of the full range of possible model scores (very highest score = +1, very lowest score =−1); these are used consistently across indicators and metrics for visualization purposes of the continuous data (table A5.3).

Table A5.3.—Ranges of continuous scores used to define the condition and threat classes used to characterize output scores from the Mature and Old Growth Condition Assessment (MOGCA) model. Good (poor) ecological conditions are aligned with lower (higher) threats.

| Condition Class | Threat Class | Range of Scores |
|---|---|---|
| Very Good | Very Low | +1.0 to +0.6 |
| Good | Low | +0.6 to +0.2 |
| Moderate | Moderate | +0.2 to −0.2 |
| Poor | High | −0.2 to −0.6 |
| Very Poor | Very High | −0.6 to −1.0 |

Overall MOG condition is driven more by Current Threats across the country than by Current Condition, except in the California mixed conifer forest type (much of California) where both Current Condition and Current Threats are contributing to overall poorer conditions and higher threats for MOG.

*a*



*b*

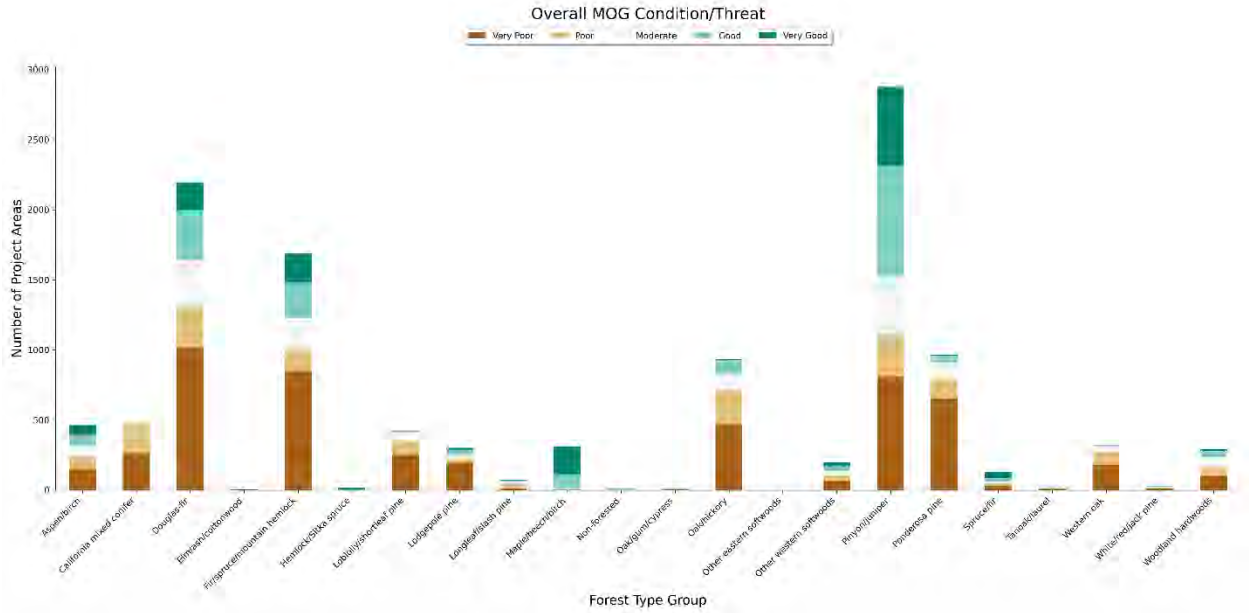



*Figure A5.4.—The Overall Mature and Old Growth Condition from MOGCA depicted by the number of Project Areas by (A5.4a) condition class and by (A5.4b) forest type group. Nationally, 5,077 Project Areas were in Very Poor condition, 1,812 in Poor condition, 1,611 in Moderate condition, 1,923 in Good condition, and 1,356 in Very Good condition.*

# Current Condition

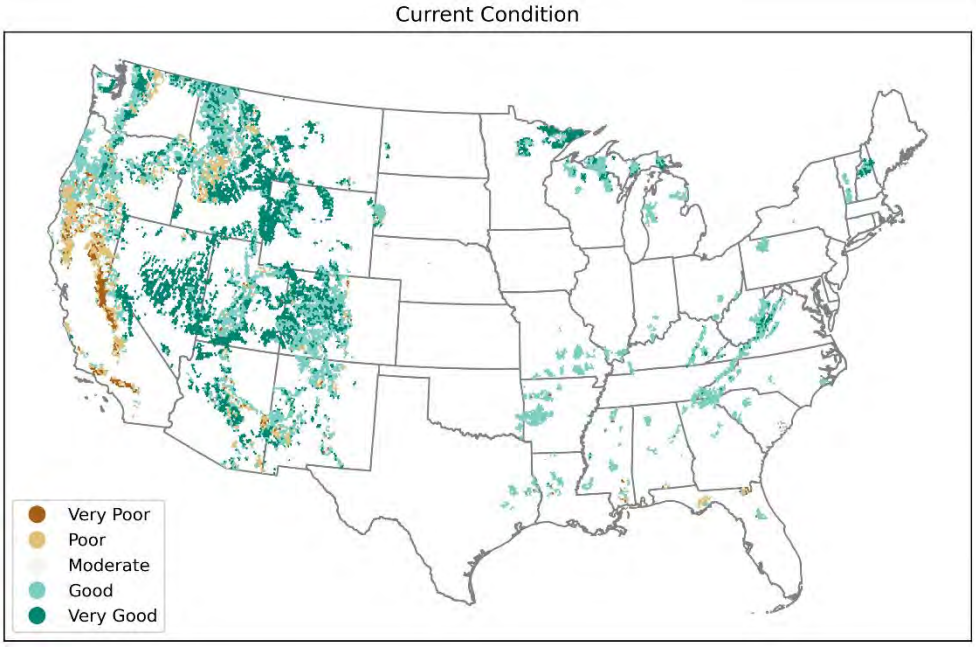



*Figure A5.5.—The Current Condition of Project Areas containing federally owned forest land from the MOGCA model. Current Condition is determined by the outcomes of Recent Disturbances and Vegetation Condition which includes various stressors and characteristics of the current forest vegetation community.*

# Recent Disturbances

## Tree Mortality from Insect and Disease Outbreaks

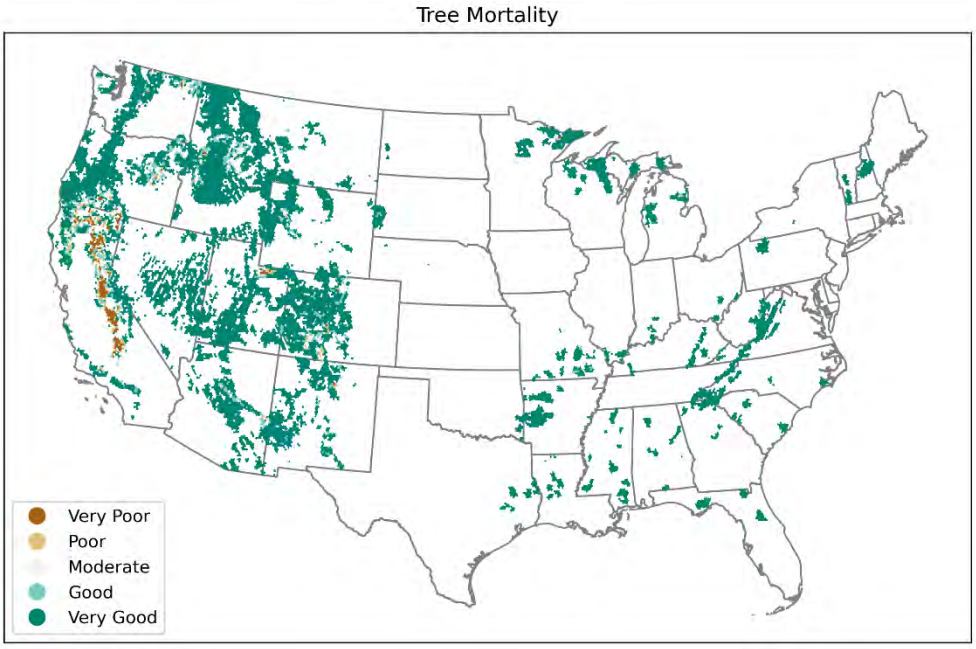
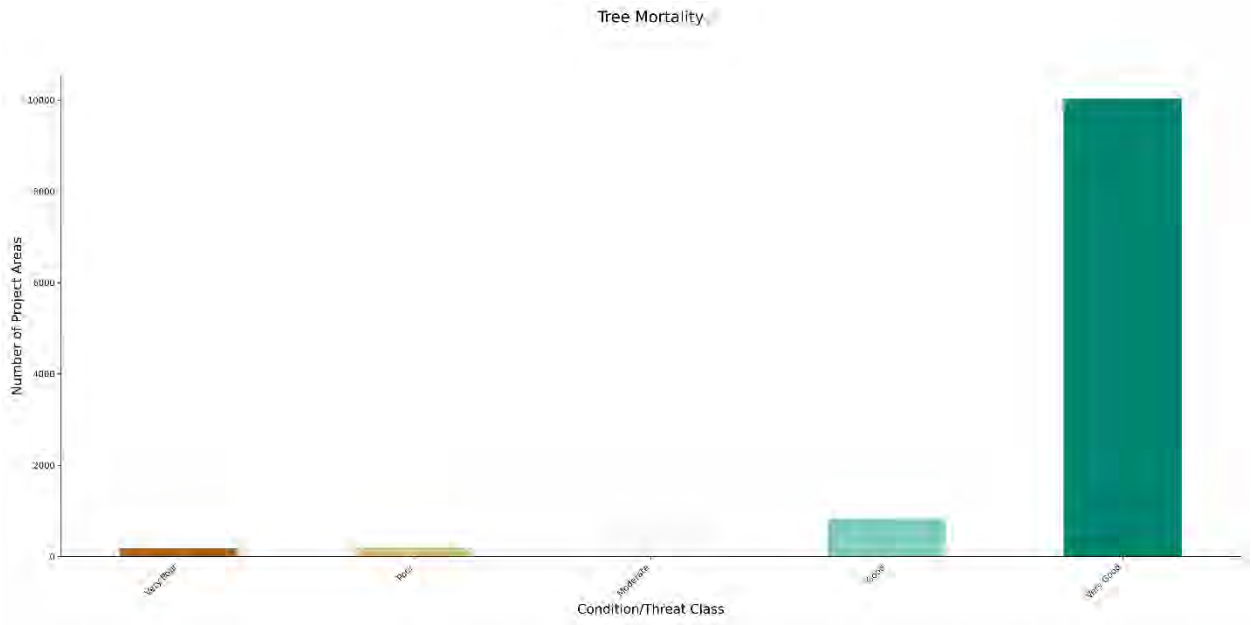



*Figure A5.6.—Mapped condition classes of the Tree Mortality indicator for Project Areas containing federally owned forest land from the MOGCA model. The Tree Mortality indicator is composed of two metrics looking at extent of tree mortality documented in the most recent five years (2021-2017) and the five years preceding that period (2016-2012).*

Although insect and disease events have occurred across the country over the last 10 years (figure A5.6), the outbreaks contributing to tree mortality events have been concentrated in the California mixed conifer forest type with some notable mortality occurring in the Fir, spruce, mountain hemlock forest type (figure A5.7b). In total, about 3 percent or 392 Project Areas had enough area experiencing tree mortality from insects and disease to be classified as Poor or Very Poor, and this represented just over 4 percent of the federally owned forested land considered in this analysis or about 6.7 million acres. This leads to more than 90 percent of Project Areas representing approximately 149 million acres of federally owned forested land having scores classified as Good and Very Good conditions where significant tree mortality was not observed during the two time periods analyzed.

*a*




*b*

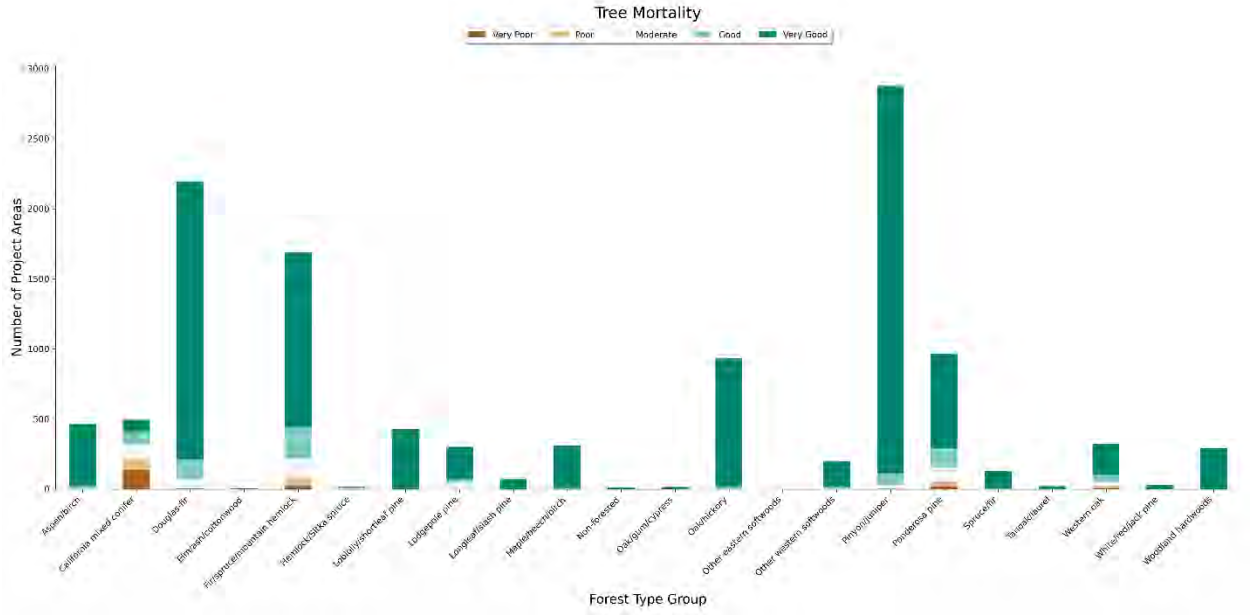



*Figure A5.7.—The number of Project Areas by (A5.7a) condition class and by (A5.7b) forest type group for the Tree Mortality indicator. Nationally, 192 Project Areas were in Very Poor condition, 200 in Poor condition, 528 in Moderate condition, 824 in Good condition, and 10,035 in Very Good condition. Most Project Areas rated as in Poor or Very Poor conditions for this indicator occurred in the California mixed conifer forest type group.*

## Uncharacteristic Wildfires

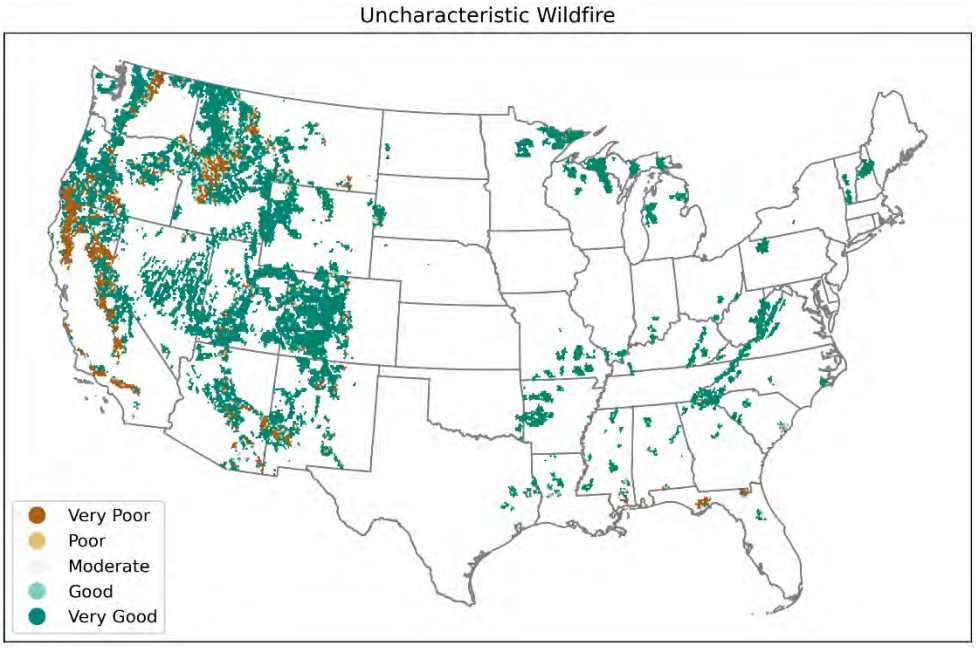
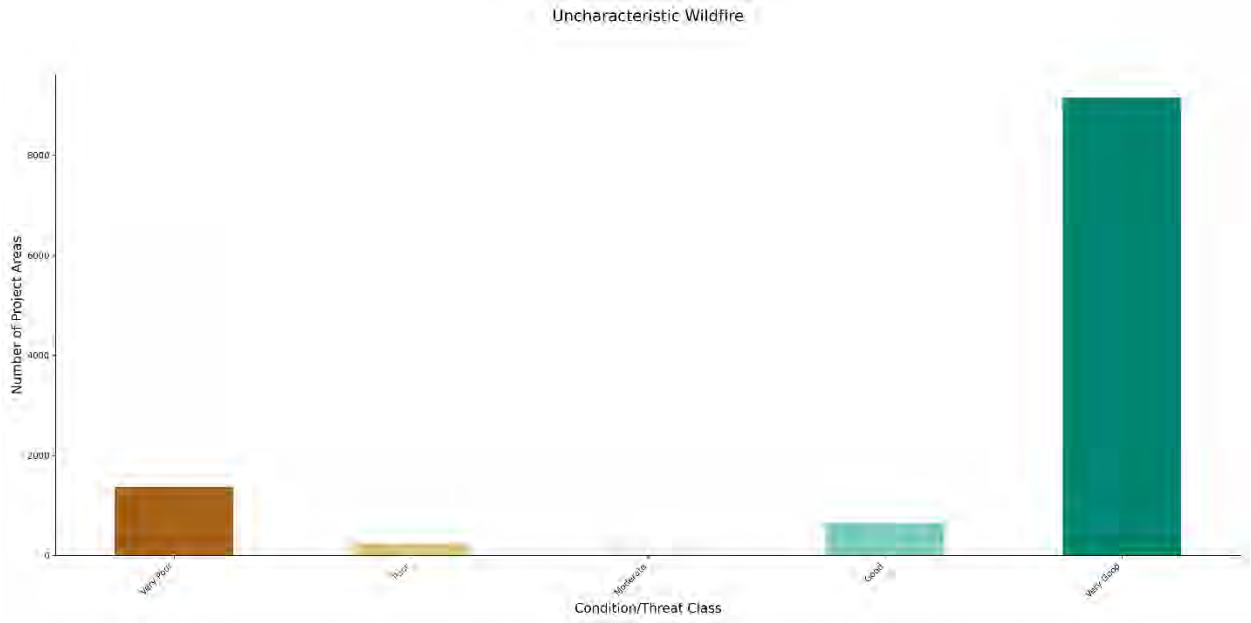



*Figure A5.8.—Mapped condition classes of the Uncharacteristic Wildfire indicator for Project Areas containing federally owned forest land from the MOGCA model. The Uncharacteristic Wildfire indicator depicts where areas have burned more severely than expected based on the historical fire regime. It is composed of two metrics: one focused on areas with ecosystems characterized by low severity fire regimes that burned at higher severities and another on ecosystems characterized by moderate/mixed severity fire regimes that burned at high severities.*

More Project Areas have experienced uncharacteristically severe wildfires than significant tree mortality from insects and disease with 1,609 Project Areas receiving scores rated as Poor and Very Poor conditions (figure 5.8, figure A5.9a); this represents over 28 million acres of federal forested lands. Lower scores indicate that more of the Project Areas have burned at a higher severity than expected for that ecosystem. Many Project Areas with uncharacteristically severe burned portions were dominated by the California mixed conifer forest type, although many Project Areas burned at uncharacteristically high severities occurred in the Western oak forest type (figure A5.9b). It is also worth noting the number of Project Areas with uncharacteristically severe fires in Project Areas dominated by Douglas fir, and Ponderosa pine forest types. These forest types that contain more uncharacteristically severe burned areas are occurring in western forest types.

*a*




*b*

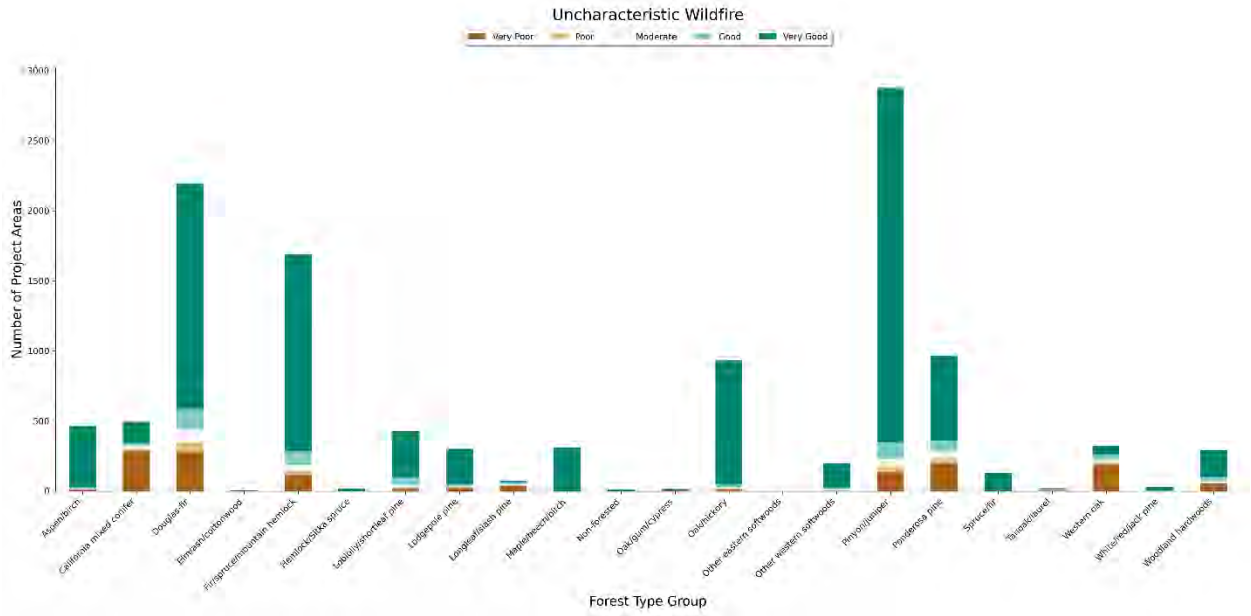



*Figure A5.9.—The number of Project Areas by (A5.9a) condition class and by (A5.9b) forest type group for the Uncharacteristic Wildfire indicator. Nationally, 1,370 Project Areas were in Very Poor condition, 239 in Poor condition, 363 in Moderate condition, 652 in Good condition, and 9,155 in Very Good condition.*

# Stressors and Characteristics of Vegetation Conditions

## Climate

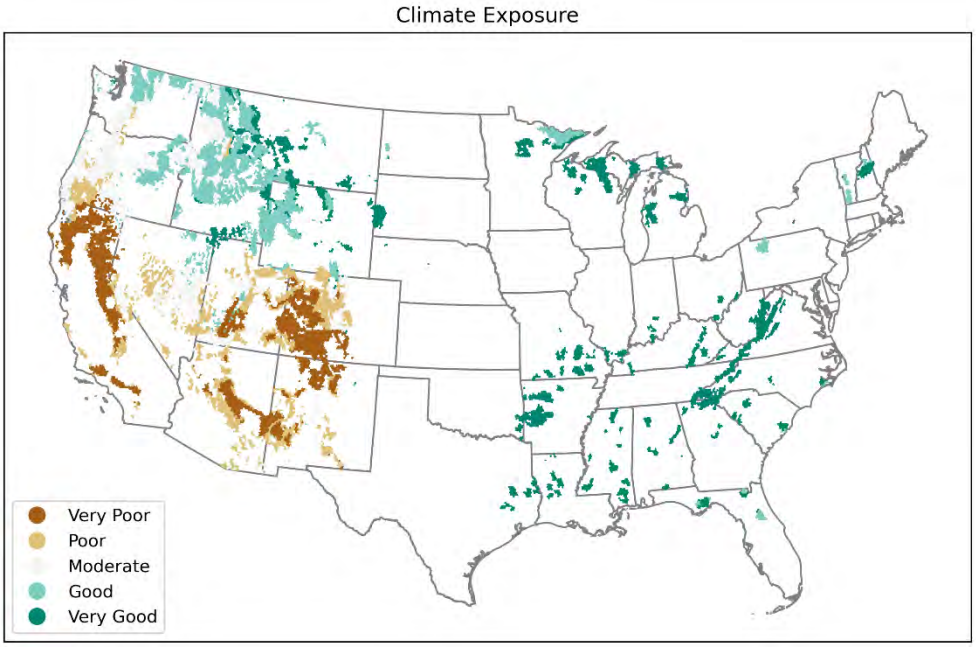



*Figure A5.10.—Mapped condition classes of the Climate Exposure indicator for Project Areas containing federally owned forest land from the MOGCA model. The Climate Exposure indicator depicts how much recent climate conditions have deviated from the historical record. It considers metrics on seasonal temperature, seasonal precipitation, and drought.*

Lower scores correspond to current climatic conditions (i.e., drought from 2021 to 2019 and seasonal temperatures and precipitation from 2021 to 2017) that are more departed from the historical baseline (climate records back to 1900), and the more departed values are interpreted to represent more stress and therefore poorer ecological conditions (figure A5.10). These more departed (with lower scores classified as poorer conditions) climate measures are concentrated in the southwestern portions of the United States with Project Areas dominated by the California mixed conifer, Pinyon-juniper, Tanoak-laurel, and Western oak forest types (figure A5.11). More Project Areas dominated by these forest types were classified as Poor or Very Poor than the other condition classes. These conditions correspond with Drought (figure A5.12) and Temperature measures (figure A5.13), especially spring, summer, and fall temperatures that are much warmer than the historical record. Warm winter temperatures have a different pattern with more eastern portions of the country showing departures from the historical record with more Poor and Very Poor ratings during this season compared to others for the Longleaf-slash pine, Maple-beech-birch, Oak-gum-cypress, and Oak-hickory forest types.

Seasonal precipitation measures indicate drier conditions are more prevalent in the West compared to the East over the recent past compared to the historical record as is indicated by lower scores representing the Poor and Very Poor condition classes (figure A5.14).

Summer conditions for both temperature (indicating warmer than the historical record) and precipitation (indicating drier than the historical record) have much more area in Very Poor conditions (scores below -0.6) than the other seasons, and those areas are predominantly in the western United States.

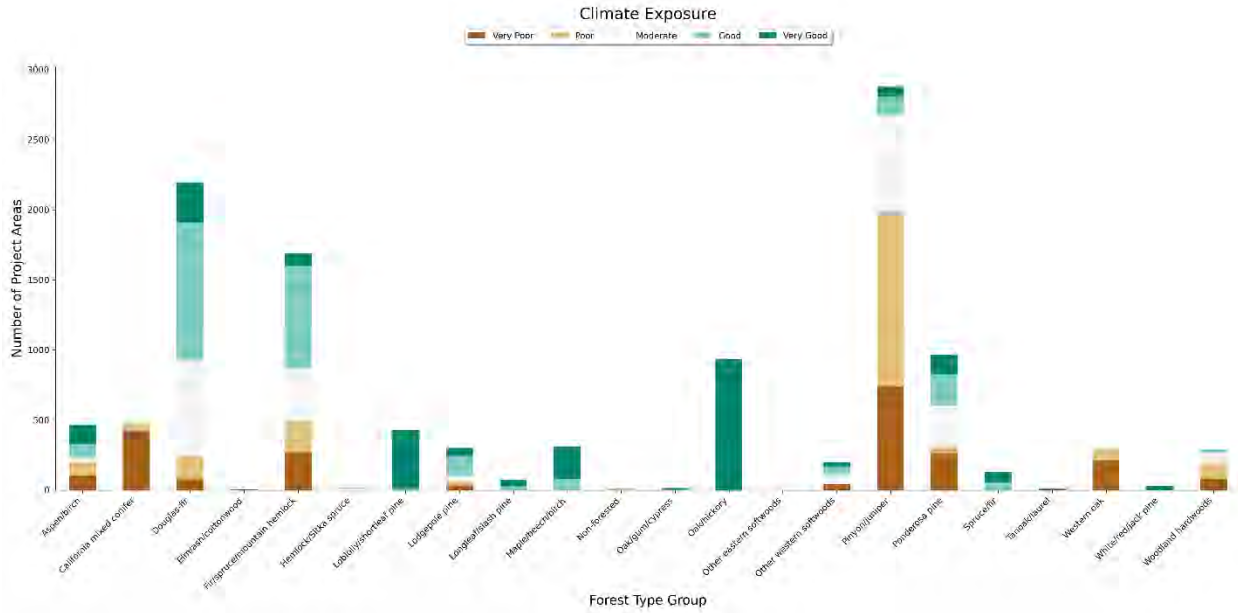



*Figure A5.11.—The number of Project Areas by forest type group and condition class for the Climate Exposure indicator. Nationally, across all forest type groups, 2,247 Project Areas were in Very Poor condition, 2,081 in Poor condition, 2,336 in Moderate condition, 2,573 in Good condition, and 2,542 in Very Good condition.*

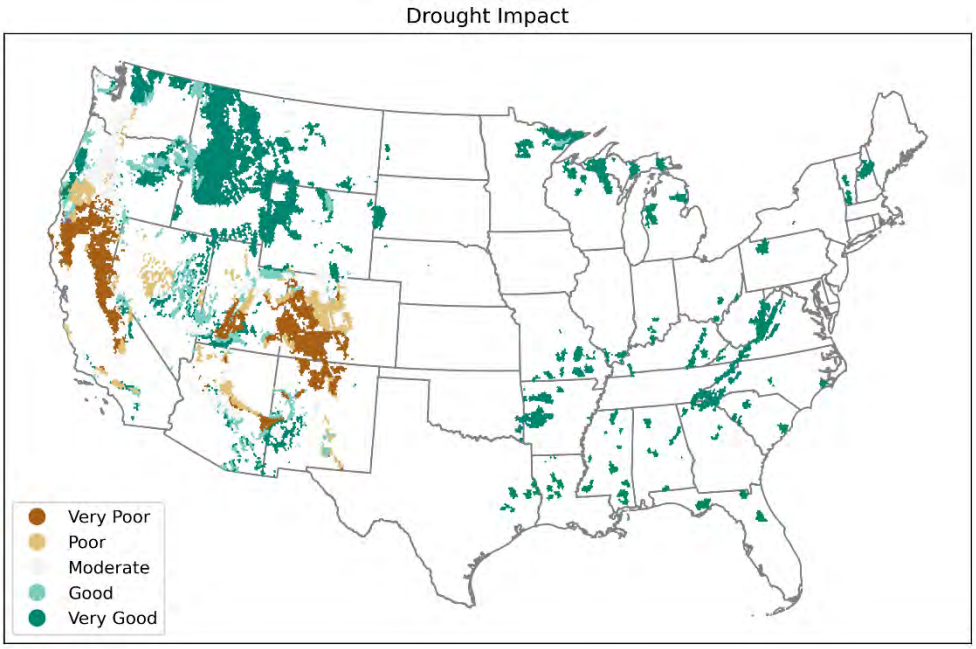



*Figure A5.12.—Mapped condition classes of the Drought metric for Project Areas containing federally owned forest land from the MOGCA model. The Drought metric examines MDZ scores over the last three years (2021-2019) compared to the historical record. It is one of 13 metrics considered in the Climate Exposure indicator in the MOGCA model.*

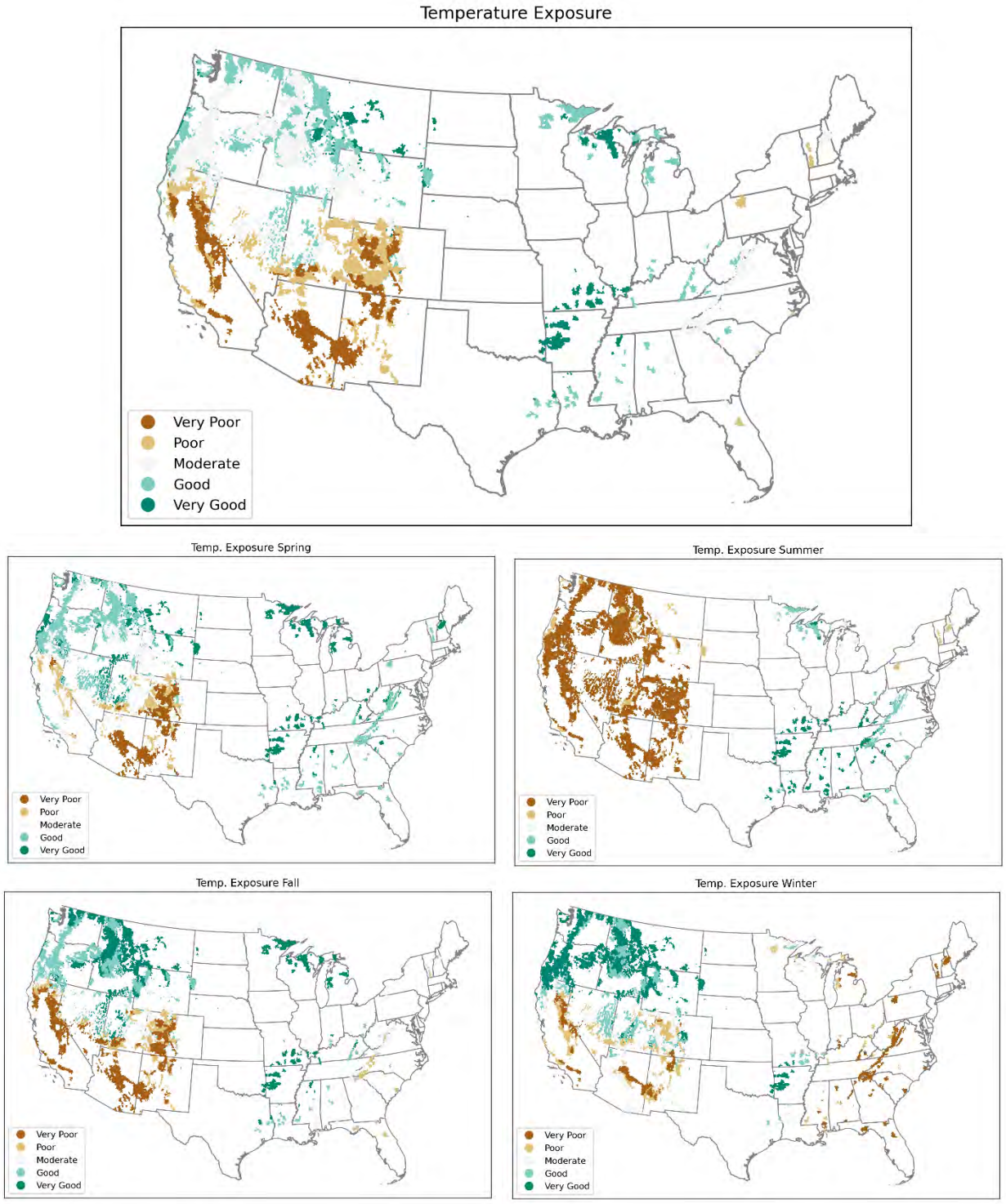



*Figure A5.13.—Mapped condition classes of the Temperature Exposure metrics for Project Areas containing federally owned forest land from the MOGCA model. Temperature Exposure is generated from four seasonal measures (Spring, Summer, Fall, and Winter) that look at average seasonal temperatures over the most recent 5 years (2021-2017) compared to the historical record.*

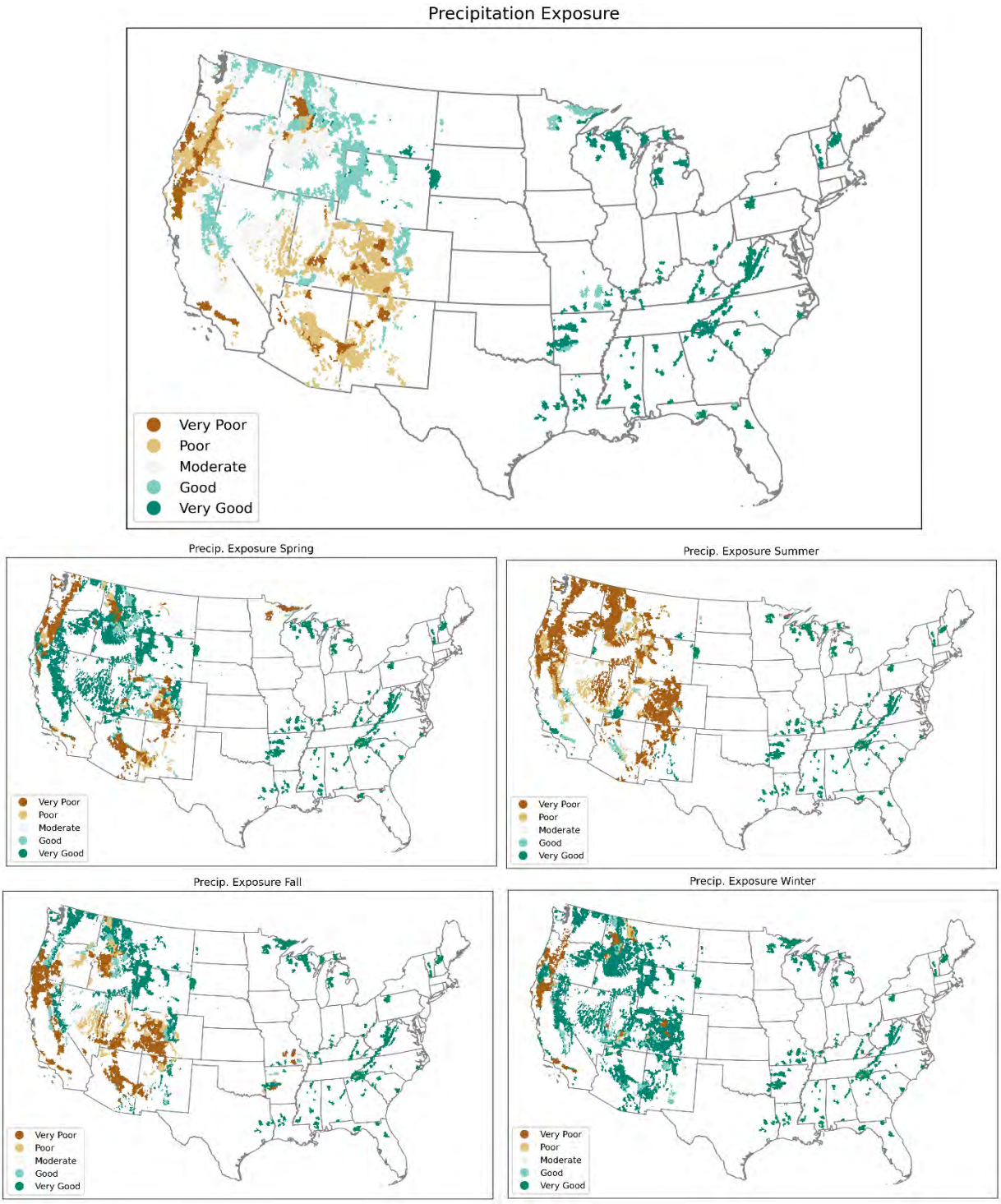



*Figure A5.14.—Mapped condition classes of the Precipitation Exposure metrics for Project Areas containing federally owned forest land from the MOGCA model. Precipitation Exposure is generated from four seasonal measures (Spring, Summer, Fall, and Winter) that look at average seasonal precipitation amounts over the most recent 5 years (2021-2017) compared to the historical record.*

## Roads

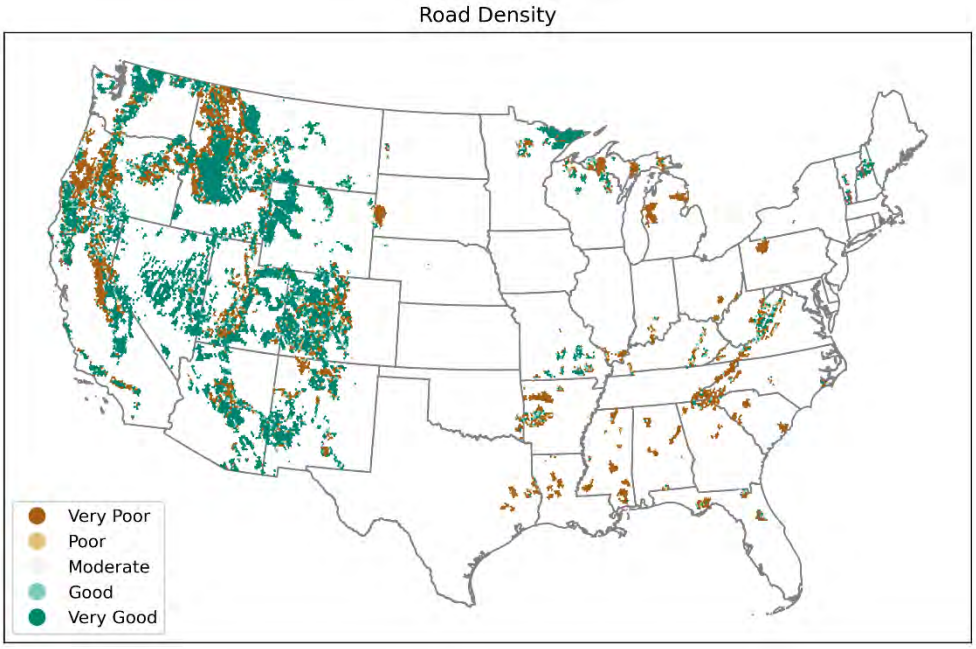



*Figure A5.15.—Mapped condition classes of the Road indicator for Project Areas containing federally owned forest land from the MOGCA model. The Roads indicators is derived from three roads metrics that capture different road types that vary in their size and volume of traffic: paved roads, light duty roads, and unimproved roads. Roads negatively impact ecological conditions by fragmenting the landscape while also providing conduits for access which is necessary to enable restoration work.*

Roads can fragment and break-up the continuity of ecosystems with numerous impacts to wildlife and ecosystem processes, most of which are adverse (Clifford 1959, Forman et al. 2003, Miller et al. 1996, Watkins et al. 2003). They provide conduits that increase the risk of fire starts and the spread of invasive species. They also can detract from characteristics perceived as important to MOG conditions such as solitude. Conversely, roads can be viewed positively from social and economic perspectives as they provide access for recreation and restoration work. Uniquely, they are an indicator that impacts most regions of the country (figure A5.15), indicated by Very Poor conditions occurring across most forest types (figure A5.16). Most notable is the Loblolly-shortleaf pine, Longleaf-slash pine, Oak-hickory, and White-red-jack pine forest types across the eastern US where the majority of Project Areas dominated by those forest type groups have scores below −0.6, indicating Very Poor conditions.

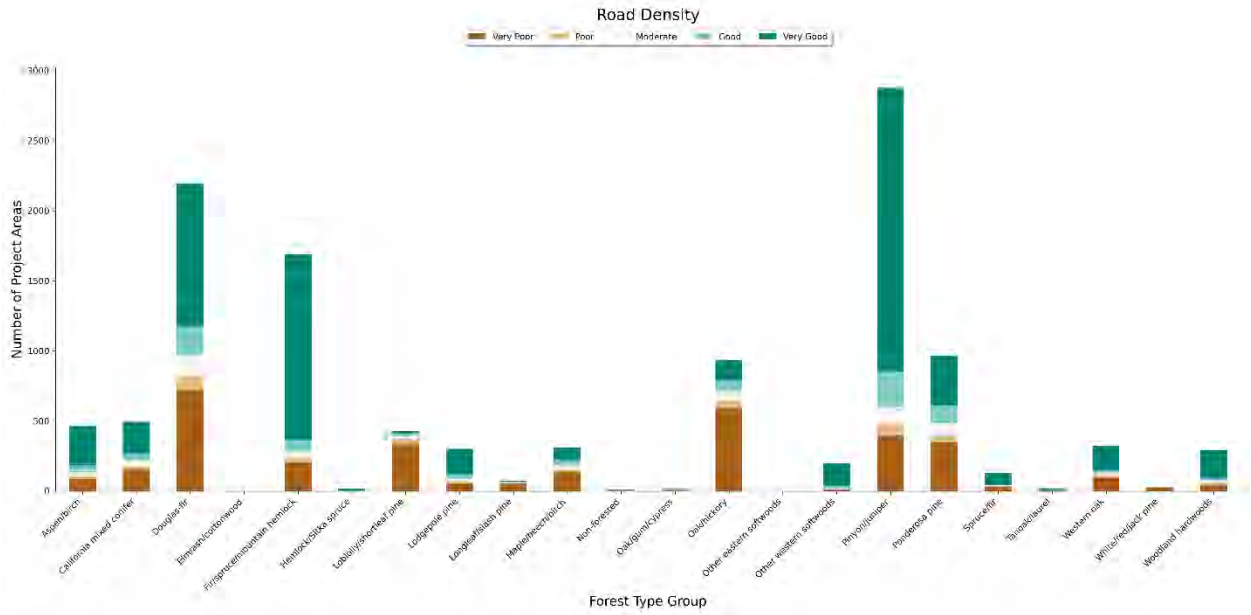



*Figure A5.16.—The number of Project Areas by forest type group and condition class for the Road Density indicator. Nationally, 3,313 Project Areas were in Very Poor condition, 489 in Poor condition, 632 in Moderate condition, 1,024 in Good condition, and 6,321 in Very Good condition.*

## Vegetation Departure

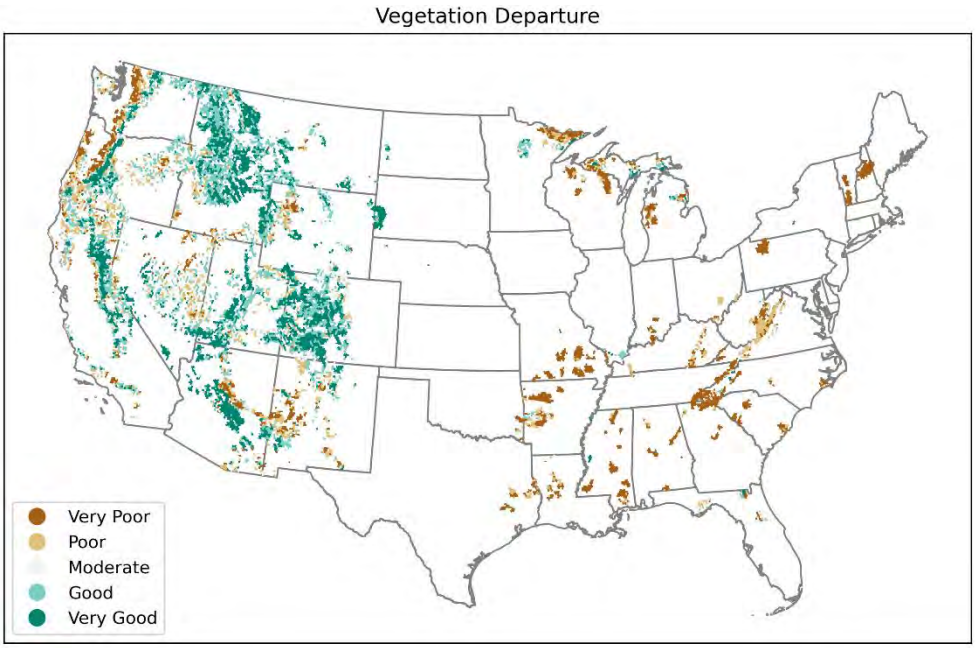



*Figure A5.17.—Mapped condition classes of the Vegetation Departure indicator for Project Areas containing federally owned forest land from the MOGCA model. Vegetation Departure depicts the departure of the distribution of observed successional classes compared to the expected distribution for that ecosystem.*

Vegetation Departure has low scores represented by Poor and Very Poor condition classes across the country (figure A5.17). This indicates that the distribution of successional classes deviates from the expected distribution for many ecosystems (as defined in the biophysical

settings from LANDFIRE, Blankenship et al. 2021). All ecosystems (i.e., individual biophysical settings) have their own expected areal distribution across successional classes, and these distributions vary widely across ecosystems. Based on the indicator scores alone, however, it is not discernable if that deviation is due to over-representation of early, mid, or late seral stages. Further examination of the input data could help elucidate this, and it may be appropriate based on management objectives to have some departure on the landscape at any given time. If departure is from an over-representation of early seral, time may be needed to remedy the departure because it will allow some areas to grow into older successional classes. If departure is from an over-representation of late seral, that may be deemed acceptable because of the time needed for late seral to develop; however, management actions might be warranted to mitigate future disturbances depending on forest type, location, and local context (i.e., management objectives, community needs, and stakeholder perspectives). If the departure is from mid-seral, it might be worth hastening the development of late seral conditions through management activities depending on forest type and local conditions or promoting early seral stages for diversity.

Understanding the expected distribution of successional classes compared to the observed informs the types of management actions needed to promote MOG conditions into the future and to ensure age-class diversity appropriate to the ecosystem which can promote ecosystem resilience for when inevitable disturbances do occur.

### Air Pollution

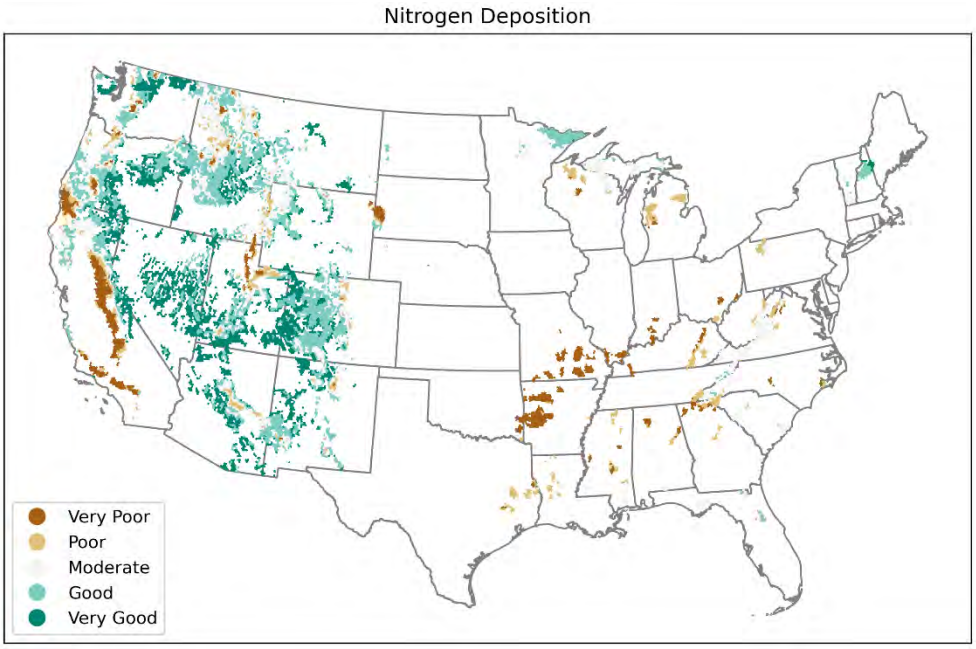



*Figure A5.18.—Mapped condition classes of the Nitrogen Deposition metric for Project Areas containing federally owned forest land from the MOGCA model. The Nitrogen Deposition metric makes up the Air Quality indicator in the MOGCA model.*

The Air Pollution indicator examines nitrogen deposition levels in the context of critical loads (i.e., levels of deposition when ecological impacts are observed) relevant to the region.

Generally, areas downwind of large population areas have lower scores indicating more exceedances of critical load levels for nitrogen deposition (figure A5.18). The critical loads used are related to decreases in biodiversity of lichens and herbaceous plants to determine initial ecological impacts from nitrogen deposition amounts elevated above background levels. Higher critical loads represent disruptions to ecological processes (e.g., hydrologic fluxes of nitrogen) and indicate more ecological impacts are likely as deposition levels increase. Most areas of the country have scores less than Very Good which indicate some level of nitrogen deposition above background rates to the point of having a likely impact on the ecosystem. More ecological impacts are more likely in areas with lower scores which correspond to higher levels of deposition.

## Current Threats

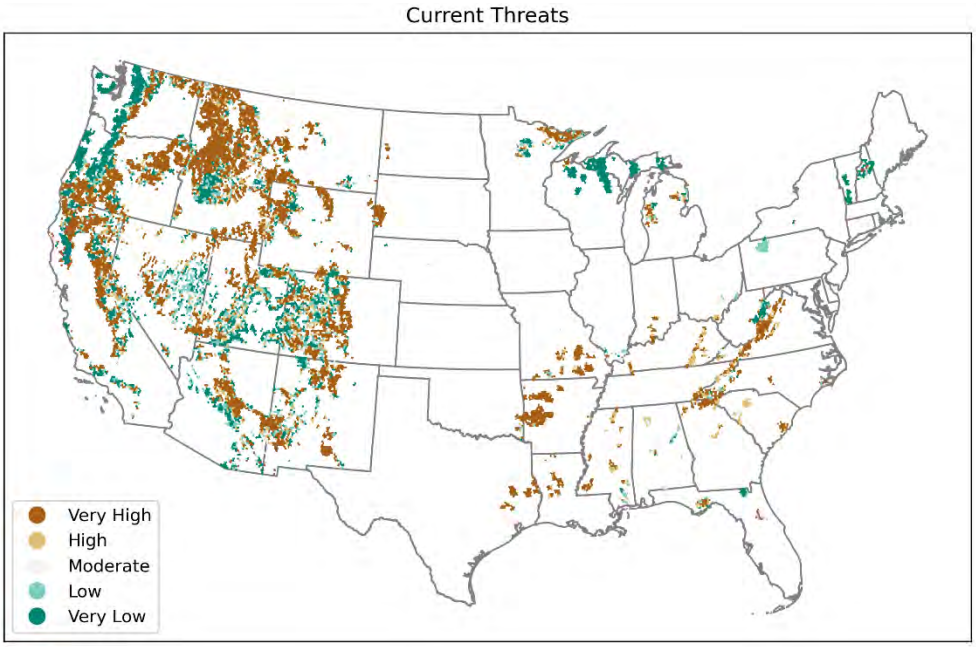



*Figure A5.19.—Mapped condition classes of the Current Threats measure for Project Areas containing federally owned forest land from the MOGCA model. Current Threats are derived from three different potential threats analyzed by the MOGCA model: wildfire, insects and disease, and fire exclusion.*

Different indicators representing different potential threats drive and contribute to the picture of the Current Threats across the country (figure A5.19). Over half of the Project Areas dominated by Fir-spruce-mountain hemlock, Ponderosa pine, Oak-hickory, Loblolly-shortleaf, Lodgepole, and Oak-gum-cypress are rated as having Very High threat (scores less than −0.6) by the MOGCA model (figure A5.20).

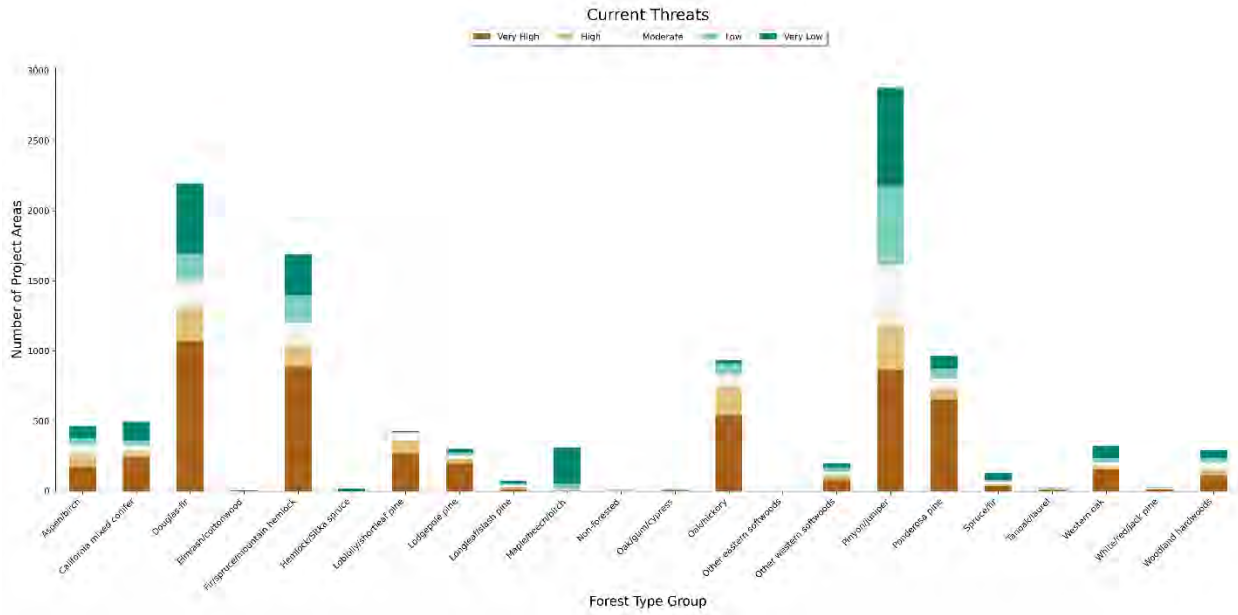



*Figure A5.20.—The number of project areas by forest type group and condition class for the Current Threat measure which is determined by the scores (outcomes) of the Wildfire Threat to Late Seral Forests, Insect and Disease Hazard, and Fire Deficit indicators in the MOGCA model. Nationally, 5,324 Project Areas were in Very Poor condition, 1,379 in Poor condition, 1,310 in Moderate condition, 1,379 in Good condition, and 2,387 in Very Good condition.*

## Wildfire Threat to Late Seral Forest

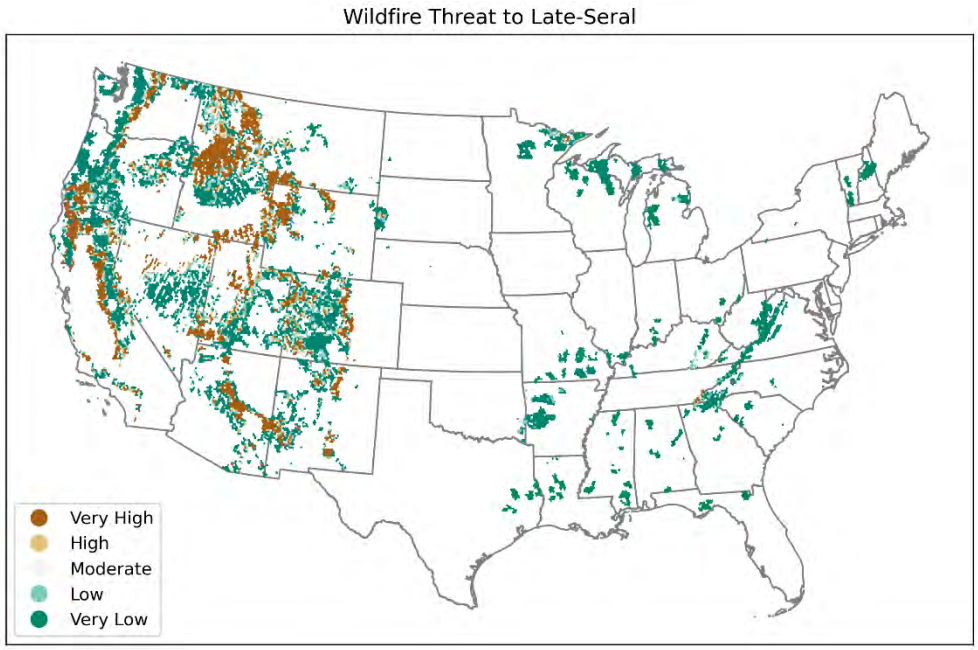



*Figure A5.21.—Mapped condition classes of the Wildfire Threat to Late Seral Forest indicator for Project Areas containing federally owned forest land from the MOGCA model. This indicator represents the likelihood that fire could cause tree mortality to older forests defined as areas classified as late seral by LANDFIRE Successional Class data.*

Wildfire Threat to Late Seral is focused on where the probability is high for wildfires that are damaging to the point of causing tree mortality and the loss of late seral forest (figure A5.21).

This threat is highly concentrated with approximately 50 percent of the threat identified in the cumulative eNVC occurring in 7.6 percent of the Project Areas examined in this analysis, which represent about 10 percent of the federally forests areas. Nearly 2,500 Project Areas were rated with a very high threat for this measure, and they represent nearly 44 million acres of federally owned forest land. The highest threats to late seral forests are in Project Areas dominated by Western oak, Fir-spruce-mountain hemlock, Douglas fir, Pinyon-juniper, Lodgepole pine, and California mixed conifer (figure A5.22).

Of note, some Project Areas do not have late seral forest (as captured in the successional class data from LANDFIRE). These Project Areas are represented by null values for this indicator in the MOGCA model results.

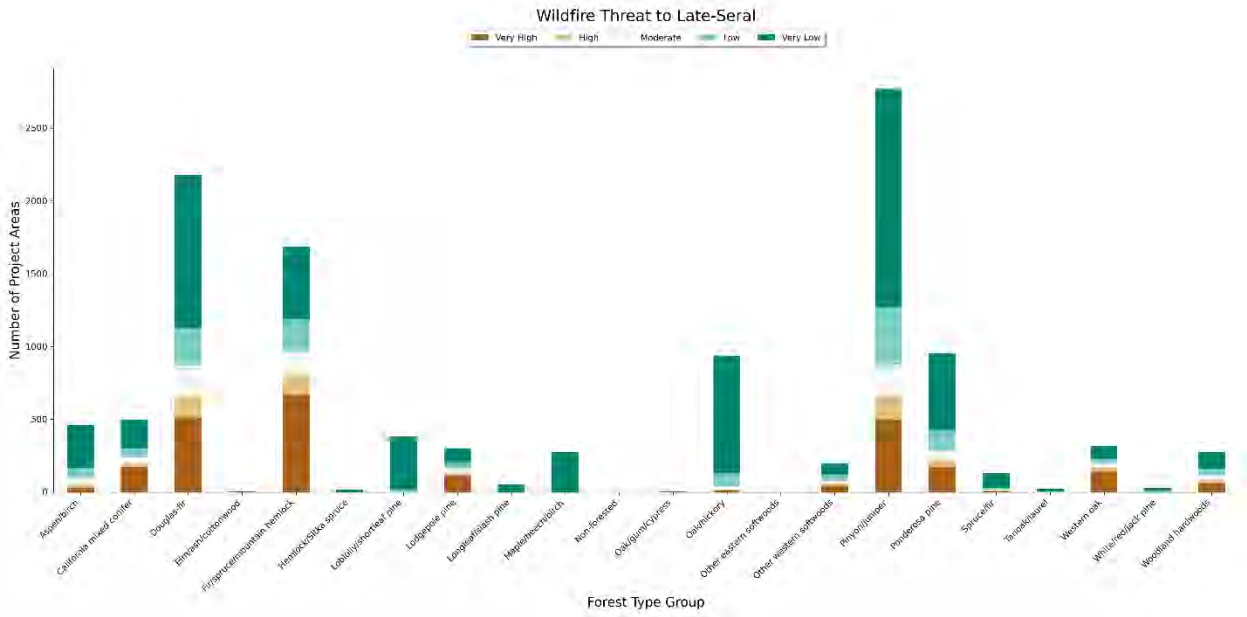



*Figure A5.22.—The number of project areas by forest type group and condition class for the Wildfire Threat to Late Seral Forests indicator. Nationally, 2,427 project areas were in Very Poor condition, 636 in Poor condition, 886 in Moderate condition, 1,438 in Good condition, and 6,106 in Very Good condition.*

## Insect and Disease Hazard

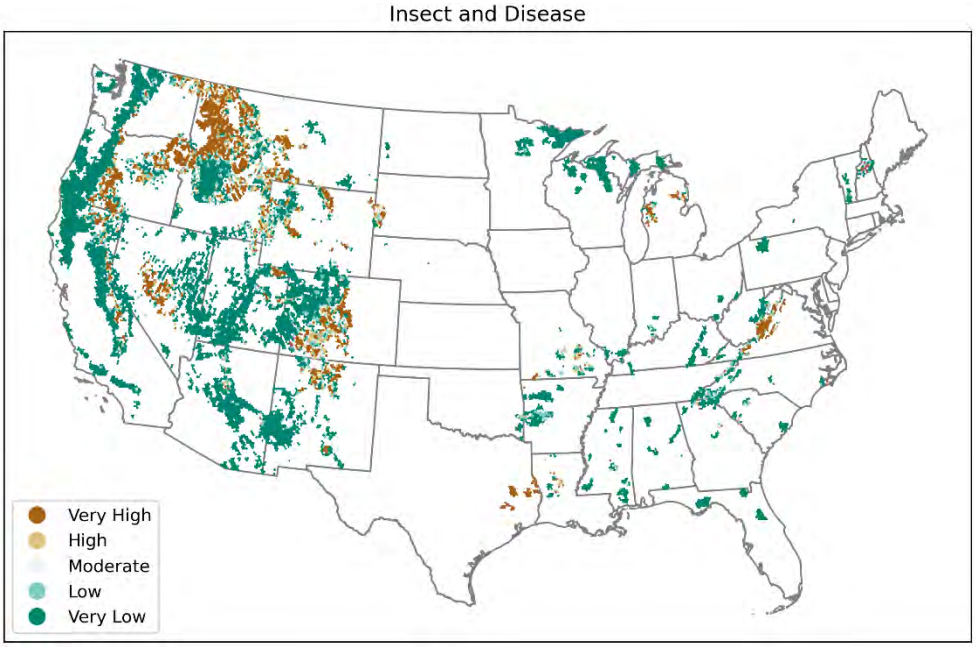



*Figure A5.23.—Mapped condition classes of the Insect and Disease hazard indicator for Project Areas containing federally owned forest land from the MOGCA model. Insect and Disease hazard leverages the National Insect and Disease Risk Map to determine areas likely to experience significant tree mortality from insects and disease in the next 15 years.*

High and Very High insect and disease hazard conditions were found in 2,712 Project Areas representing nearly 24.5 million acres or 25.3 percent of federally forested lands examined for this analysis (figure A5.23). Project Areas dominated by Douglas-fir, Fir-spruce-mountain hemlock, Pinyon-juniper, and Ponderosa pine forest types each have over 200 Project Areas rated as having very high potential threat as indicated by low scores in the MOGCA model (figure A5.24).

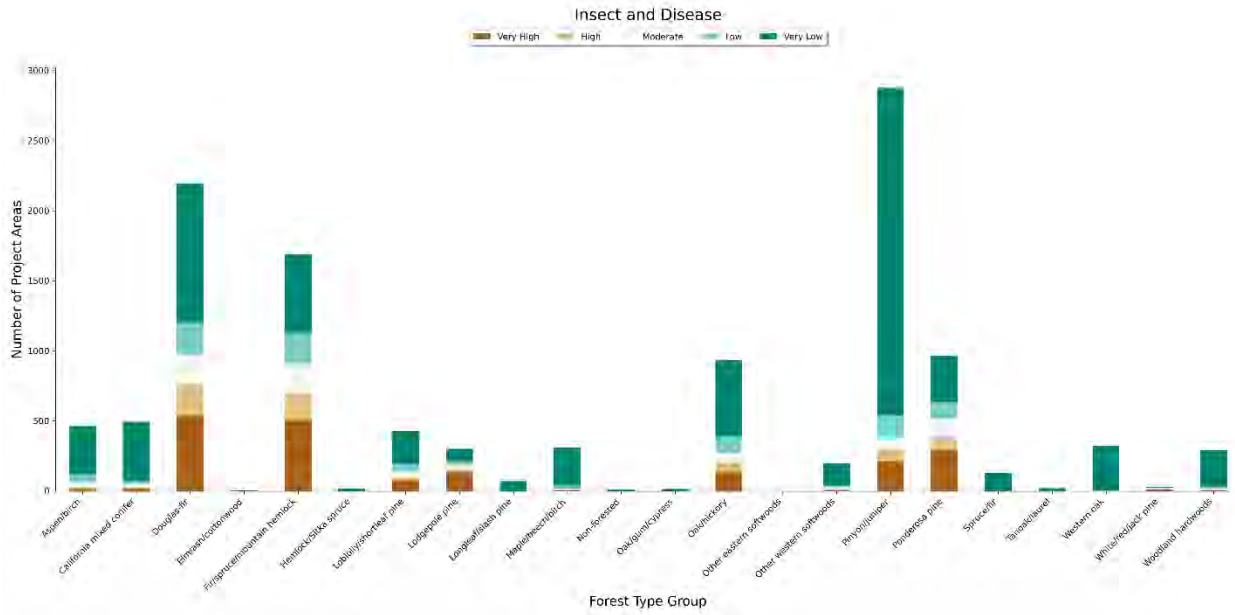



*Figure A5.24.—The number of Project Areas by forest type group and condition class for the Insect and Disease Hazard indicator. Nationally, 1,960 Project Areas were in Very Poor condition, 752 in Poor condition, 863 in Moderate condition, 1071 in Good condition, and 7,129 in Very Good condition.*

## Fire Deficit

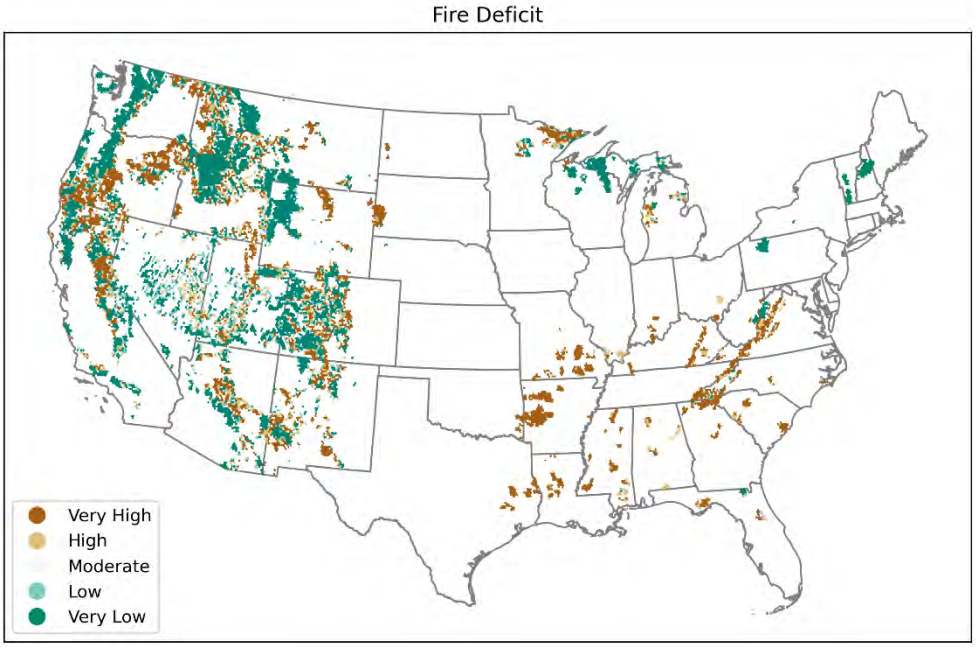



*Figure A5.25.—Mapped condition classes of the Fire Deficit indicator for project areas containing federally owned forest land from the MOGCA model. Fire Deficit is identifying where ecosystems dependent on fire (based on mean fire return intervals) have not had fire at the ecologically appropriate frequency. This deficit is driven predominantly by fire exclusion.*

Fire Deficit depicts the lack of fire occurring on the landscape which is usually the result of fire suppression and exclusion (figure A5.25). Reduced fire frequencies, especially in frequent fire forested ecosystems, can lead to the buildup of fuels and limit ecological processes (e.g.,

regeneration of trees and herbaceous species) that depend on fire. Ecosystems where fire is infrequent compose many of the areas with Very Low threat. Many of the frequent fire ecosystems have not had fire occur throughout the 20th century, or fire has not occurred with the same frequency as it did historically. This is especially apparent in the Project Areas dominated by Loblolly-shortleaf pine and Oak-hickory forest types (figure A5.26). Frequent fires help lower fire intensities which promotes numerous ecological benefits of fires and can improve resiliency of the ecosystem.

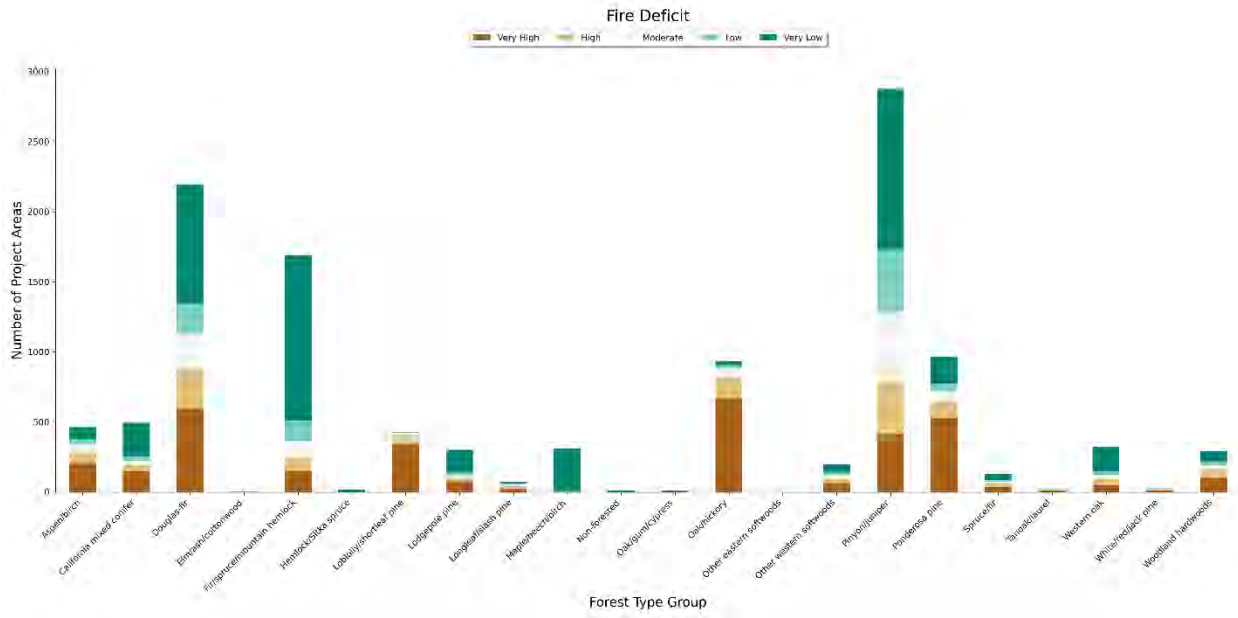



*Figure A5.26.—The number of Project Areas by forest type group and condition class for Fire Deficit indicator. Nationally, 3,434 Project Areas were in Very Poor condition, 1,420 in Poor condition, 1,282 in Moderate condition, 1,054 in Good condition, and 4,589 in Very Good condition.*

# Appendix 6 – Regional Fire Summary

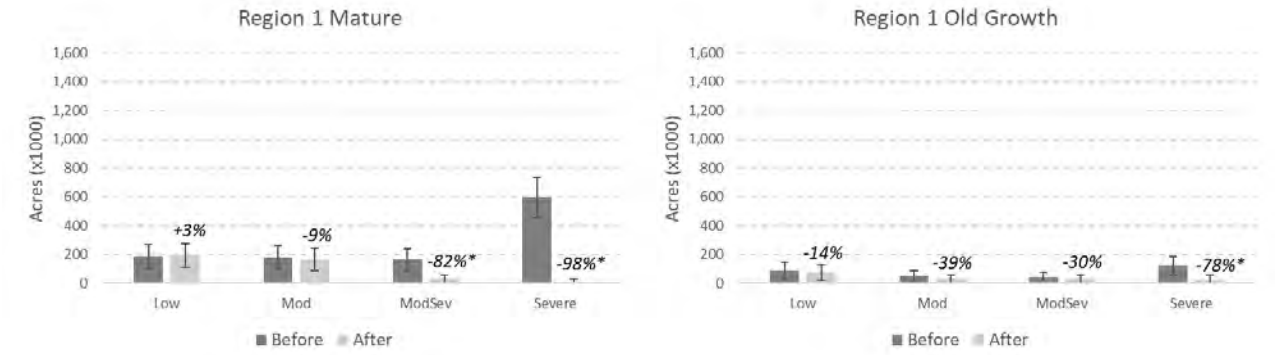



*Figure A6.1.—Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

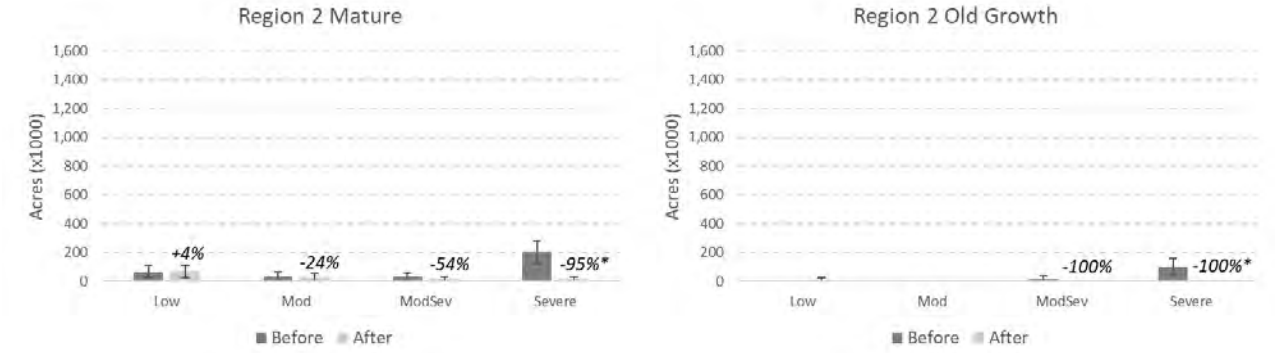



*Figure A6.2.—Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

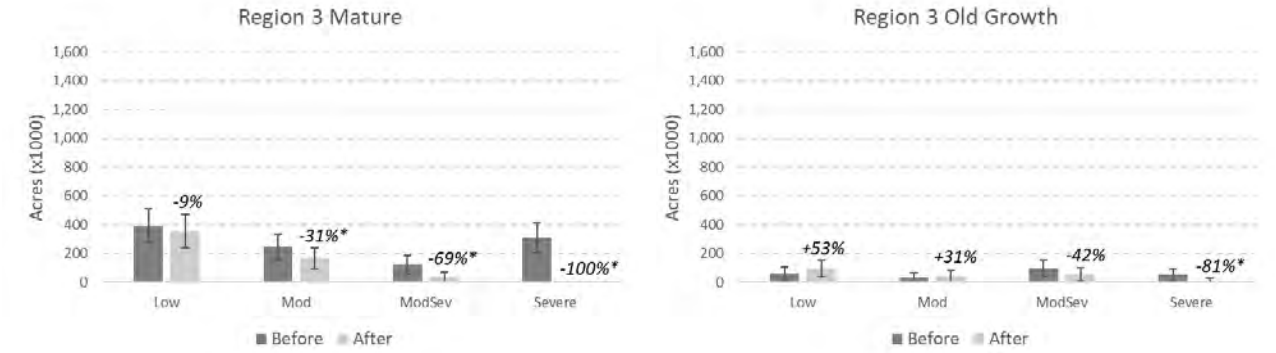



*Figure A6.3.—Region 3 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

.

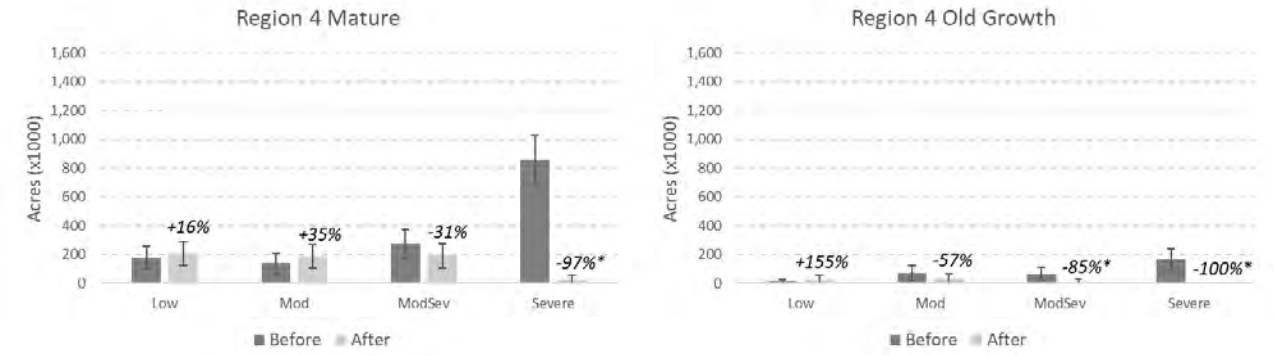



*Figure A6.4.—Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

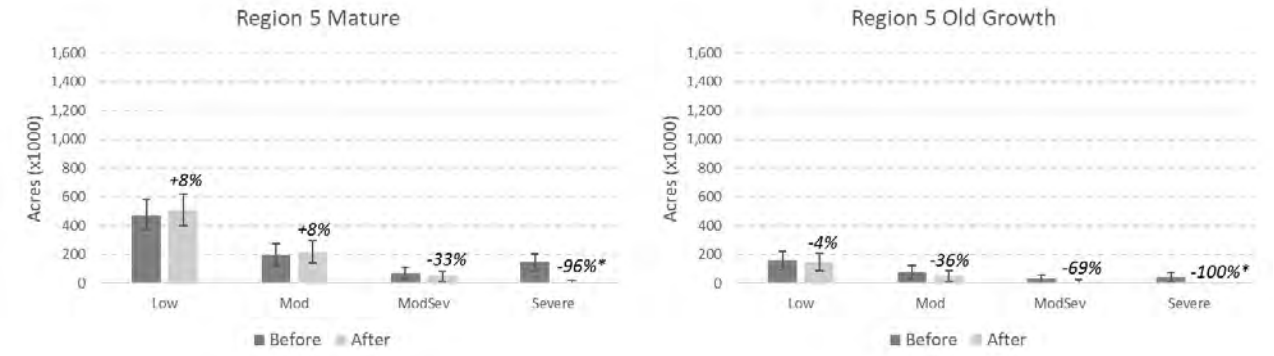



*Figure A6.5.—Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

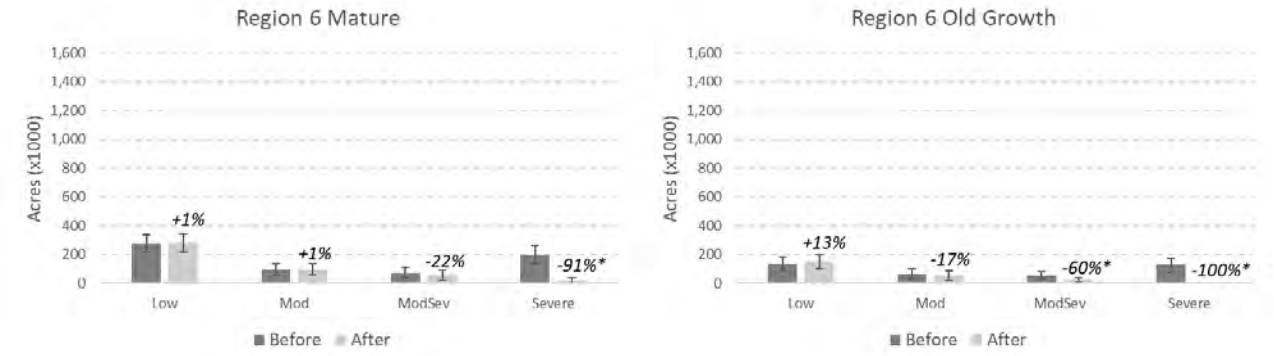



*Figure A6.6.—Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

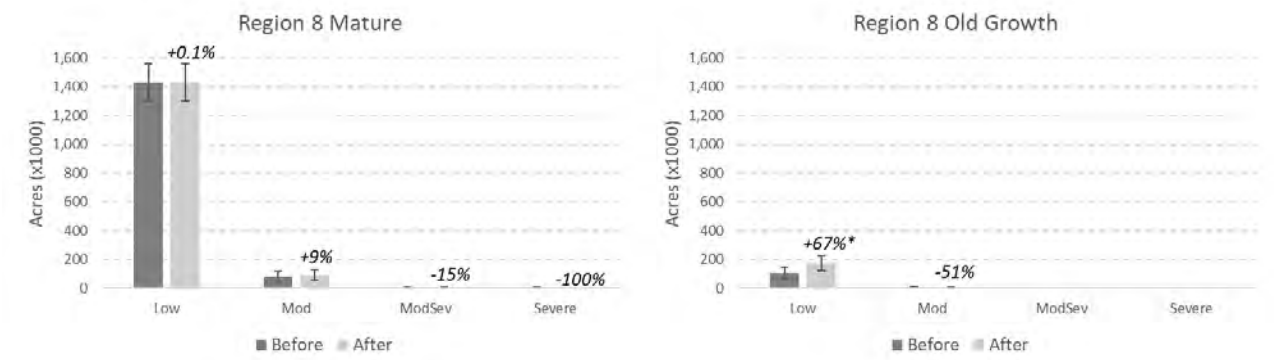



*Figure A6.7.—Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

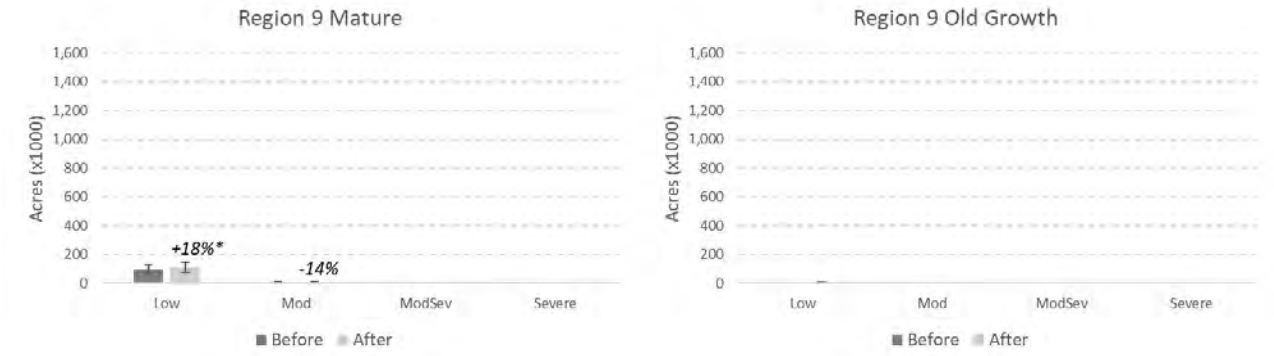



*Figure A6.8.—Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality)..*

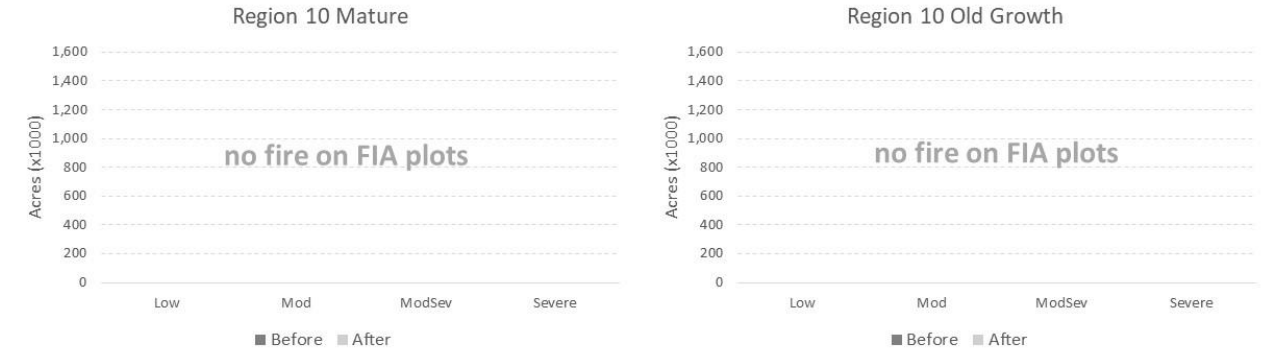



*Figure A6.9.—Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a fire disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

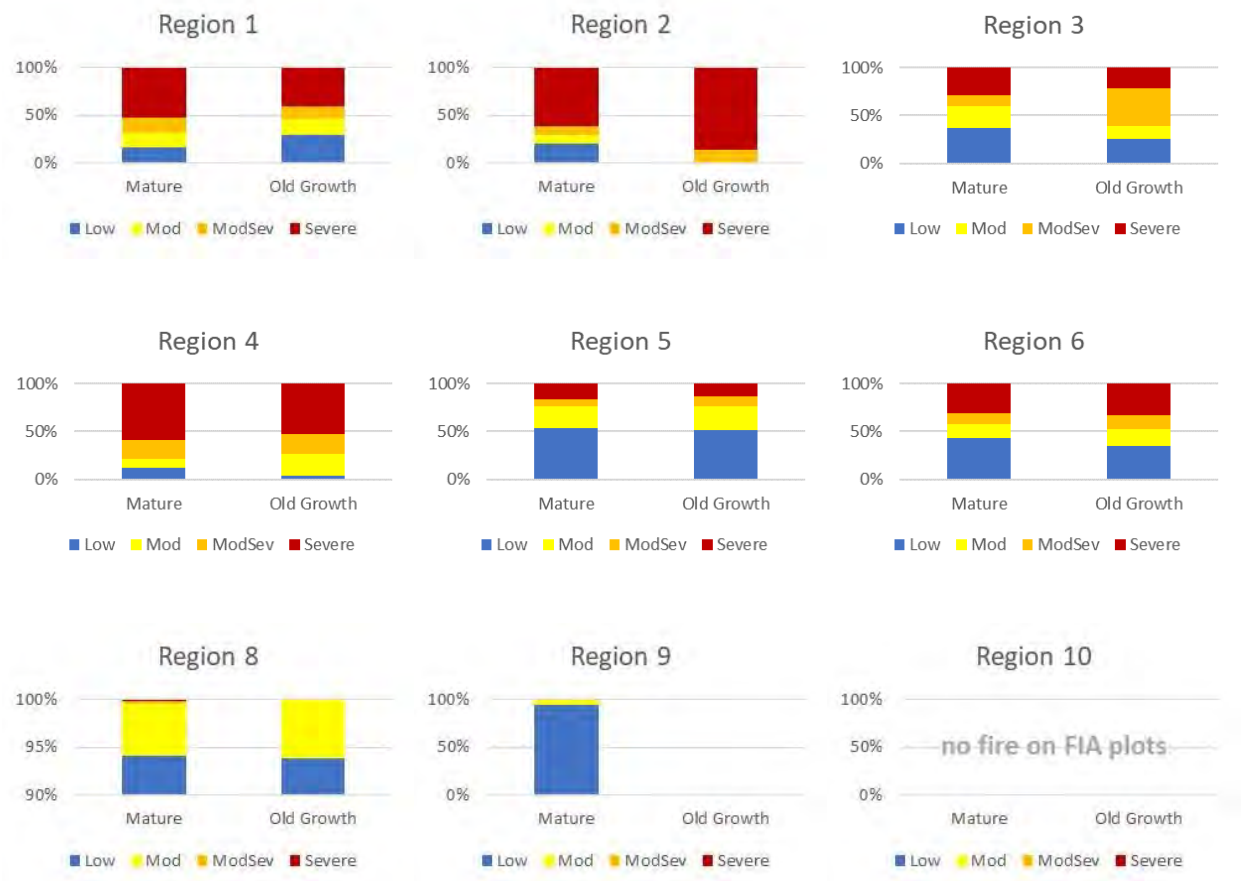



*Figure A6.10.— Regional variations in fire disturbance severity (based on live tree basal area mortality) for mature and old-growth forests. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

# Appendix 7 – Monitoring Trends in Burn Severity Analysis

A comparison (masked to forest land) between the National Burn Probability (BP) map (Dillon et al. 2023) and the fire risk map from Anderegg et al. (2022) was done to inform how the National BP map compares to fire exposure classes used for the mature and old-growth (MOG) forest threat analysis (main document, table 2). Both maps in (shown in figure A7.1) are based on continuous model outputs that were reclassified into five map classes (table A7.1).

Table A7.1.—Map class thresholds for the continuous model outputs for the National BP and Anderegg maps.

| Map Class | National Burn Probability (2023)<br>Annual probability of a fire | Anderegg et al. (2022)<br>Annual percent area burned by moderate- to high-severity fire[5] |
|---|---|---|
| Very low | ≤ 0.000100 | ≤ 0.000072 |
| Low | 0.000100–0.000464 | 0.000072–0.000494 |
| Moderate | 0.000464–0.002154 | 0.000494–0.000825 |
| High | 0.002154–0.010000 | 0.000825–0.001562 |
| Very high | >0.010000 | >0.001562 |

In appearance, the classified maps are very similar in the western contiguous United States (US), but not in eastern US. The main reason for this difference is that the National BP map represents the annual probability of wildfire of *any* severity (low to high); whereas the Anderegg et al. (2022) map represents the probability (defined by them as "risk") of only moderate- to high-severity wildfire. Based on Monitoring Trends in Burn Severity (MTBS) data (https://www.mtbs.gov/ ) moderate- to high-severity fire comprises a much smaller proportion of area burned in the eastern US than it does in the West. Thus, the National BP map shows less "very low" and more "moderate to high" map classes in the East than the Anderegg map does.

5 Fire risk was modelled as a fraction of a 4-km grid cell burned per year.

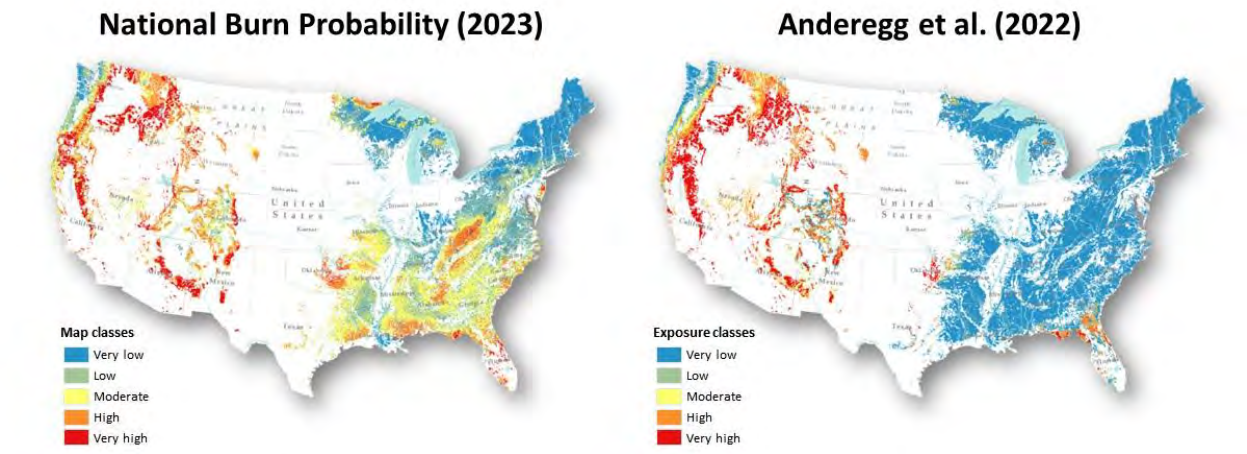



*Figure A7.1.—A side-by-side visual comparison of the National Burn Probability map (L) with the Anderegg et al. (2022) map [8].*

An additional MTBS analysis was done for two time periods to understand the relationship between exposure classes in the Anderegg map and forest area burned (figure A72). The analysis was conducted on all forests, since a map of mature and old-growth forest based on inventory definitions (USDA and USDA 2023) was not available. The analysis was masked to NFS and BLM forest lands with firesheds.

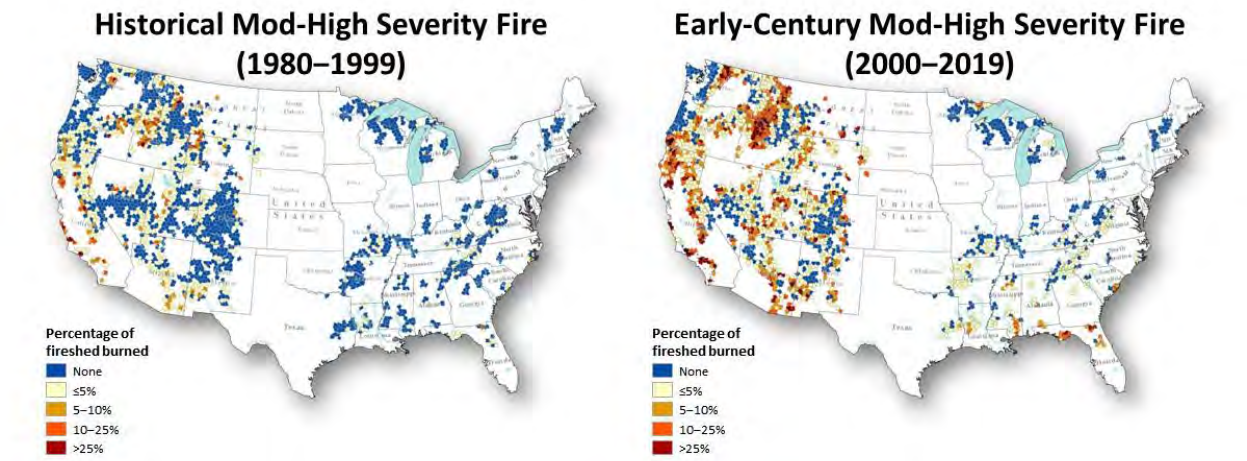



*Figure A7.2.—Fireshed analysis based on percentage of forests on NFS and BLM lands burned by large (>1,000 ac in the west and 500 ac in the east) moderate- to high-severity fire using Monitoring Trends in Burn Severity (MTBS) data.*

The area burned at moderate- to high-severity fire during the early-century (2.5 million ac) was more than 4-times what was burned during the historical period (0.6 million acres). Table A7.2 shows total and an annual average percentage of NFS and BLM forests burned for each map exposure class (combined across all firesheds) for the historical period (1980–1999) and early-century period (2000–2019).

Table A7.2.—Proportion (total and averaged annually) of NFS and BLM forest burned by moderate to high-severity wildfires. Historical data for Monitoring Trends in Burn Severity only extends back to 1984.

| Exposure Class | Historical (1984–1999) Total (%) | Historical (1984–1999) Annual (%) | Early Century (2000–2019) Total (%) | Early Century (2000–2019) Annual (%) |
|---|---|---|---|---|
| Very low | 0.09 | 0.005 | 0.65 | 0.033 |
| Low | 0.46 | 0.023 | 1.40 | 0.070 |
| Moderate | 1.75 | 0.088 | 2.86 | 0.143 |
| High | 2.27 | 0.113 | 6.66 | 0.333 |
| Very high | 2.94 | 0.147 | 10.61 | 0.530 |

The results of this analysis show that the forested area burned by moderate- to high-severity wildfires has increased since recent historical records (1984–1999). A result that is consistent with Anderegg et al. (2022) that indicated fire risks are projected to increase by a factor of >4 for throughout the 21st century.

# Appendix 8 – Resources Planning Act Assessment of Future Mature and Old-Growth Forests

## Background on the RPA Forest Dynamics Model and RPA Scenarios

The Resources Planning Act (RPA) Forest Dynamics Model is a stochastic modeling system that projects the FIA database at the plot (condition) level using an imputation approach (Coulston et al. 2023). This approach allows for consistent projections that are based on the observed relationships among FIA variables at the plot level through the projection period. The Forest Dynamics Model is informed by exogenous variables including climate, timber prices, human population, and income, as well as by a set of sub-models representing harvest choices, forest disturbance, growth, aging, regeneration, and forest type transitions over time. The Forest Dynamics Model was only applied to FIA plots that meet the RPA definition of forest land, which is a subset of all FIA forest land and matches international forest land definitions. The RPA forest land definition has a minimum height requirement and excludes some woodlands, primarily in the southwestern U.S. (Oswalt et al. 2019).

The 2020 RPA Assessment includes projections of forest conditions and areas from the Forest Dynamics Model for the contiguous U.S. for the period 2020-2070 under a set of future scenarios that incorporate warming, socioeconomic growth, and alternative climate models. The RPA scenarios pair two alternative climate futures (Representative Concentration Pathways, or RCPs) with four alternative socioeconomic futures (Shared Socioeconomic Pathways, or SSPs) in the following combinations: RCP 4.5 and SSP1 (lower warming-moderate U.S. growth, LM), RCP 8.5 and SSP3 (high warming-low U.S. growth, HL), RCP 8.5 and SSP2 (high warming- moderate U.S. growth, HM), and RCP 8.5 and SSP5 (high warming-high U.S. growth, HH) (see O'Dea et al. 2023 for more information on scenarios). The 2020 RPA Assessment pairs these four RPA scenarios with five different climate models that capture the wide range of projected future temperature and precipitation across the contiguous United States (O'Dea et al. 2023, Joyce and Coulson 2020).

For this analysis, the national forest dynamics model projections from the 2020 RPA Assessment were summarized specifically for mature and old growth forests on Forest Service and BLM lands across the contiguous U.S. and for RPA regions (figure A7.1). We present projected trends in mature and old growth forest areas, areas of forest land burned by wildfires, and harvest removal volumes. Importantly, while the areas of mature, old growth, and younger forests change over time in these projections, no land use change occurs on Forest Service and BLM lands in the Forest Dynamics Model, so the total area of

forest land remains constant for those ownerships. Furthermore, because the projections are based on the FIA inventory, sampling error associated with inventory design is inherent in these projections, remains constant over time at 2020 levels for all variables projected, and is not shown in the figures, although the sampling error associated with individual realizations comprises a portion of the variability across model realizations.

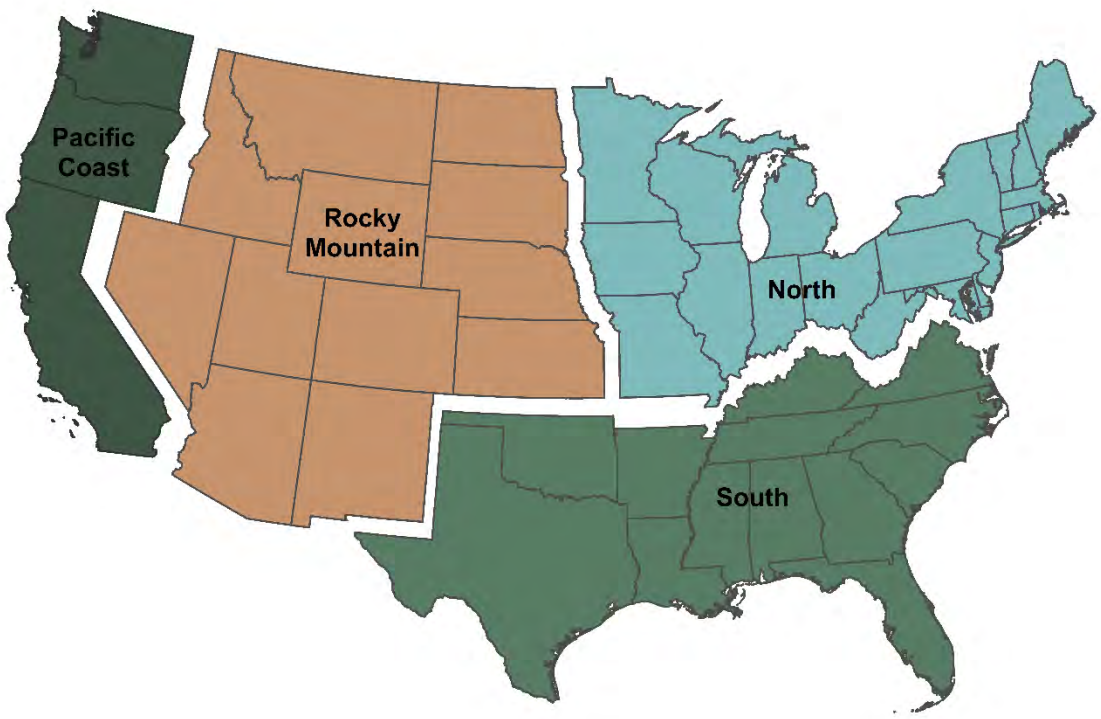



*Figure A8.1.—Resources Planning Act Assessment regions within the contiguous United States.*

# Projected Mature and Old-growth Forest Areas

Forest Dynamics Model projections indicate an increase over the next 50 years in old growth forest area on Forest Service and BLM land in the contiguous U.S. This trend is consistent across scenarios that combine levels of warming and socioeconomic growth, and across the climate models analyzed within each of those scenarios (figure A7.2). Projections also indicate a decrease in younger forest across all scenarios and climate models. The area of mature forest is expected to remain steady or increase or decrease slightly depending on the scenario and climate model. The projections show regional differences in area change, with old growth increasing in the Rocky Mountains, the Pacific Coast, and the North, but increasing or decreasing depending on the scenario in the South (Figure A8.3; only the high warming / moderate growth scenario is shown here). Mature forest, meanwhile, may increase in the North and Pacific Coast Regions while remaining relatively steady in the Rocky Mountains and the South. These results indicating an increase in old growth area and a decrease in younger

forest area are consistent with the overall forest succession and aging trends projected for all forests in the contiguous U.S. in the 2020 RPA Assessment (Coulston et al. 2023).

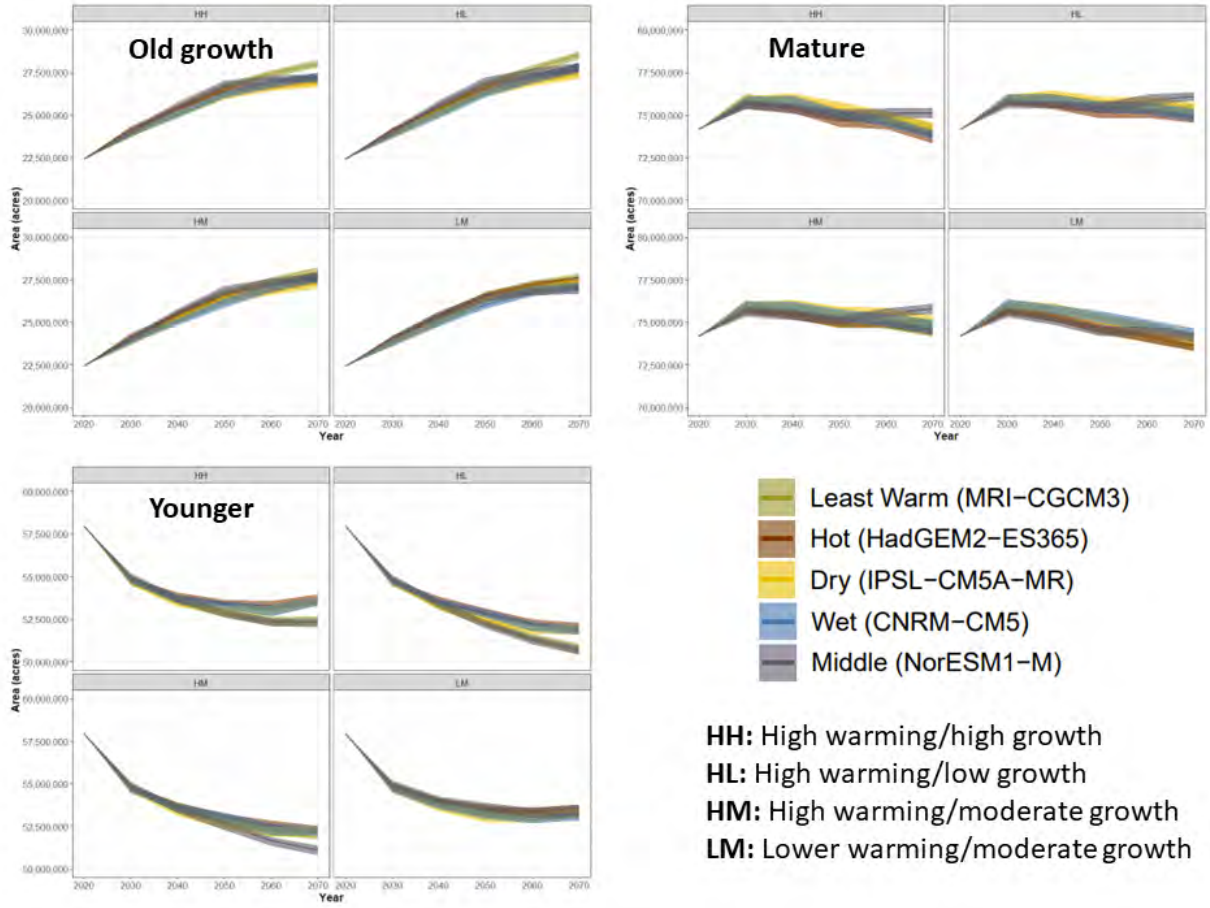



*Figure A8.2.—Acres of old growth, mature, and younger forest on Forest Service and Bureau of Land Management land in the contiguous United States until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Note the difference in the scale of the y-axes. Climate models are represented by colors, and results for each scenario are shown in separate panels.*

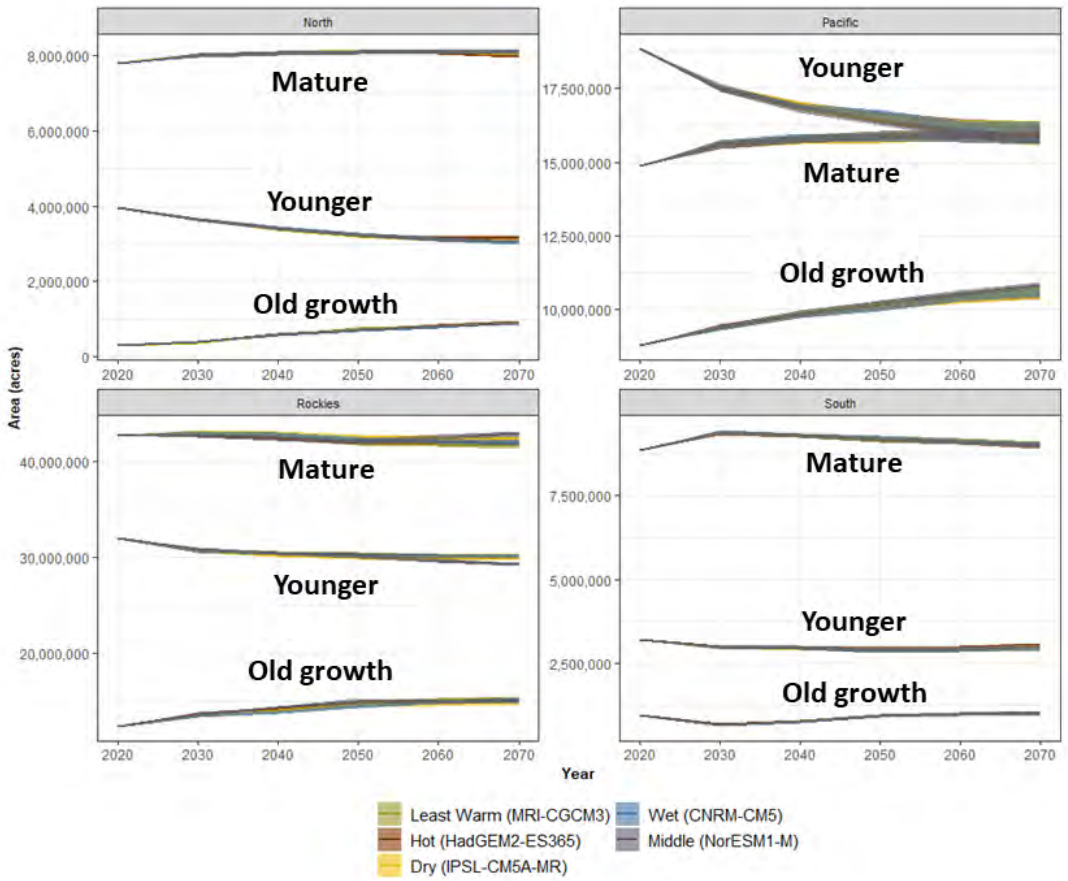



*Figure A8.3.—Acres of old growth, mature, and younger forest on Forest Service and Bureau of Land Management land by region until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model, for the high warming/moderate growth scenario only. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors. The other three scenarios showed similar trends. Note the difference in the scale of the y-axes on each panel.*

# Wildfire

The Forest Dynamics Model contains a sub-model that projects the future fire occurrence and tree mortality resulting from fire based on FIA data, and links to other sub-models that modify forest characteristics over time, including basal area, down woody material that can act as fuels, stand age, species composition, and harvest probability. Because of the limited ability of FIA field crews to detect low-severity fires, fires that do not lead to tree mortality are omitted from the Forest Dynamics Model. Thus, the projections can be used to examine changes in annual areas burned by moderate and high severity wildfires over time (Costanza et al. 2023).

The Forest Dynamics Model projects increases in annual area burned by moderate to high severity wildfires for both old growth and mature forest across most scenarios and climate models (Figure A8.4). For old growth forests, annual area burned is projected to increase by 2070 compared with 2020 in the hot (HadGEM2-ES365), dry (IPSL-CM5A-MR), and wet (CNRM-

CM5) climate models in all scenarios, while the largest decreases were projected for the least warm (MRI-CGCM3) climate model in the high warming/high growth and high warming/low growth scenarios. For mature forests, annual area burned is expected to increase by 2070 compared with 2020 in all scenarios and climate models, with the greatest increases expected in the hot and dry models in the three scenarios with high warming. Projected values of annual area burned by 2070 for both mature and old growth forest show greater variability across climate models in each of the high warming scenarios than for the low warming scenario. In all regions and in all time steps, the annual area burned is relatively small compared to the overall areas of mature and old growth forests.

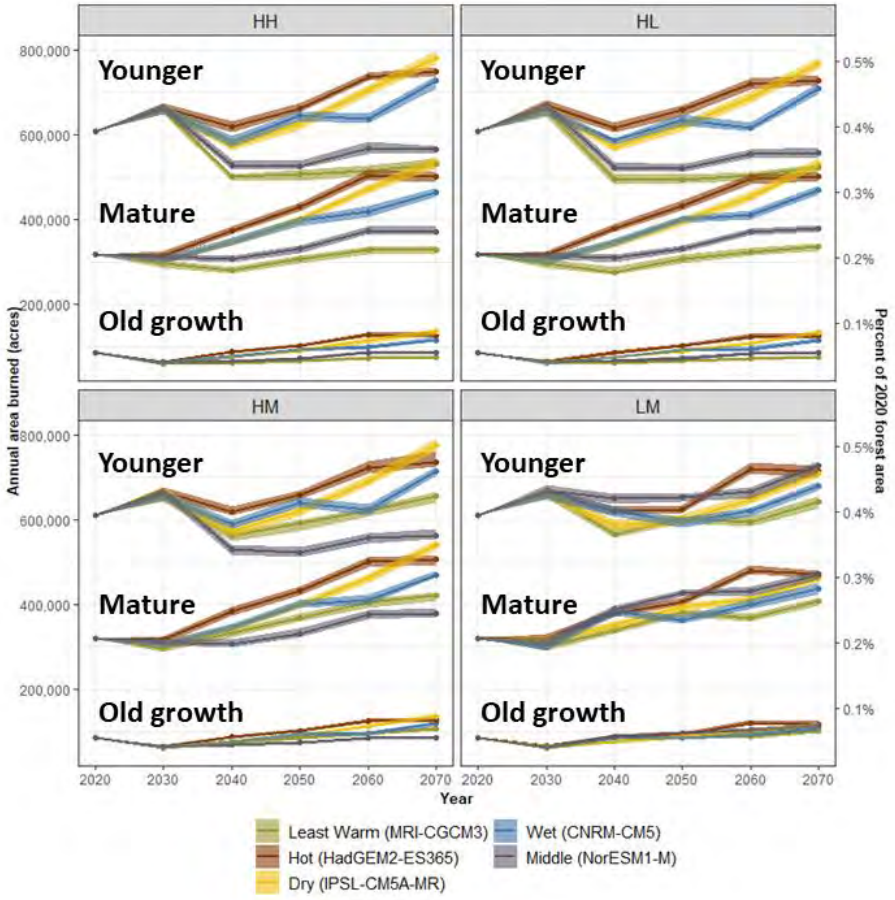



*Figure A8.4.—Annual area burned (in acres) of old growth, mature, and younger forest on Forest Service and Bureau of Land Management land in the contiguous United States until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors, and results for each scenario are shown in separate panels. The secondary y-axis indicates the proportion of total Forest Service and BLM forest land in 2020 that corresponds to the given annual area burned.*

The area of old growth forest burned annually by moderate to high severity wildfires is projected to generally increase by 2070 across climate models for the Rocky Mountain and North regions, remain relatively steady or decrease in the South, and decrease under all climate models in the Pacific Coast (Figure A8.5). Annual area burned in mature forests is

projected to generally increase by 2070 compared with 2020 in all regions in all climate models. The projected increases in area burned annually for mature forests are consistent with the overall increases in annual area burned for all forests in most futures in the 2020 RPA Assessment.

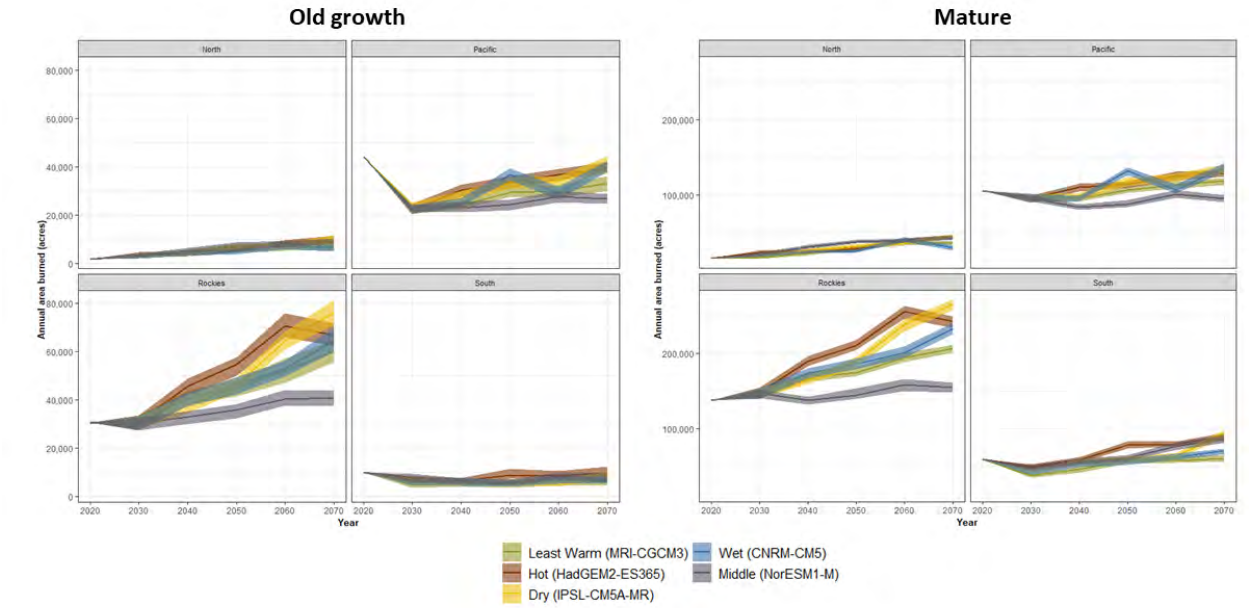



*Figure A8.5.—Annual area burned (in acres) on old growth and mature forest on Forest Service and Bureau of Land Management land by region until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model, for the high warming/moderate growth scenario only. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors. The other three scenarios showed similar trends. Note the difference in the scale of the y-axes for old growth and mature.*

### Tree Cutting

The Forest Dynamics Model contains a sub-model that projects harvest choices, and, like the wildfire sub-model, it links to other sub-models that modify forest characteristics over time. In the model, choices about harvests are linked to forest conditions, prices, and demand for wood over time nationally and globally, and reflect the empirical relationships between those endogenous and exogenous drivers and harvest. These relationships are modeled separately by RPA region, and vary by ownership, so that the historic price sensitivities of different forest ownership categories are empirically captured in the models.

We summarized volumes of harvest removals over time from the Forest Dynamics Model. The model projects increases in tree removal volumes from mature and old growth forests over the projection period, with the largest increases by 2070 occurring under the high warming/high growth and the lower warming/moderate growth scenarios (Figure A8.6). Increases in removals for both old growth and mature forests are more moderate under the high warming/low growth and high warming/moderate growth scenarios. These trends are consistent across regions, with particularly large growth in harvested volumes under the high

warming/high growth and the lower warming/moderate growth scenarios for mature forests in the Pacific and South and for old growth forests in the Pacific (Figure A8.7). The greater increases in removals by 2070 under the high warming/high growth and lower warming/moderate growth scenarios are consistent with the projections for all forest land summarized in the 2020 RPA Assessment; these increases are attributed in that assessment to the greater use of bioenergy in the LM and HH scenarios (Coulston et al. 2023).

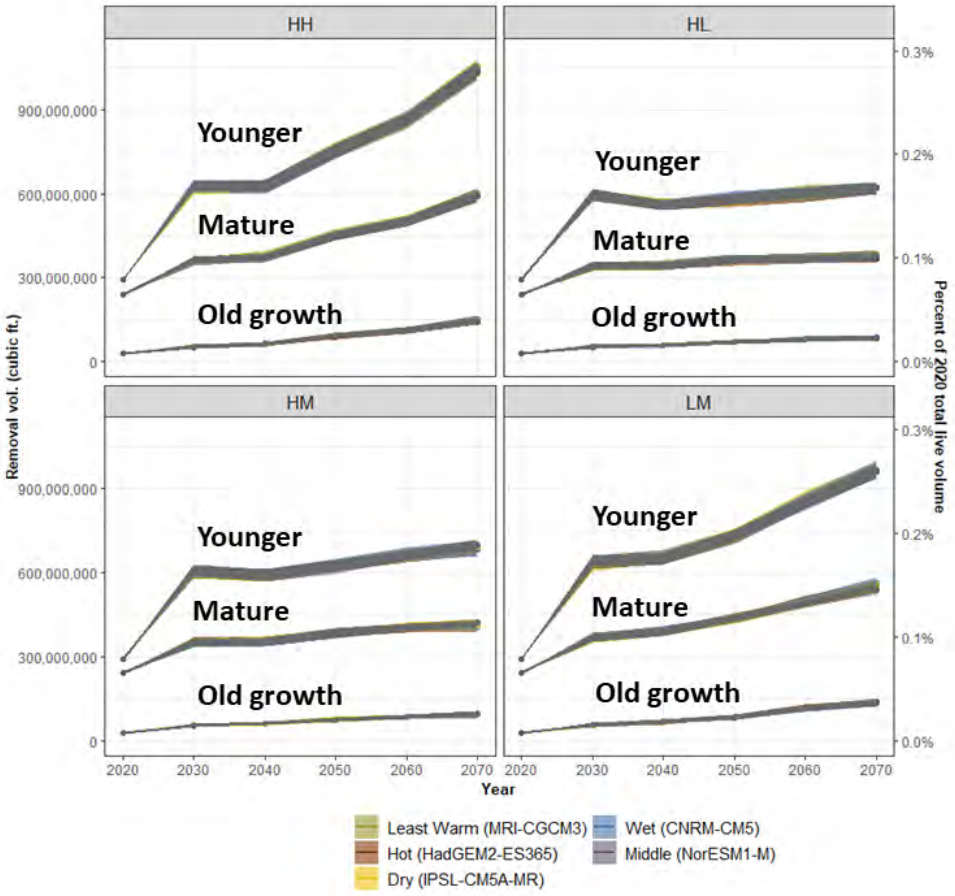



*Figure A8.6.—Annual harvested volume of trees (in cubic feet) from old growth, mature, and younger forest on Forest Service and Bureau of Land Management land in the contiguous United States until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. Climate models are represented by colors, and results for each scenario are shown in separate panels. The secondary y-axis indicates the proportion of total live volume on Forest Service and BLM forest land in 2020 that corresponds to the given annual removal volume.*

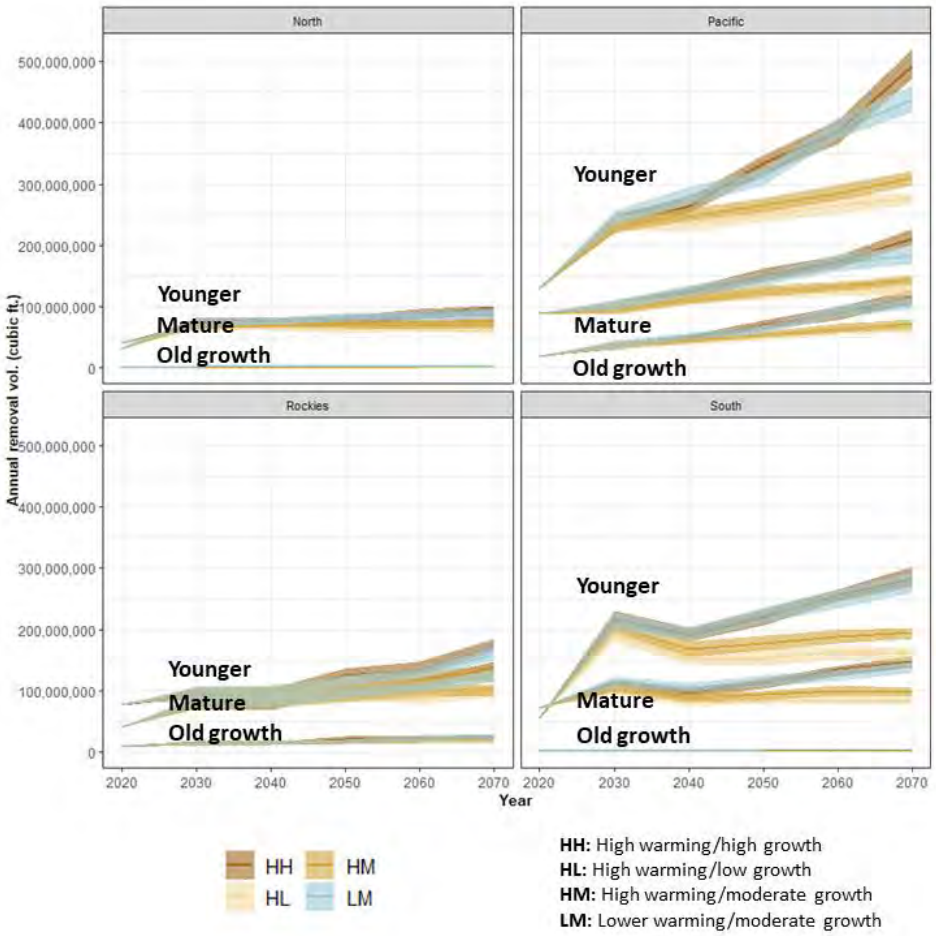



*Figure A8.7.—Annual harvested volume of trees (in cubic feet) from old growth and mature forest on Forest Service and Bureau of Land Management land by region until 2070, projected by the Resources Planning Act Assessment Forest Dynamics Model, for the middle climate model (NorESM1-M) only. For each curve, the dark line represents the median projection across 100 replications of the model. The shading represents the interquartile range (middle 50%) of the 100 replications. The other climate models showed similar trends.*

# Appendix 9 – Regional Insect and Disease Summary

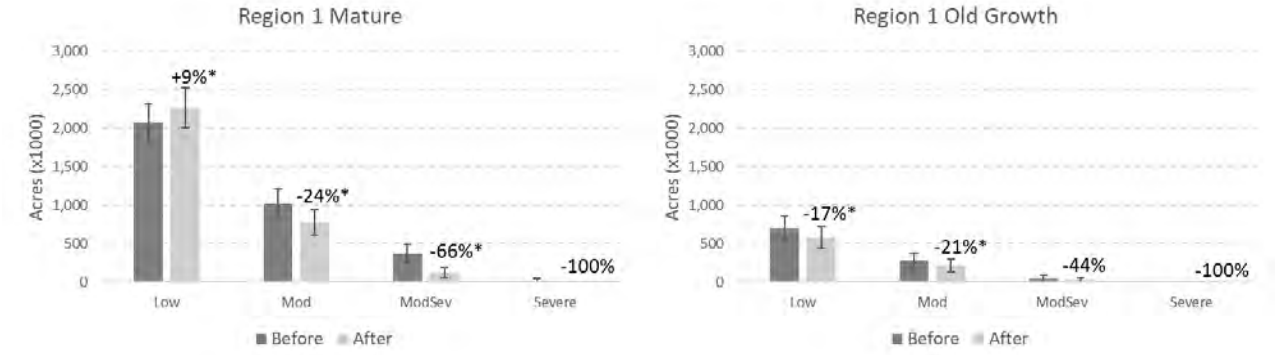



*Figure A9.1.—Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

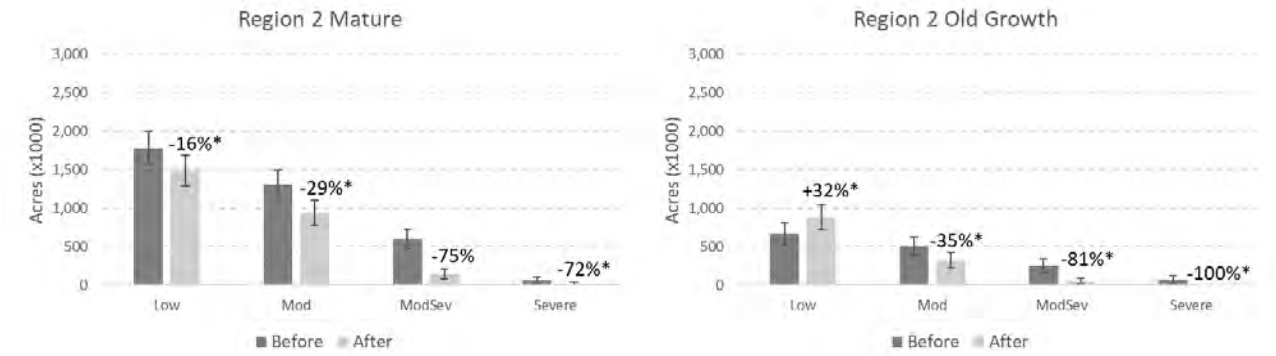



*Figure A9.2.—Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

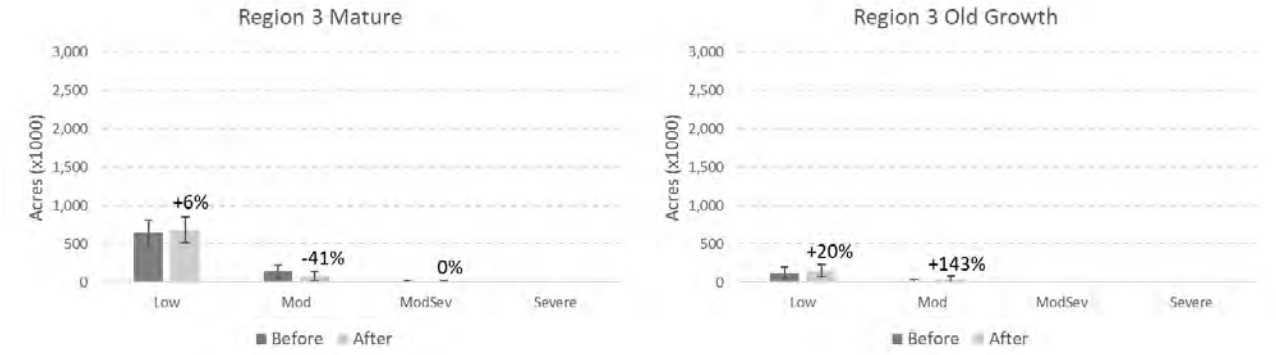



*Figure A9.3.—Region 3 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

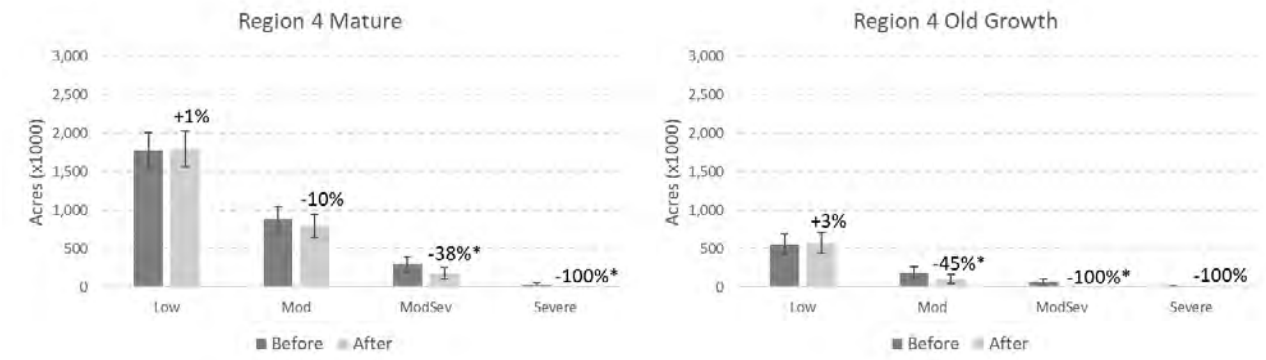



*Figure A9.4.—Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

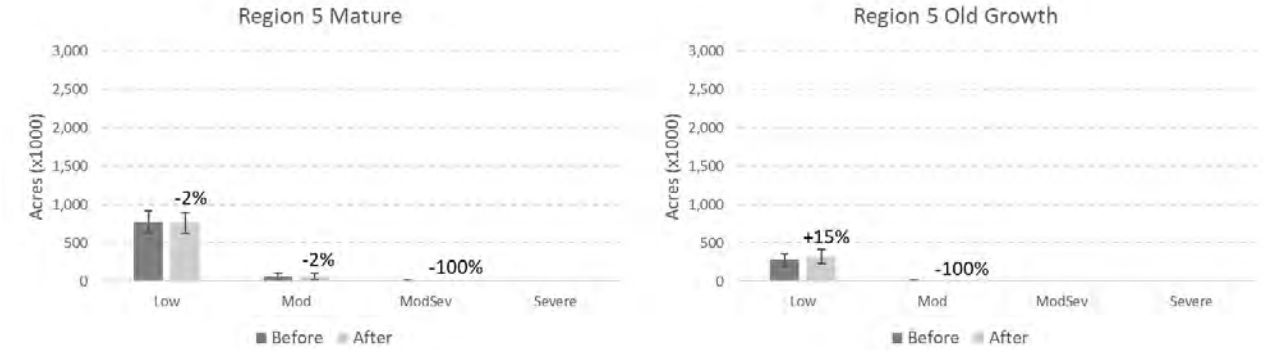



*Figure A9.5.—Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

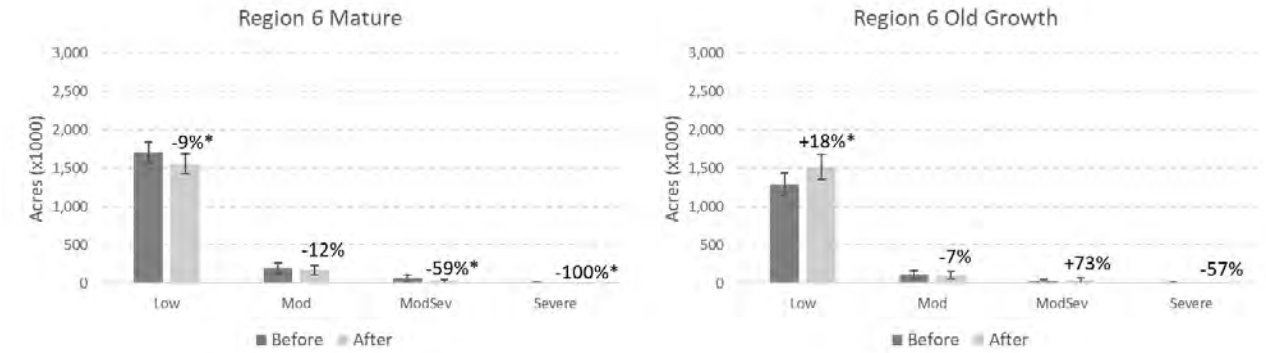



*Figure A9.6.—Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

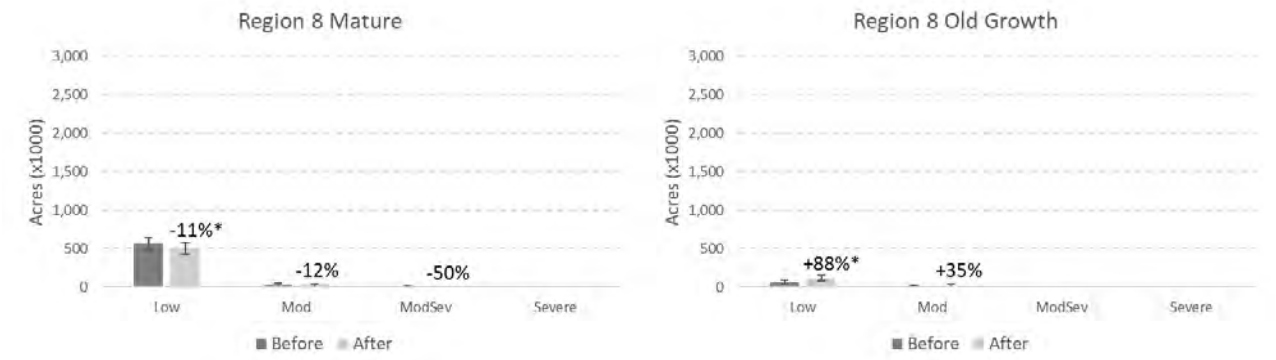



*Figure A9.7.—Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

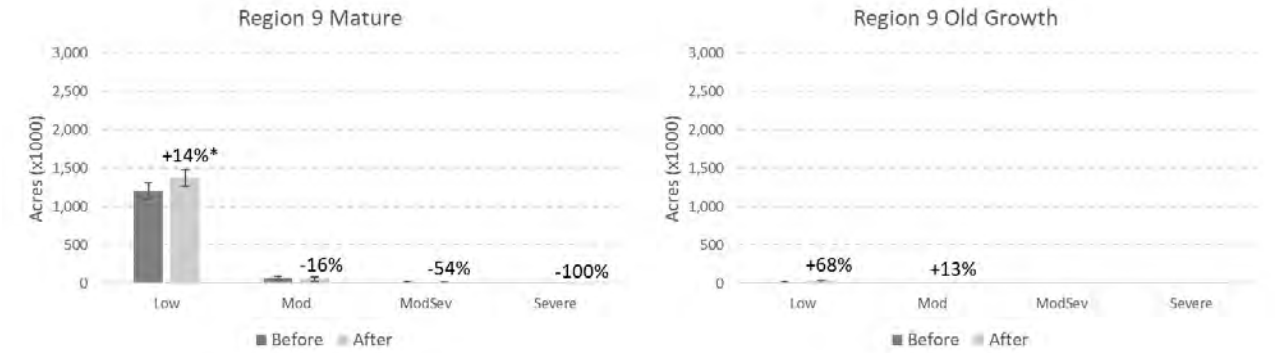



*Figure A9.8.—Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

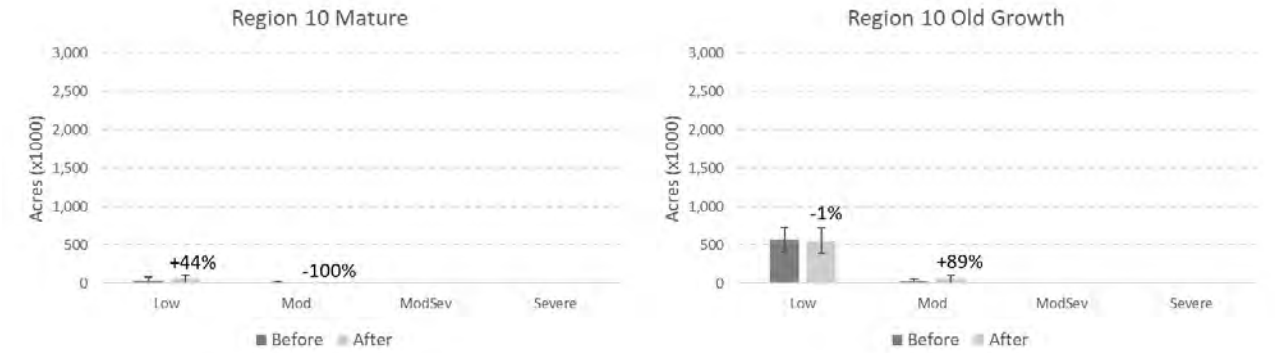



*Figure A9.9.—Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after an insect/disease disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*




*Figure A9.10.— Regional variations in insect/disease disturbance severity (basal area mortality) for mature and old-growth forests. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

# Appendix 10 – Regional Weather Summary

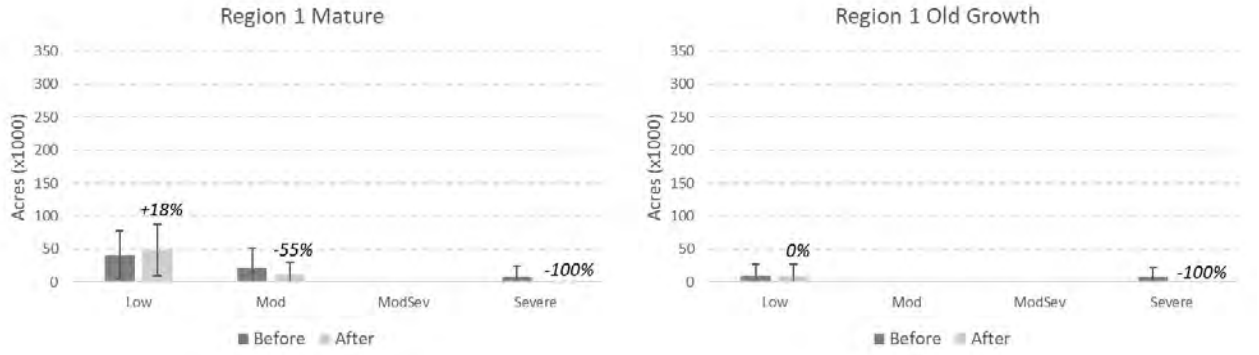



*Figure A10.1.—Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

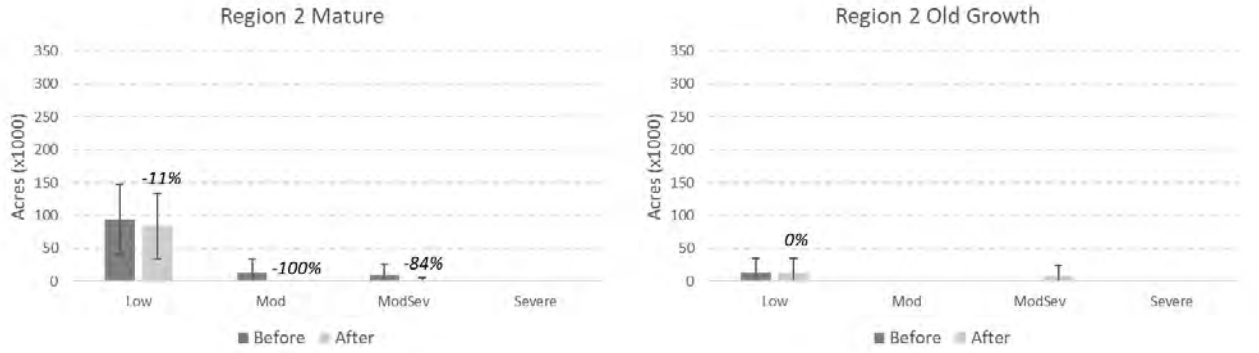



*Figure A10.2.—Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

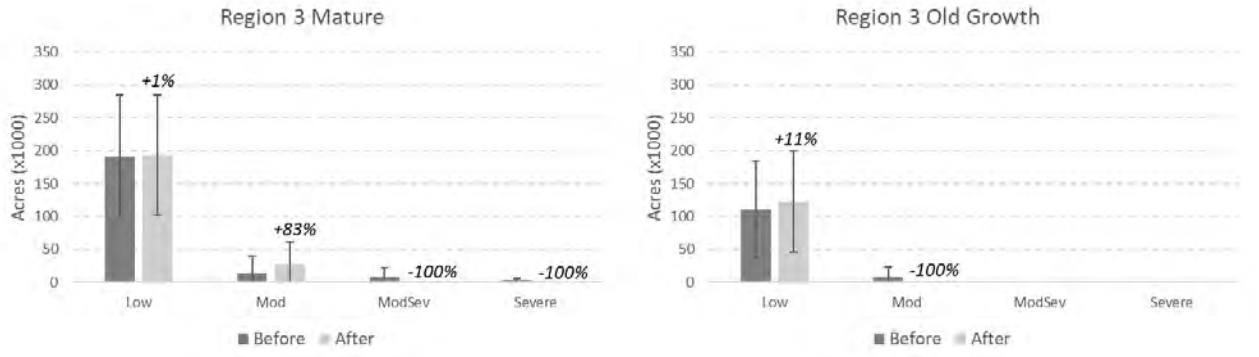



*Figure A10.3.—Region 3 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

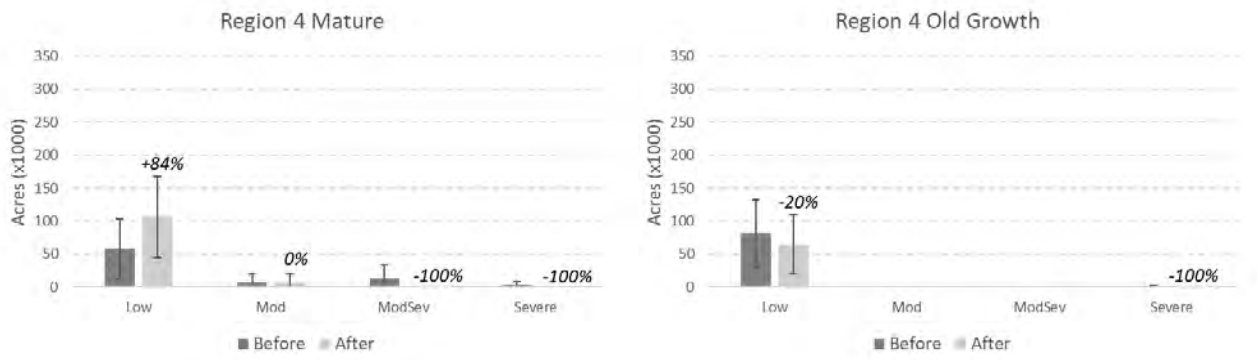



*Figure A10.4.—Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

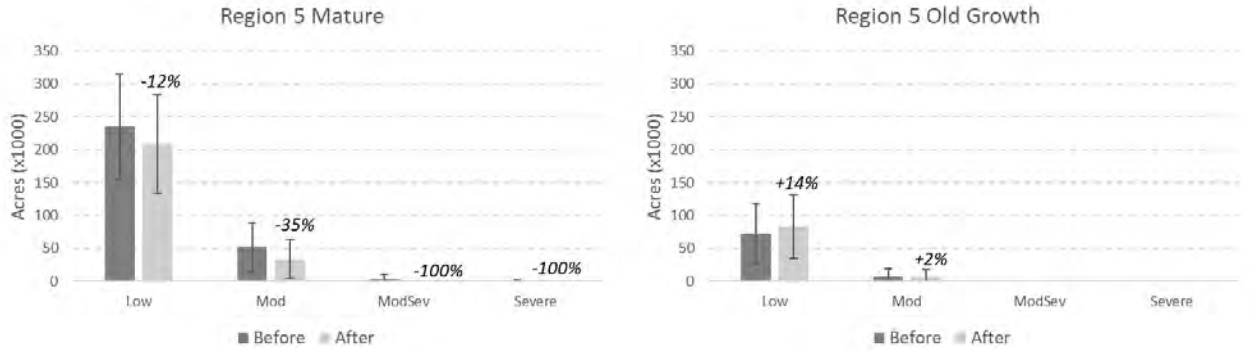



*Figure A10.5.—Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

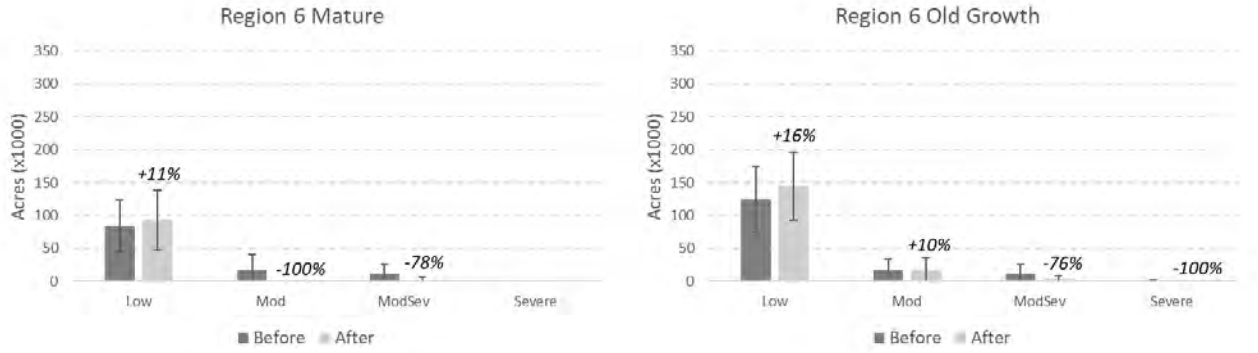



*Figure A10.6.—Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

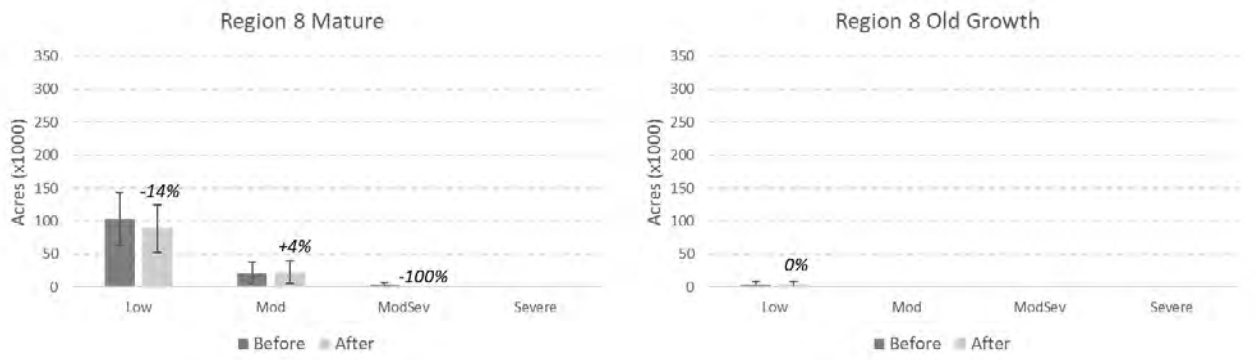



*Figure A10.7.—Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

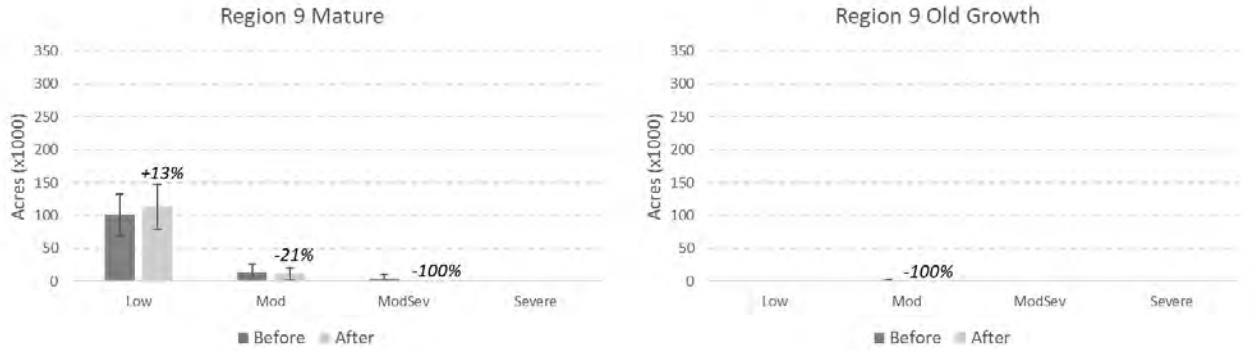



*Figure A10.8.—Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*

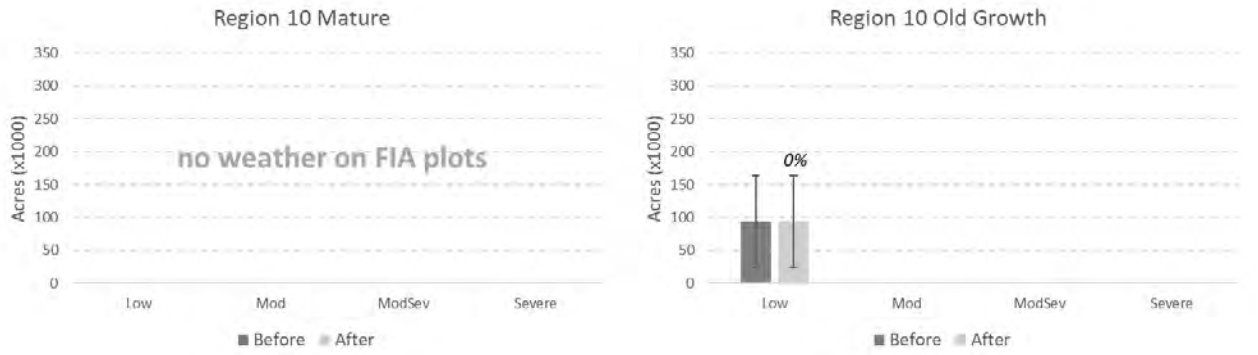



*Figure A10.9.—Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a weather disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality).*




Figure A10.10.— Regional variations in weather disturbance severity (basal area mortality) for mature and old-growth forests. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60 –90% basal area mortality), or Severe (>90% basal area mortality)..

# Appendix 11 – Complex Perspectives on Tree Cutting

This appendix highlights the complex language used to describe tree cutting in land management and the associated range of perspectives expressed through that language.

Similar to ecological relationships between tree cutting and adverse outcomes in mature and old growth forests, social, cultural, and economic values interact with tree cutting in a complex way. Discussing the relationship between diverse values and tree cutting requires acknowledging the variety and complexity of terms used by different people and the potential miscommunication stemming from the language employed. Responses to questions posed during threat analysis engagement sessions illustrate the array of terms used to describe tree cutting (appendix 2). Engagement responses that mentioned what this threat analysis labeled 'tree cutting' differed among stakeholder groups (figure A11.1)

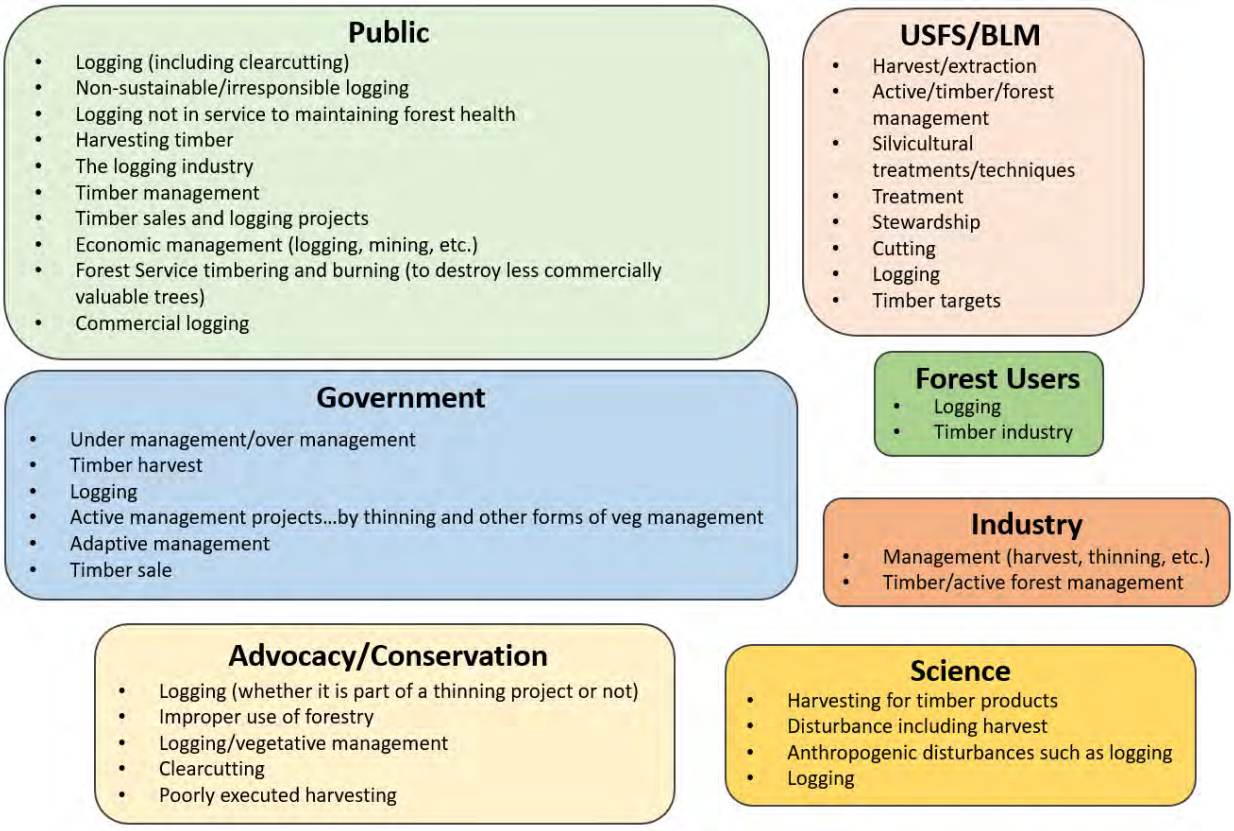



*Figure A11.1.—Stakeholder responses to the term 'tree cutting' illustrate the complexity of perspectives on the subject.*

Most groups used the term “logging”, though it was more common among some than others. Only one FS/BLM respondent used “logging”, while most other FS/BLM employees used “management”. The most important takeaway is that many terms are in use, and it is not always clear what people mean when they use one term or another. Indeed, a FS/BLM employee cited “common language and transparency” as a challenge to federal management and stewardship of MOG forests. Some employees feel the responsibility for addressing this could rest with the agency, as another employee stated the challenge is “lack of communication to our public of why we are managing our forested landscapes. We don’t provide the context of conservation outcomes that are important.”

Confusion and miscommunication may result in part from describing the process in different terms, but lack of public trust can also be a factor. Through engagement session feedback, some stakeholders and members of the public described tree cutting in ways that suggest they view it as a Forest Service ruse; the agency claims to be pursuing one set of objectives but in fact has others in mind. For example, one member of an advocacy group named logging as a threat “…either in the name of timber production or in the name of supposedly ameliorating the damage to MOG forests from climate change, insects, disease, drought, etc.” Another suggested it takes place “…under the cover of ‘ecological thinning’ or ‘community resiliency’…” Some members of the public took similar positions. One articulated “There are all too many fire management strategies that involve cutting down large (commercially valuable) trees with limited actual fire benefit – they’re logging disguised as fire management…”

The views expressed through these examples are not unanimous. Another advocacy group member stated “I think management is a very small concern. It is regulated. There is a public process, etc.” Some attendees teased out nuance in the process while bringing in political concerns. For example, “The FS may argue that it’s not in [the] business of logging older firsts [sic] but what if we get a trump 2.0 who targets unprotected MOG to bump up board feet. Additionally, the FS does log mature and that’s not necessarily a bad thing – maybe there’s too much in some places. That said, we may need a lot of mature in other places to reestablish old growth.”

Forest Service and BLM employees identified the complexity around tree cutting and the need to communicate with the public to acquire social license to perform management actions the agency deems necessary. When asked about challenges to management and stewardship of MOG forests, employees who attended engagement sessions in July 2023 wrote about issues regarding communication with the public, public perceptions, and social license. In fact, by a wide margin, this category garnered the largest number of responses in answer to this question. One pointed out that challenges to managing MOG include “…public perception of stewardship, esp. in dry or mixed forest types: treatment and burning as beneficial to restoring health vs. no-touch preferences (with perception of ‘logging’ being a threat to MOG, as it was historically)”. This statement also shows that the various values for which the agencies seek to manage are factors in the challenges of communicating with, and working with, a variety of stakeholder groups. A non-FS/BLM government employee also

noted a challenge stemming from "… public misperceptions about government agency intentions."

All told, the nuance and complexity of tree cutting and the language used to describe it can result in confusion when the terminology isn't commonly understood. Understanding requires unpacking terminology used, the nuances of goals and desired outcomes, and the range of both the perceived and actual extent and effects of tree cutting. The complexity of evaluating potential threats also stems from the multiple outcomes as tree cutting interfaces with human values and ecological outcomes: tree cutting can reduce certain social and cultural values or forest ecosystem services, while generating and maintaining other social and cultural benefits and ecosystem services, at the same time and in the same location.

# Appendix 12 – Regional Tree Cutting Summary

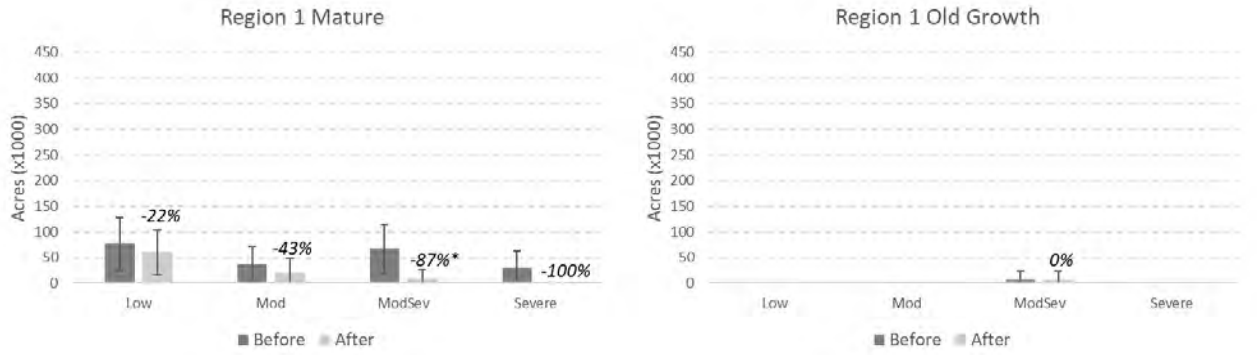



*Figure A12.1.—Region 1 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

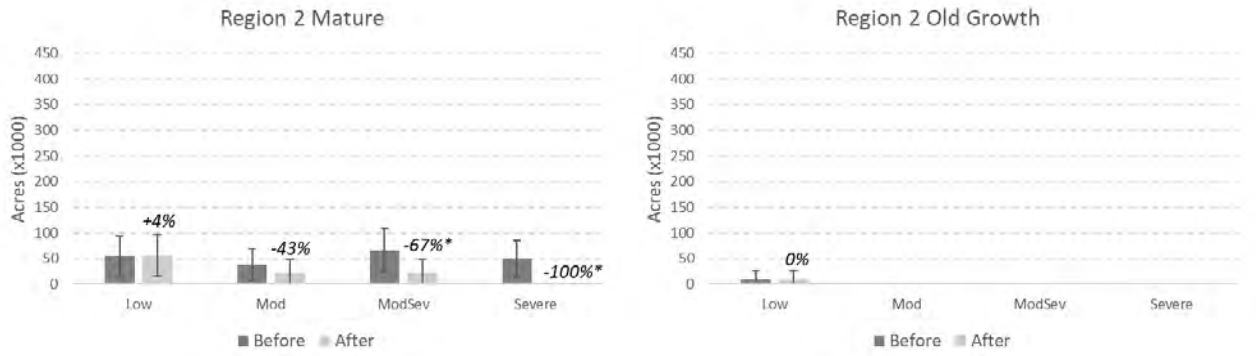



*Figure A12.2.—Region 2 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

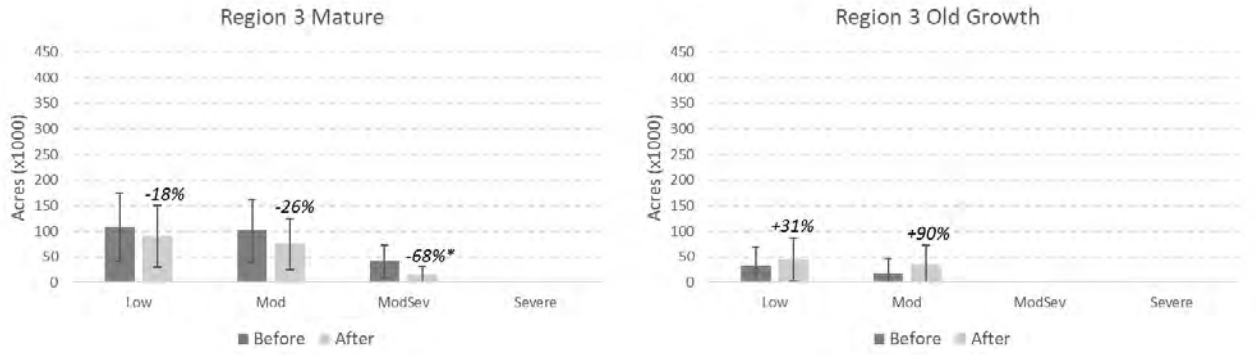



*Figure A12.3.—Region 3 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

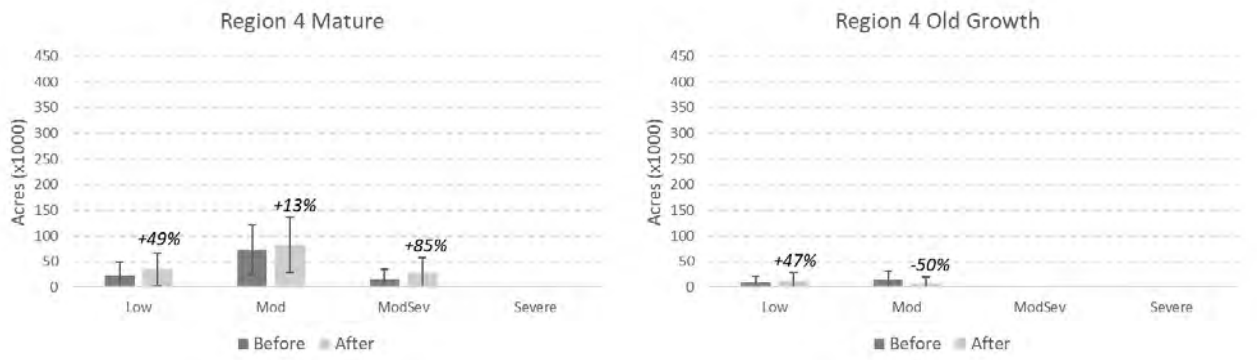



*Figure A12.4.–Region 4 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

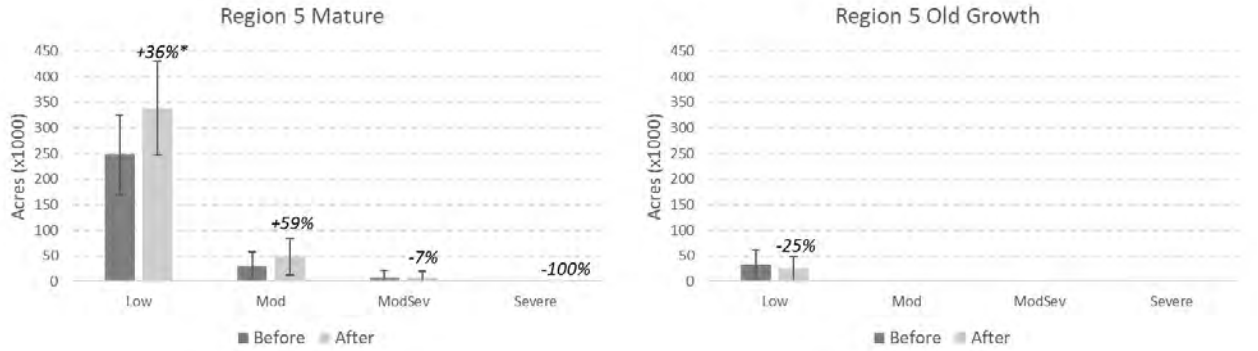



*Figure A12.5.—Region 5 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

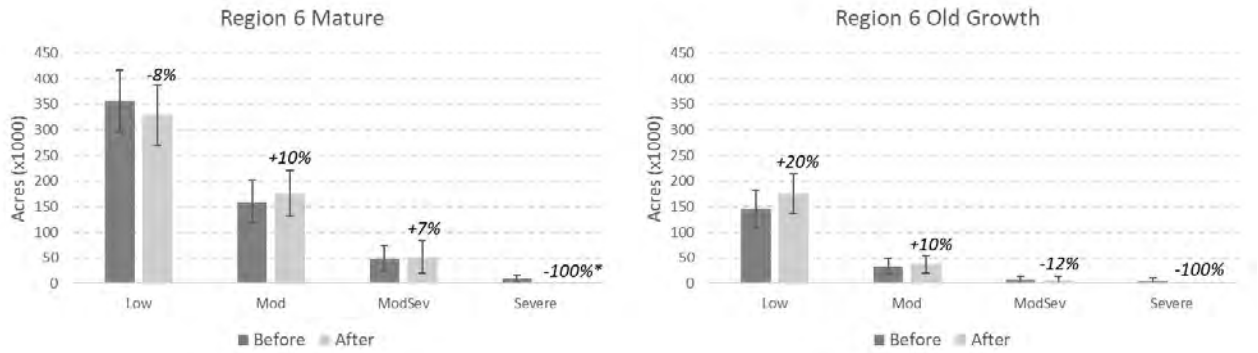



*Figure A12.6.—Region 6 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

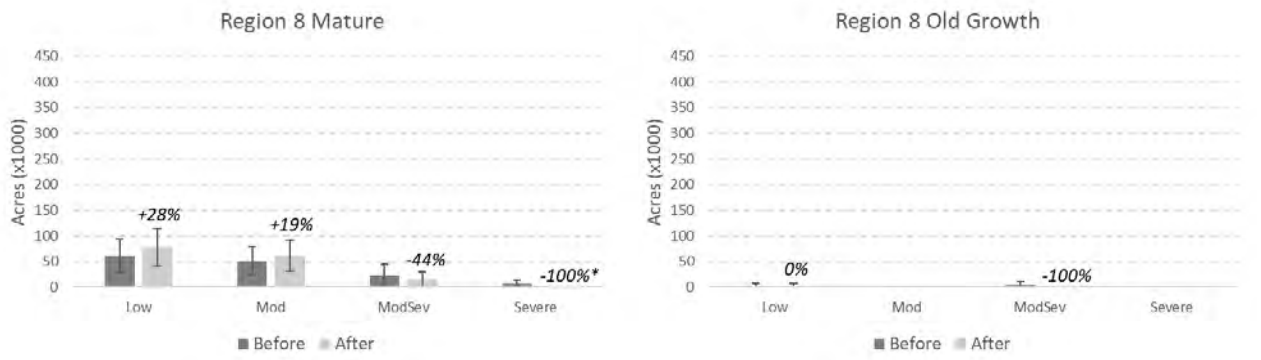



*Figure A12.7.—Region 8 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

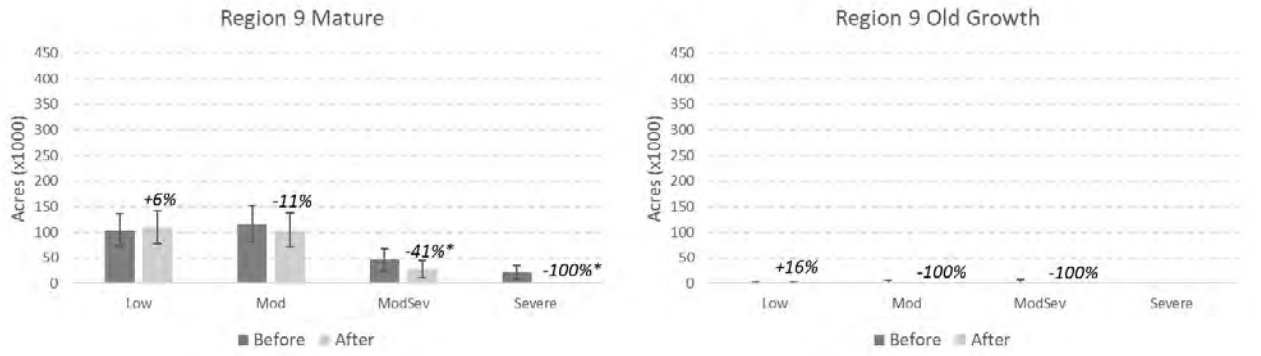



*Figure A12.8.—Region 9 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

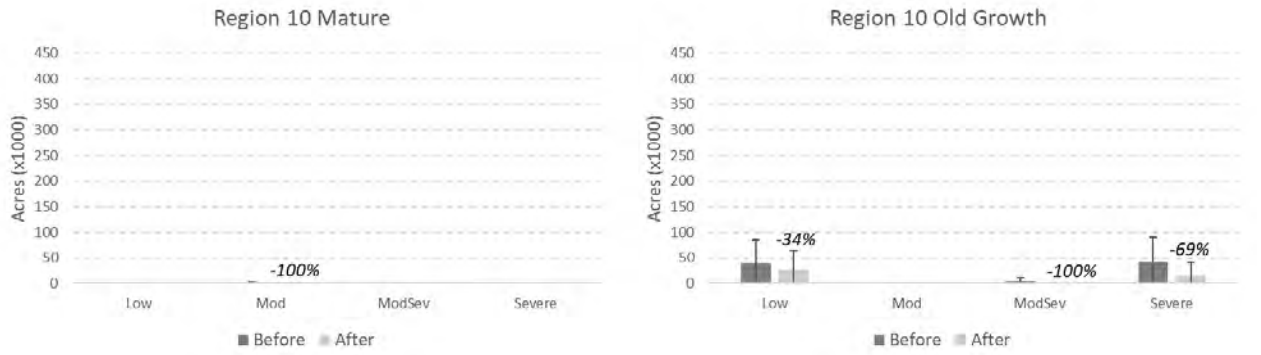



*Figure A12.9.—Region 10 net changes in mature and old-growth forest acres (with 95-percent confidence intervals) before and after a tree cutting disturbance. Asterisks (*) indicate net change was statistically significant. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*




*Figure A12.10.— Regional variations in tree cutting disturbance severity (basal area mortality) for mature and old-growth forests. Disturbance severity was classified as Low (<25% basal area mortality), Mod (25–60% basal area mortality), ModSev (60–90% basal area mortality), or Severe (>90% basal area mortality).*

# Appendix 13 – Regional All Disturbances Summary

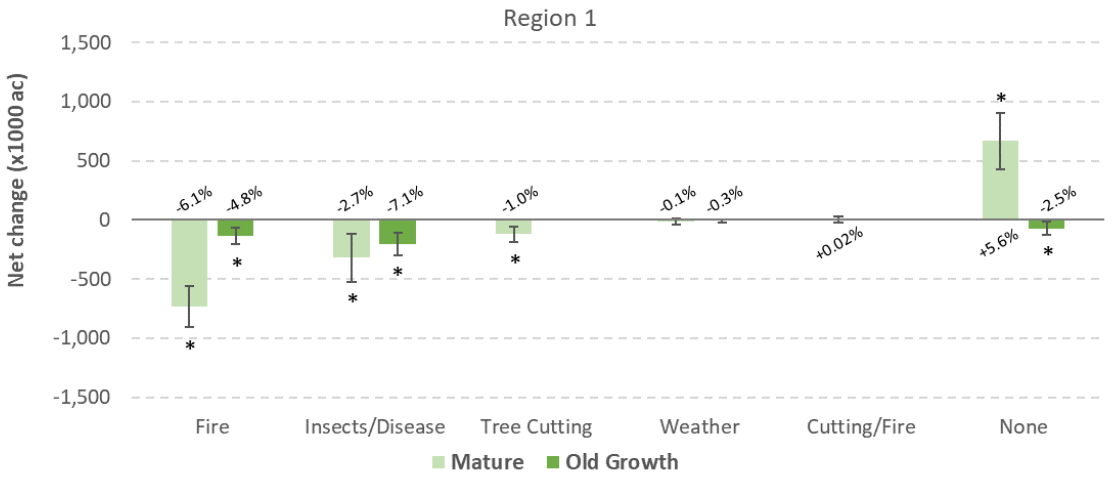



*Figure A13.1.—Region 1 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

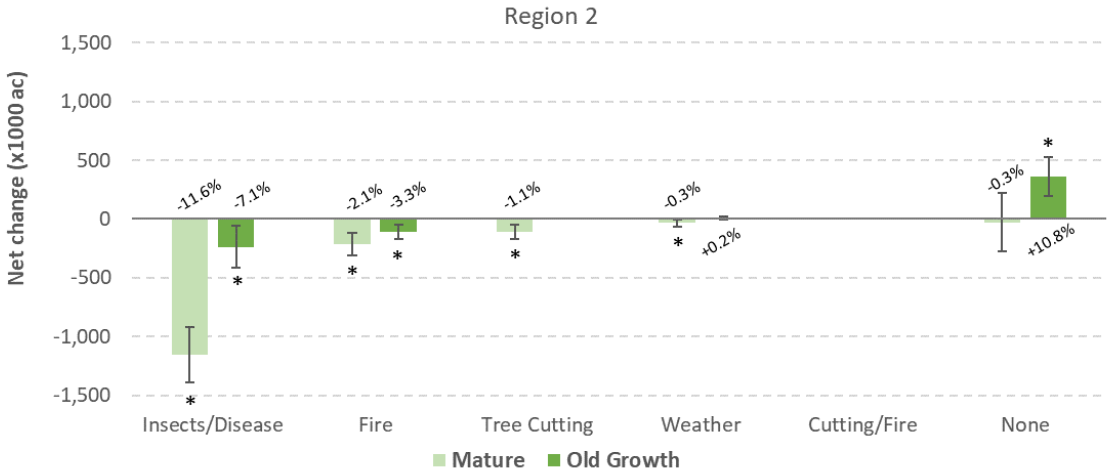



*Figure A13.2.—Region 2 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

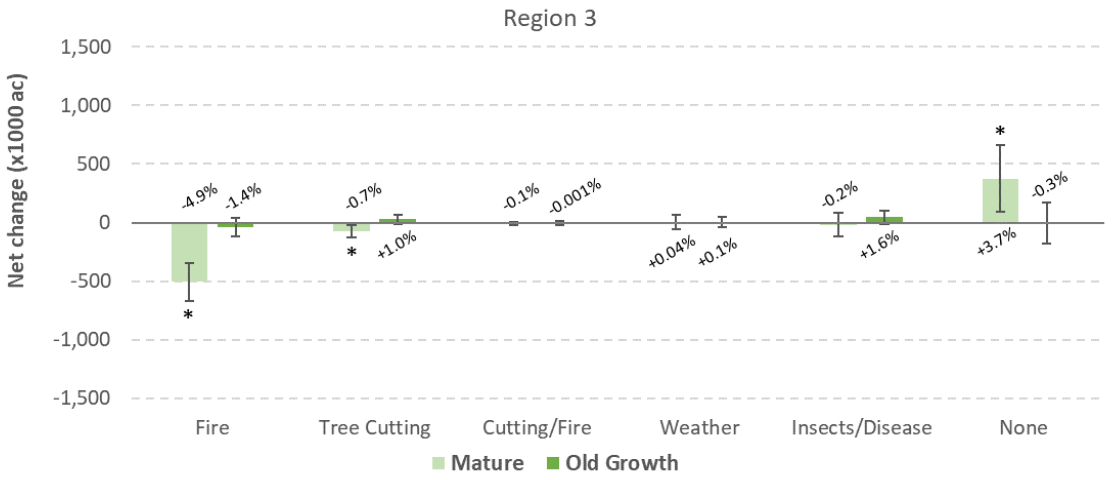



*Figure A13.3.—Region 3 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

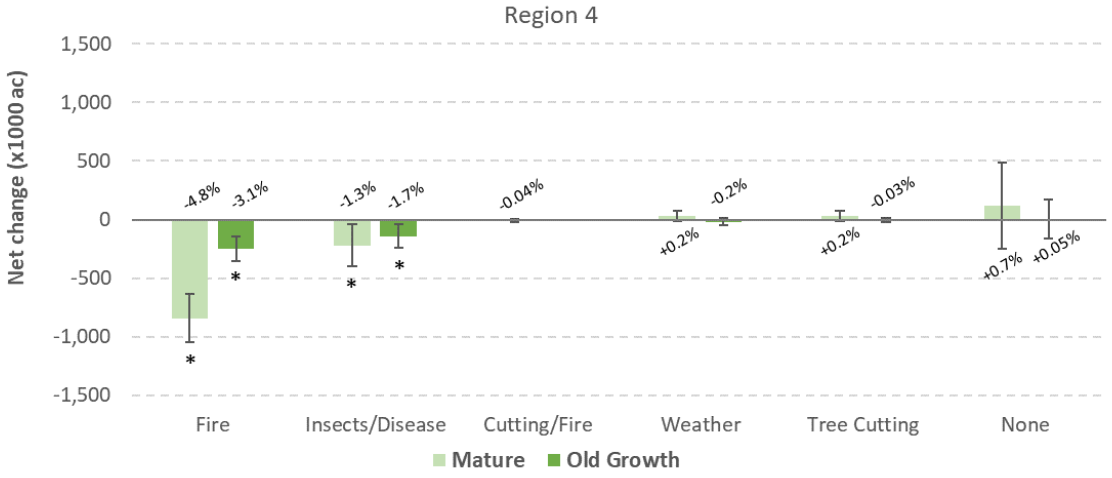



*Figure A13.4.—Region 4 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

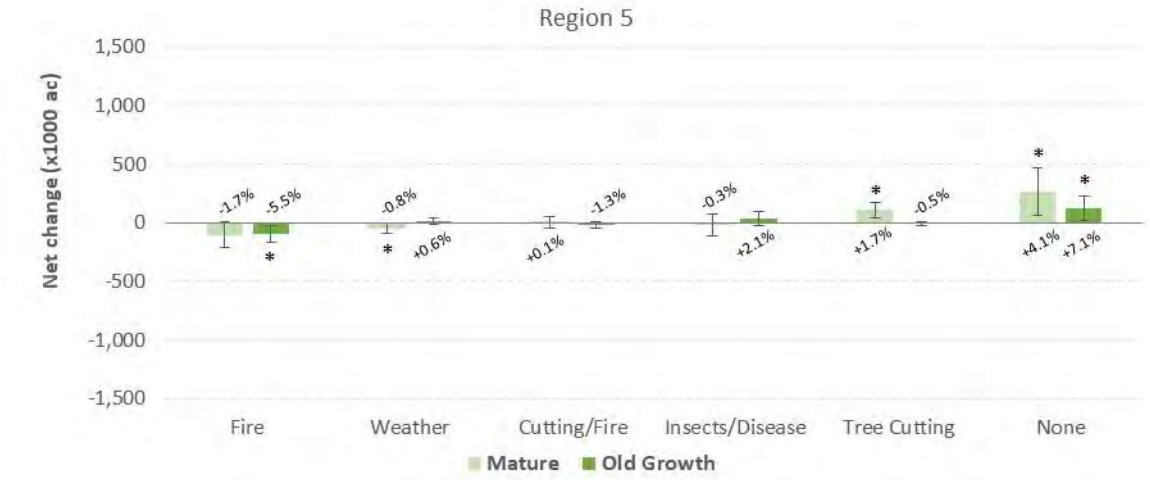



*Figure A13.5.—Region 5 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

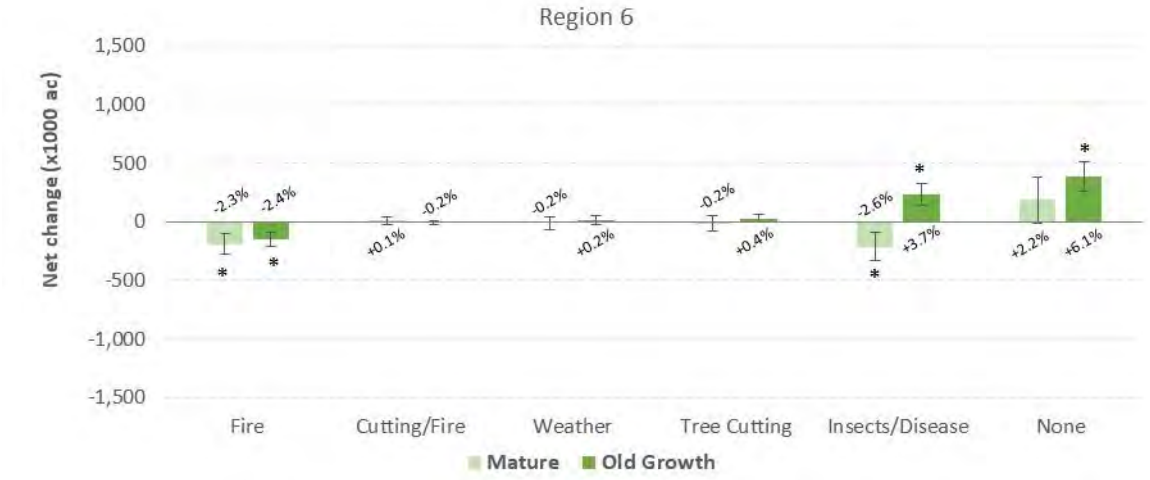



*Figure A13.6.—Region 6 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

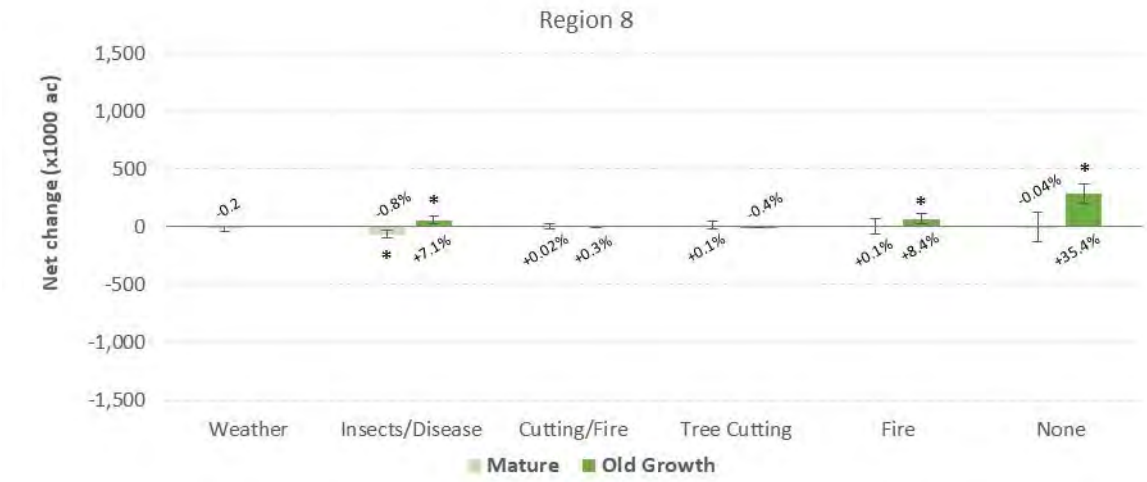



*Figure A13.7.—Region 8 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

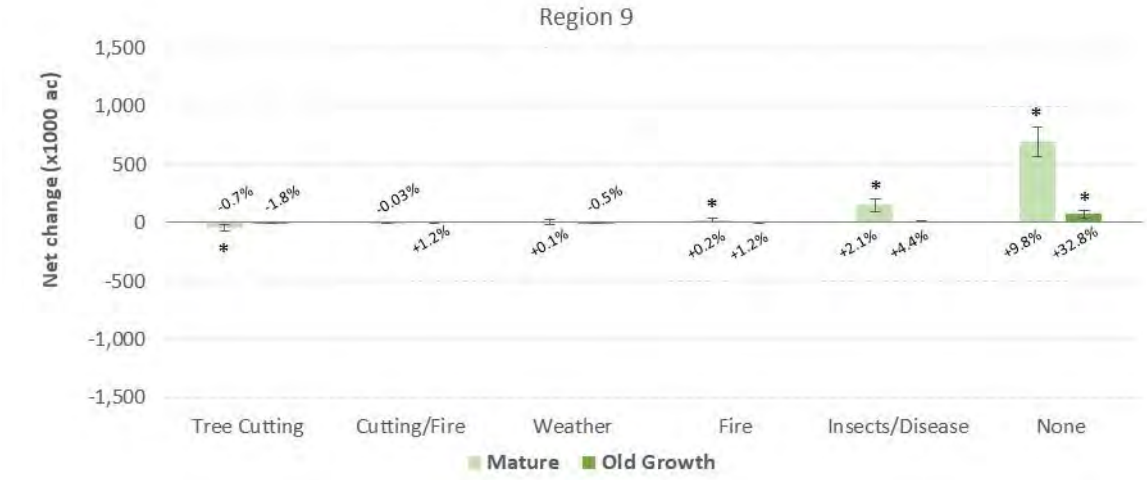



*Figure A13.8.—Region 9 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

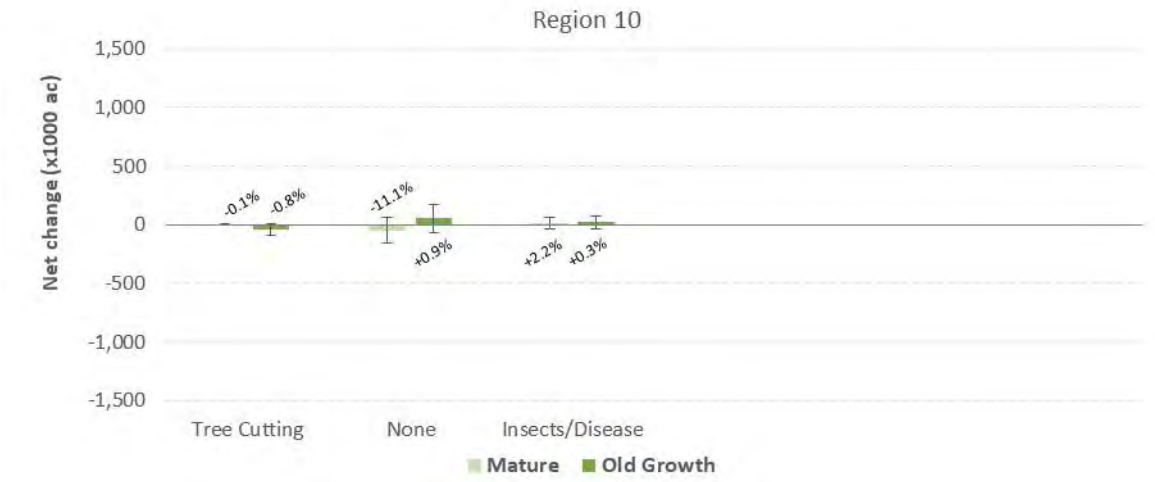



*Figure A13.9.—Region 10 net changes (with 95-percent confidence intervals) to mature and old-growth forest acres based on remeasured Forest Inventory and Analysis (FIA) plots ordered (from left to right) by largest net losses to largest net gains. Percentages are mean net changes. Asterisks (*) indicate a statistically significant net change.*

# Appendix 14 – Mature and Old Growth Climate Change Vulnerability Assessment Synthesis

## Overview

The ecological and social significance of mature and old-growth forests has made them a priority for conservation on public lands. This was recently institutionalized by Executive Order 14072, Section 2(b) and the report "Mature and Old-Growth Forests: Definition, Identification, and Initial Inventory on Lands Managed by the Forest Service and Bureau of Land Management". Although MOG forests have been protected from harvest in wilderness areas and other protected lands for many years, there is now increased urgency to increase the extent of MOG forests on other federal lands that are typically managed with multiple resource objectives. Restoration and long-term sustainable management of MOG are currently a major emphasis on Forest Service and Bureau of Land Management lands throughout the nation.

Climate change is a relatively new challenge for the conservation of MOG forests. Tree species that are present in current forest landscapes have persisted through a broad range of climatic variability at annual to millennial scales, as well as extensive timber harvesting and other human activities. However, recent human-caused climate change, and associated extreme weather events and disturbances, are creating conditions that increase stress for many species and perhaps opportunities for others. Climate change is superimposed on an existing template of diverse stress complexes that include biological components (e.g., insects, diseases) and human factors (e.g., land-use change, air pollution).

The effects of climate change on forest ecosystems, including MOG forests, will be mediated primarily through extreme weather events and disturbances that are provoked by extreme weather and climate. This includes drought, insect outbreaks, pathogen epidemics, increased frequency and extent of wildfire, and increased flooding. These disturbances test the tolerance levels of trees, and following the disturbance, set the stage for a competition among trees that will determine which species will persist in a warmer climate with more frequent disturbances. Chronic climate-related factors (e.g., temperature increase) affect tree regeneration, physiology, and growth at longer time scales. This sharpens the competition among tree species, tests their adaptive capacity, and ultimately affects their distribution and abundance across large landscapes.

In this document, we assess the potential effects of climate change on MOG forests in the western continental United States, divided in sections for the six Forest Service Regions within this geographic area. Inferences are based on published climate change vulnerability assessments and other scientific literature available for this area; projections should be relevant through at least the end of the 21st century. Each section describes climate change

effects by “forest types,” which are intended to characterize assemblages of common species in general geographic locations. Effects on existing MOG forests are discussed explicitly, with additional discussion on long-term effects on forest dynamics and regeneration to support inferences about the potential for MOG forests to persist within each region. This longer view is needed to inform conservation of MOG forests and sustainable resource management in general.

# Intermountain Region

Higher temperature is expected to cause a gradual change in the distribution and abundance of dominant forest species in the Intermountain Region. Increased ecological disturbance, driven by higher temperatures, is expected to cause near-term effects on forest and age-class structure, and will facilitate long-term changes in dominant vegetation. In forest ecosystems, native and non-native insects are expected to be significant stressors in a warmer climate; in fact, this appears to already be occurring. An increase in the frequency and extent of wildfire will be a significant stressor in all forest types, especially where fuel loadings are high. Nonnative plant species will continue to expand, potentially displacing native species and altering fire regimes. A combination of these and other stressors (stress complexes), exacerbated by climate, may accelerate the rate of change in forest ecosystems, reducing productivity and carbon storage.

At low elevations, MOG forests are relatively uncommon because of a long history of logging, although some MOG forests can still be found in wilderness areas and other protected lands. At high elevations, MOG forests are more common because they are less accessible and were less affected by logging. A notable exception is lodgepole pine and spruce forests where beetles have caused large areas of mortality. Effects of climate change are summarized for five forest types:

- Subalpine forest
- Mixed conifer forest
- Aspen forest
- Montane pine forest
- Riparian forest

## Subalpine Forest

Subalpine forests dominated by whitebark pine will be highly vulnerable in a warmer climate, primarily because this species is already subjected to considerable stress from white pine blister rust and mountain pine beetles. As a result, populations are in decline and reproductive capacity is limited, even when germination conditions are suitable. In areas where wildfire has been excluded for many decades, elevated fuel loadings may create high-intensity fires that lead to mortality of MOG trees. Ongoing decline in whitebark pine has cascading effects on other species that eat its seeds, especially Clark’s nutcracker. Subalpine forests in which bristlecone pine is a major component are mostly in dry locations that could become increasingly stressed by low soil moisture, which would reduce growth.

Other subalpine forests are expected to be moderately affected by a warmer climate. Limber pine, subalpine fir, Engelmann spruce, and white fir may all have increased growth in the upper subalpine zone because of a longer, snow-free growing season. These species may migrate to

higher elevations where conditions are suitable, although this would be a slow process over many decades. If wildfire increases in the subalpine zone, especially where it has been excluded in the past, crown fires may be prevalent, quickly eliminating MOG trees across the landscape. Limber pine is stressed by mountain pine beetles and white pine blister rust.

Spruce-fir forests will be moderately vulnerable to a warmer climate. Subalpine fir, Engelmann spruce, and blue spruce may all have increased growth in the upper subalpine zone because of a longer snow-free growing season, so overall productivity could increase. These species may migrate to higher elevations where conditions are suitable, although this would be a slow process over decades to centuries. If wildfire increases in the subalpine zone, especially where it has been excluded in the past, crown fires may be prevalent, quickly eliminating MOG stands across the landscape. Spruce beetles and spruce budworms are significant stressors, especially in dense, older forests.

Bark beetle outbreaks in Engelmann spruce and lodgepole pine are often severe and can accelerate succession in areas of high tree mortality. Most subalpine species are fire intolerant, but because most lodgepole pine populations have serotinous cones and the potential for dense regeneration, it is likely to persist in high-elevation landscapes. Quaking aspen in subalpine forests will be minimally affected by a warmer climate, especially compared to aspen at lower elevations. Where Douglas-fir is a seral species, it could increase in distribution and abundance where sufficient soil water is available. In addition, Douglas-fir is more fire tolerant than its associates, so it may become more common and move upslope as wildfire increases.

## Mixed Conifer Forest

The composition of mesic mixed conifer forest varies across the region, with site conditions and species assemblages determining vulnerability to climate change. In general, MOG forests will become increasingly susceptible to wildfire, especially where fire has been excluded for many decades and fuel loads are elevated. Firs and lodgepole pine are subject to high mortality from intense fires. As snowpack declines and summer temperature increases, growth and productivity will probably decrease, except on north aspects.

Douglas-fir and ponderosa pine have high fire tolerance and can survive mixed-severity fires. Therefore, if wildfire extent and intensity increase in the future, these species will become more common, and other species in MOG stands will become less common. Douglas-fir and ponderosa pine tolerate dry soils, so they are likely to persist across the landscape, but their growth rates will likely decrease. Lodgepole pine and quaking aspen, which are also common, both respond to wildfire with rapid, abundant regeneration and are expected to persist across the landscape, possibly with increased stress from insects and pathogens.

Dry mixed conifer forests are located in lower-elevation montane sites, often on steep slopes and shallow soils. This forest type contains some of the most drought-tolerant species in the region. Common seral species include ponderosa pine, which is fire tolerant and regenerates well after fire, and quaking aspen, which sprouts heavily and reproduces by seed after fire. The woodland species curl-leaf mountain mahogany, Gambel oak, and bigtooth maple are drought tolerant, and the latter two sprout vigorously after fire. Therefore, a major component of dry mixed conifer forest should be able to cope with drier soils and increased wildfire.

Two-needle pinyon and single-leaf pinyon are drought tolerant, and although intense fire typically kills them, they can usually regenerate successfully if competition is minimal. Singleleaf pinyon at its lowest elevational extent in northern New Mexico has experienced high mortality from prolonged drought and pinyon engraver and Ips beetles during recent decades, which suggests that this species will be susceptible to increasing drought in the future. Limber pine, which is considered late seral in these forests, is drought tolerant but may be stressed by mountain pine beetle, white pine blister rust, and increasing (usually fatal) wildfire.

The growth of Douglas-fir and white fir will likely decrease in a warmer climate, and although Douglas-fir has relatively high fire tolerance, white fir tolerates fire only when it has large diameter and thick bark. In a warmer climate with more wildfire, it will be increasingly difficult for these conifer species to compete with early-seral and woodland species that are more tolerant of drought and fire. Therefore, it is likely that early-seral species will become more dominant in the future, and MOG stands will become less common and perhaps confined to north aspects and valley bottoms.

## Quaking Aspen Forest

Quaking aspen is often found in combination with other conifer and woodland species. Response to climate change will depend on associated species, ranging from high to low elevation, and from north to south aspects. Although aspen is often considered an early-seral species following wildfire, it can persist for many decades in some forests, where productivity is low and conifer species do not compete well. Large stands dominated by MOG aspen and younger trees are found at higher elevations of the subalpine zone, even in the absence of wildfire. Increased wildfire frequency and extent will be a primary factor determining future composition and structure of aspen-mixed conifer and persistent aspen forests.

Late seral species (firs, Engelmann spruce) in MOG stands of this forest type are readily killed by fire. If wildfire reaches into the subalpine zone, it is likely that mature spruce-fir forests will become less common or will persist only on north slopes and in valley bottoms. Therefore, aspen has the potential to attain increasing dominance because of its ability to sprout and establish by seed after fire. This will also be true at lower elevations, where ponderosa pine can readily survive intense fires, and other species such as aspen and Gambel oak sprout vigorously after fire. Productivity in these systems will probably be lower in a warmer climate

with more fire. But the more fire-tolerant species will persist, especially in drier locations, where they can outcompete species that are susceptible to drought and fire.

## Montane Pine Forest

Ponderosa pine is a dominant species in drier montane locations throughout much of the region. Several other conifer species (Douglas-fir, limber pine, Great Basin bristlecone pine, white fir) are included in this forest type but are rarely as abundant as ponderosa pine, except in wetter locations (north aspects, valley bottoms). Ponderosa pine is persistent in these forests because it is drought tolerant and fire tolerant, allowing it to develop into MOG stands in some places. Consistently drier soils will cause this species to grow slower, but mortality may be rare unless drought lasts for several consecutive years and biotic agents cause additional stress.

The expected increase in frequency and extent of wildfire in a warmer climate will favor ponderosa pine over its less fire-tolerant competitors, thus ensuring dominance in most forests. But limber pine and bristlecone pine, species that are often in MOG stands, will probably persist at higher elevations where fuel loads are low. An exception might be in areas where fire exclusion has increased stand density and fuel loads conducive to crown fires, but even then, regeneration of ponderosa pine will probably be sufficient to maintain dominance after fire. If bark beetles become more prevalent in a warmer climate, they could increase stress and mortality in pine species, especially during drought periods.

## Riparian Forest

Riparian forests are distributed throughout the region, adjacent to lakes, streams, seeps, springs, and high-water tables. Vegetation is diverse, including a broad range of conifer and hardwood species. Historically, wildfire has infrequently burned into riparian areas, making it possible for MOG stands to develop in some locations. Some of these species occur only in riparian systems, providing habitat for many animal species. In some drier locations, nonnative saltcedar and Russian olive reduce the available groundwater, displacing native species and creating what could be considered undesirable MOG stands.

Riparian systems will be vulnerable in a warmer climate because they depend on a reliable water supply. Higher temperatures will accelerate evapotranspiration as soils dry faster and as vegetation takes up water earlier and faster during the growing season. Surface and subsurface water flows will decrease if snowpack decreases and melts earlier, precluding recharge during dry summers. This will alter vegetation dominance to species that are more tolerant of seasonal drought, including ponderosa pine and other deep-rooted conifers in some places. Hardwood species that rely on periodic high water levels for regeneration could become less common. Riparian forests associated with small or transient water sources (e.g., springs) will be more susceptible than forests near large water sources (e.g., rivers). Low-elevation riparian forests near small water sources will be more susceptible than high-elevation forests where snowpack is retained into spring or early summer.

# Northern Region

Increasing air temperature, through its influence on soil moisture, is expected to cause gradual changes in the abundance and distribution of tree species throughout the Northern Rocky Mountains, with drought-tolerant species becoming more competitive. The earliest changes will be at ecotones between lifeforms (e.g., upper and lower treelines). Ecological disturbance, including wildfire and insect outbreaks, will be a primary facilitator of vegetation change, and future forest landscapes may be dominated by younger age classes and smaller trees. High-elevation forests will experience declines in snowpack and longer growing seasons and are especially vulnerable to increased disturbance frequency. Increased abundance and distribution of nonnative species, as well as the legacy of past land uses, create additional stress for regeneration of native forest species.

At low elevations, MOG forests are relatively uncommon because of a long history of logging, although some MOG forests can still be found in wilderness areas and other protected lands. At high elevations, MOG forests are more common because they are less accessible and were less affected by logging. A notable exception is lodgepole pine forests in which mountain pine beetles have caused large areas of mortality over the past 30 years. The effects of climate change are summarized for five forest types:

- Dry ponderosa pine/Douglas-fir forest
- Western larch mixed mesic forest
- Mixed mesic western white pine, western redcedar, western hemlock, and grand fir forest
- Lodgepole pine mixed subalpine forest
- Whitebark pine mixed upper subalpine forest

## Dry Ponderosa Pine/Douglas-fir Forest

Dry ponderosa pine and Douglas-fir forests are found at lower elevations in some of the driest locations in the Northern Rockies. They are often in the foothills of mountain ranges and in flatlands bordering grasslands and shrublands. Historically, frequent low-intensity wildfires often maintained pure to mixed ponderosa pine woodlands and savannas. However, fire exclusion has led to increased tree density and abundance of Douglas-fir, making these forests susceptible to high-severity fire.

A hotter, drier climate may reduce the range of this forest type in some parts of its current range. Although MOG ponderosa pines are typically tolerant of drought, increased frequency and magnitude of droughts may, at a minimum, increase stress, thus decreasing tree vigor. This will in turn increase susceptibility to western pine beetles and mountain pine beetles, which can ultimately kill the trees. However, as drought increases, younger stands may expand into the mixed mesic forest type, especially on south slopes and other dry sites. The dry ponderosa pine/Douglas-fir forest type will probably be dynamic in the future, with many current forests seeing losses in Douglas-fir balanced by gains in ponderosa pine.

Fire exclusion for many decades in this forest type has increased stem densities and fuel loadings. This creates a higher likelihood of high-severity crown fires that can kill many MOG trees across the landscape. In addition, regeneration may be limited and/or slow because of loss of seed source, limited soil moisture, and high surface temperature.

## Western Larch Mixed Mesic Forest

Western larch mixed mesic forests are located primarily at lower elevations in the northwestern portion of the region. They consist of a patchy mixture of western larch, ponderosa pine, lodgepole pine, Douglas-fir, and Engelmann spruce. Because these species have different tolerances for low soil moisture, they tend to be differentially distributed according to topographic position. Larch is less common than it was historically (when it was maintained by wildfire) because of selective logging of this species, although planting of larch has increased in recent decades.

These forests evolved under a mixed-severity fire regime, although high-severity fire was more common on moist and cool sites, producing large burn patches, often with legacy western larch. Fire exclusion has advanced succession, with larch being replaced with mixed stands of lodgepole pine, Douglas-fir, and grand fir in many areas. The increased density of many of these forests puts them at risk to high-severity fire.

Western larch mixed mesic forests have undergone dynamic change over the past century and will continue to do so with the added influence of climate change. Fire exclusion is expected to continue to reduce western larch and increase the more shade-tolerant Douglas-fir, grand fir, and subalpine fir in some locations. Additional accumulation of surface and canopy fuels, combined with increased fire danger due to climate change, will make MOG trees in these forests susceptible to high-severity fire. In addition, western larch may transition to more northerly aspects where soils retain moisture during the growing season.

Some attributes of this cover type may make it more resilient to climate change in the future. Western larch is not as susceptible to the insects and diseases that affect other species, and it is the most fire-tolerant conifer species in western North America. Stands and landscapes with conditions that are within the historical range of variability are more likely to maintain resilience to climate change.

## Mixed Mesic Western White Pine-Western Redcedar-Western Hemlock-Grand Fir Forest

Moist forests within the Northern Rockies are influenced by a maritime climate with wet winters and dry summers. Complex topography, microclimate, soil conditions, and various disturbances create vegetative mosaics in which abundance and distribution of dominant species differ considerably. Up to 10 different tree species can occupy a given stand, including ponderosa pine, western larch, Douglas-fir, grand fir, western white pine, western redcedar, western hemlock, lodgepole pine, and Engelmann spruce.

Natural disturbances (snow, ice, insects, disease, wildfire) create heterogeneity in patch sizes, forest structures, and composition. Native insects (e.g., bark beetles) and diseases (e.g., Armillaria root rot, dwarf mistletoes) infect and kill old or stressed individuals and tend to increase spatial diversity in forest stands. A mixed-severity fire regime also creates a mosaic of forest compositions and structures. White pine blister rust has killed a large portion of western white pines that were not logged. Timber harvest has removed most of the large ponderosa pine and western larch, which are early seral and fire tolerant.

Douglas-fir and grand fir regenerated aggressively in response to historical logging and fire exclusion. In addition, fire exclusion has prevented the creation of canopy openings and seedbeds for regeneration of pine and larch. Now, when wildfires occur, surface organic layers are consumed, decreasing the nutrition and microbial processes that sustain these forests.

If future moisture regimes no longer support the current distribution of western hemlock, the remaining species that thrive on the upland western redcedar habitat types are likely to become dominant. In addition, increasing fire danger in combination with elevated fuel loadings will facilitate more high-severity wildfires that can kill large trees in MOG stands. The exact nature of altered wildfire and other disturbance changes (intensity, extent, and return interval) will influence the distribution and abundance of species at all spatial scales.

## Lodgepole Pine Mixed Subalpine Forest

This forest type is broadly distributed in the Northern Rockies, with vast subalpine areas dominated by even-aged and multi-aged stands of lodgepole pine, mixed with subalpine fir and quaking aspen. Although trees are smaller than in lower-elevation forests, MOG stands are extensive. Lodgepole pine forests are typically found at higher elevations in dry, cold environments. Aspen, which is often associated with wetter sites sprouts vigorously after wildfire, which limits dense regeneration of subalpine fir. Although subalpine fir has probably increased because of fire exclusion, most of this cover type is (or was recently) dominated by MOG lodgepole pine. Mountain pine beetles have killed large portions of these MOG forests in many parts of the region.

Subalpine forests in the Northern Rockies evolved with high-severity and mixed-severity fire regimes. Mixed-severity fire regimes were common in central Montana on flatter slope positions and produced a diverse pattern of patches of different ages and tree sizes with stand-replacing fire-return intervals of 100–500 years. The interaction of insects and wildfire also affects stand dynamics. For example, stands reaching 60–80 years often suffered mortality from mountain pine beetles, creating snags and down fuel.

This interaction between insects and fire could be further influenced by the effects of a warmer climate and drought on both disturbances. Stressed trees are more susceptible to insects, and mountain pine beetle populations and distribution at higher elevations are promoted by higher temperatures. In addition, wildfire frequency and extent are expected to increase, in some cases spreading from lower-elevation forests, decreasing the abundance of

MOG trees across the landscape. Although the extent of this cover type may fluctuate over time, it is not likely to change substantially in a warmer climate unless frequent reburns occur.

## Whitebark Pine Mixed Upper Subalpine Forest

Influenced by cold continental air masses, whitebark pine mixed upper subalpine forests are located at the highest elevations where trees exist in the Northern Rockies. Here, whitebark pine is found with subalpine fir, Engelmann spruce, mountain hemlock, and subalpine larch across 5 million acres, primarily on higher ridges and mountaintops. Historically, over 14 percent of the Northern Rockies could have consisted of whitebark pine forests, with late seral mixed fir-spruce patches mixed throughout.

Disturbance agents, including disease, insects, and climate comprise a stress complex that has greatly reduced whitebark pine populations (MOG and other ages) in western North America, leading to this species being classified as “threatened” in the United States. Extensive epidemics of white pine blister rust and outbreaks of mountain pine beetles over the past several decades have reduced whitebark pine and favored spruce, fir, and nonforest vegetation in some places.

Whitebark pine and associated species developed under a stand-replacing fire regime on steep north slopes, and under a mixed-severity fire regime in other locations. More frequent high-intensity fires could further reduce MOG whitebark pine populations. Although mountain pine beetle outbreaks have occurred three times over the past century, the outbreak that started in the mid-2000s (and has continued) has been especially damaging. This outbreak has occurred during a period of climatic warming, which is known to facilitate high beetle populations.

The combined stress from disease, insects, and a warmer climate will lead to additional mortality in MOG whitebark pine. Blister rust will be an ongoing chronic stressor, causing extensive mortality, while beetle outbreaks and wildfire (both affected by a warmer climate) will occur periodically with potentially severe effects across large landscapes. The current transition of dominance from whitebark pine to subalpine fir, and to a lesser extent Engelmann spruce and lodgepole pine, is expected to continue. The loss of older, cone-bearing whitebark pine trees will make it difficult for this species to recover. Fire can, in some cases, create conditions in which whitebark pine can establish, but recovery is unlikely in the absence of extensive planting of rust-resistant pine seedlings. Land management may be a bigger factor than climate in dictating the future composition and extent of this forest type.

# Pacific Northwest Region

Increasing air temperature, through its influence on soil moisture, is expected to cause changes in the abundance and distribution of tree species throughout the Pacific Northwest Region. Increased frequency and extent of wildfire and insect outbreaks will facilitate vegetation change by causing increased mortality of susceptible species. Drought- and fire-

intolerant species will likely be reduced in abundance, affecting the structure and function of MOG forests. High-elevation MOG forests will experience declines in snowpack and longer growing-season droughts, increasing their vulnerability and the potential for more frequent disturbance. Increased abundance and distribution of nonnative species, as well as the legacy of past land uses, create additional stress for regeneration of native forest species.

At low elevations, MOG forests are relatively uncommon because of a long history of logging, although some MOG forests can be found in wilderness areas and other protected lands. At high elevations, MOG forests are more common because they are less accessible and were less affected by logging. The effects of climate change are summarized for 10 forest types:

- Douglas-fir/western hemlock forest
- Sitka spruce forest
- Douglas-fir/tanoak forest
- Pacific silver fir forest
- Mountain Hemlock forest
- Ponderosa pine forest
- Mixed conifer forest
- Subalpine forest
- Western juniper woodland
- Riparian woodland

## Douglas-fir/Western Hemlock Forest

Douglas-fir/western hemlock forests are found from low to middle elevations in moist forest west of the Cascade Range. Douglas-fir is the primary canopy dominant, and western hemlock and western redcedar become increasingly important in MOG forests. Fires occurred multiple times a century prior to European colonization and played an important role in the development of MOG forest, particularly at lower elevation and drier locations in Oregon. Infrequent, high-severity fires also occurred at centennial scales, sometimes affecting large areas under extreme east-wind conditions.

Douglas-fir/western hemlock forests are expected to continue experiencing increased wildfire activity. The greatest increase in fire activity in moist forests is expected in the Oregon Cascades, particularly toward the south where lightning frequency is high and recent fire activity has increased the most. The Coast Range and Olympic Peninsula are expected to experience the biggest increases in fire relative to recent decades, but fire activity will remain low with the exception of drier locations in rain shadows (e.g., eastside Olympic Mountains, interior Coast Range along valley margins). Large, high-severity wildfires in moist forest are facilitated by synoptic east-wind events that are not projected to increase in frequency. However, more ignitions and fires burning during the late summer and early fall could produce more frequent high-severity fires even if winds do not change.

Insect outbreaks and pathogens are likely to increase in MOG forests as a result of increasing soil moisture deficits that stress trees, particularly in drought-intolerant species such as

western hemlock and western redcedar. Root rots affect most coniferous species in moist forests and will likely decrease growth vigor and increase susceptibility to windthrow. Douglas-fir beetle preferentially affects larger-diameter (>40 cm) Douglas-fir in small patches but may affect larger areas following mortality from wind or fire. Winter windstorms are also an important component of the disturbance regime in these forests and may cause substantial mortality during regional-scale events.

## Sitka Spruce Forest

Sitka spruce is the dominant forest in wet coastal areas, although MOG is relatively rare except in protected areas. The distribution of this zone is mostly limited to the coast and closely related to the occurrence of summer fog, extending inland along major river valleys. Other common tree species include Douglas-fir, western redcedar, and western hemlock. Fire was infrequent historically, although high-severity fires likely occurred under extreme drought or east-wind conditions. Winter windstorms are an important component of the disturbance regime in Sitka spruce forests and may cause substantial mortality during regional-scale events. More fog-free days during the summer may have negative effects on growth by increasing vapor pressure deficits and contributing to drier fuel conditions that could facilitate fires.

## Pacific Silver Fir Forests

Pacific silver fir forests occur at middle elevations where more of the annual precipitations falls as snow. MOG forests are dominated by noble fir and Pacific silver fir which increases in importance in mature and late seral stands. Douglas-fir and western hemlock may also be found in MOG forests, especially toward the lower extent of Pacific silver fir. Alaska yellow cedar may also be present on cool, north-facing aspects. Subalpine fir, lodgepole pine, and mountain hemlock may be present at higher elevations. Most species are relatively intolerant of fire. Contemporary fires in Pacific silver fir forests have high proportions of high-severity fire.

Pacific silver fir forests currently exist at the lower extent of the snow line and will be negatively affected by reduced snowpack. Loss of snowpack will increase vulnerability to higher disturbance frequency, particularly wildfire. Root rot pathogens are also a primary disturbance agent in MOG Pacific silver fir forests. Higher temperatures and more frequent drought could reduce tree growth and increase susceptibility to mortality.

## Mountain Hemlock Forest

MOG mountain hemlock forests are commonly dominated by monospecific stands of mountain hemlock. Lodgepole pine and western white pine may also be present, as well as other high-elevation conifers including subalpine fir and whitebark pine in drier locations. Mountain hemlock forests are composed primarily of fire-intolerant species. Historically, wildfire in this forest type was infrequent, and contemporary fires have high proportions of high-severity burns.

Mountain hemlock forests will experience reduced snowpack and longer growing seasons, and will be especially vulnerable to increased disturbance frequency, particularly wildfire. Warmer temperatures and more frequent drought could increase susceptibility to mortality from biotic disturbances and reduced growth. Laminated root rot is a primary disturbance agent in MOG mountain hemlock forests. Root rot patches spread slowly over time and kill mature trees.

## Subalpine Forest

Subalpine forests and woodlands occur in relatively dry locations at the highest elevations, dominated by subalpine fir, Engelmann spruce, western white pine, lodgepole pine, and whitebark pine. Subalpine larch occurs in the northern Cascades of Washington. Mountain hemlock and Alaska yellow cedar may be present in the moister portion of the distribution of subalpine forests.

Wildfires have already affected large extents of MOG subalpine forests. In addition to fire, subalpine MOG forests are especially vulnerable to increased frequency of low-snow years. Warmer temperatures and more frequent drought could increase susceptibility to mortality from insects and pathogens, as well as reduced growth. Lodgepole pine is susceptible to epidemic outbreaks of mountain pine beetle, and both whitebark pine and western white pine have suffered extensive mortality from the invasive white pine blister rust.

## Ponderosa Pine Forest

MOG ponderosa pine forests and woodlands are comprised mostly of ponderosa pine and multiple species of shrubs and perennial grasses. Frequent low-severity wildfire was common prior to European colonization but has been infrequent during the last century. Fire exclusion, grazing, and high-grade logging of the largest trees altered the structure of MOG forests, many of which currently have high densities of small trees and a reduced large-tree component.

MOG forests are currently vulnerable to large patches of high-severity fire and outbreaks of insects including mountain pine beetle and pine butterfly. High stem density also makes MOG forests susceptible to drought-related mortality as temperatures increase and acute summer droughts become more frequent and intense. Invasions of nonnative annual grasses may increase fire frequency and affect native plant communities in MOG forest and woodlands.

## Mixed Conifer Forest

MOG mixed conifer forests occur across a broad range of moisture conditions at middle elevations in dry forest landscapes of the region. Ponderosa pine is the most common and dominant early-seral species, although western larch is common in the Blue Mountains and northeastern Washington. Frequent wildfire in both dry and moist mixed conifer forests maintains large trees of these drought and fire resistant species. However, fire exclusion and high-grade logging of the largest trees have altered the structure and composition of mixed conifer forests, greatly reducing MOG. Current basal area and density are much higher than

they were historically because shade-tolerant cohorts of white fir, grand fir, and Douglas-fir have increased. Grand fir transitions to white fir as a dominant species in the southern Cascades. Incense cedar, lodgepole pine, and western white pine may occur throughout, and sugar pine from central Oregon southwards.

Large patches of high-severity fire will be a primary stressor in MOG forests, and increased frequency and extent of wildfire will favor the fire-tolerant species ponderosa pine and Douglas-fir. Increased frequency and extent of droughts will potentially affect all species, making them more susceptible to secondary factors such as insects. Sugar pine and western white pine are affected by the invasive white pine blister rust. Mortality may be prominent in MOG forests with high stem densities, with firs being especially susceptible. Drought-tolerant species such as ponderosa pine (although this species is susceptible to bark beetles) and Douglas-fir may be "winners" in the long term, comprising a greater proportion of future MOG forests. Mortality and altered species distribution and abundance will be greater where soil moisture is relatively low—south aspects, steep slopes, and lower elevations.

## Douglas-Fir/Tanoak Forest

Douglas-fir/tanoak forests are common at low to middle elevations in the Klamath Mountains of southwestern Oregon. Douglas-fir is dominant, but tanoak and other hardwood species including Pacific madrone, bigleaf maple, chinkapin, and canyon live oak are common. Frequent, low- and mixed severity fire was an integral art of the development of MOG Dougal-fir/tanoak forests prior to European colonization. Topography played an important role in the distribution and abundance of species as well as patterns of fire severity.

Fire exclusion and drought have increased the susceptibility of Douglas-fir/tanoak forests to high-severity fire. Large trees are vulnerable to mortality and decreased growth from competitive effects associated with increased forest density. Hardwood species can resprout following high-severity fire but may be top-killed resulting in loss of large tree dominance. Invasions of non-native annual grasses are of concern and may increase fire frequency and affect native plant communities in MOG forest and woodlands.

Douglas-fir is vulnerable to mortality from drought and beetles, particularly in warmer, drier topographic settings at low elevations. Tanoak has suffered extensive mortality from sudden oak death, resulting elevated levels of large woody fuels that can increase the intensity of fire following infection and mortality.

## Western Juniper Woodland

Western juniper woodlands are found at the lowest elevations in the warmest and driest portions of eastern Oregon (with a small amount in eastern Washington), dominated by western juniper and several species of shrubs and perennial grasses. Western juniper is one the most drought-tolerant and longest-lived species in the region, often reaching >1,000 years. Fires were generally infrequent historically but generally severe due to the thin bark and low fire tolerance of western juniper. Fire frequency was historically limited by a lack of fuels to carry fire, but western juniper experienced a long period of recruitment and

expansion during the 20th century and is vulnerable to invasion of nonnative annual grasses (e.g., cheatgrass, medusahead).

Western juniper is vulnerable to high-severity fires, especially in areas where invasive grasses now provide a continuous fuel bed to carry fire. Mature trees are susceptible to mistletoe which can reduce growth and cause branch dieback. Local topographic and site factors (e.g., soils) play an important role in the structure of MOG, and more woodlands that are isolated from other continuous forests may provide refugia from future drought and wildfire.

## Riparian Woodland

Riparian woodlands can contain several hardwood species—alders, cottonwoods, willows, maples, quaking aspen and sometimes conifers. Species composition varies across the region depending on local hydrology, with major differences between the eastside and westside Cascades. These species often achieve MOG structure in the absence of wildfire and other disturbances. Higher temperature and evapotranspiration will contribute to drying and increased drought sensitivity in some riparian areas. Riparian vegetation depends on the presence of flowing water. With climate change, summer streamflow will decrease because of earlier snowmelt and earlier runoff. Some riparian areas may serve as refugia for species dependent on cooler conditions, and dense vegetation may buffer increased temperature, especially in topographically complex landscapes where cold-air drainage affects the microclimate.

The primary effects of climate change on riparian woodlands will likely be mediated through disturbance. Increased drought frequency may decrease the extent of the riparian zone in some locations and/or alter riparian vegetation composition. More frequent wildfires may kill (or at least top-kill) MOG hardwoods as well as favor nearby fire-tolerant conifers, although most hardwood species sprout vigorously. Increased flooding may uproot MOG in some riparian areas as a result of lower snowpack and increased intensity of winter precipitation events. Increased peak flows can create erosion and sedimentation, which in turn affect channel form and the fluvial dynamics of streams and their riparian zones.

# Pacific Southwest Region

Increasing air temperature, through its influence on soil moisture, is expected to cause gradual changes in the abundance and distribution of tree species throughout the Pacific Southwest Region. Fire and drought-tolerant species will likely become more competitive. Ecological disturbance, including wildfire and insect outbreaks, will be a primary facilitator of vegetation change, and future forest landscapes may be dominated by younger age classes and smaller trees. Low elevations are expected to experience increasingly long and severe droughts, coupled with an increase in fire activity where fuels are not limiting. Higher-elevation forests will experience declines in snowpack and longer growing seasons and are especially vulnerable to increased disturbance frequency including insects and wildfire. Increased abundance and distribution of nonnative species, as well as the legacy of past land

uses, create additional stress for regeneration of native forest species that interact with climate change.

At lower elevations, MOG forests are relatively uncommon because of a long history of logging and other land uses, although some MOG forests can still be found in wilderness areas and other protected lands. At high elevations, MOG forests are more common because they are less accessible, were less affected by logging, and are the focus of recent conservation efforts. The effects of climate change are summarized for six forest types:

- Redwood forest
- Douglas-fir/tanoak forest
- Foothill forest and woodland
- Subalpine/red fir/Shasta red fir forest
- Ponderosa pine forest
- Mixed conifer forest

## Redwood Forest

Redwood is the dominant forest type in wet coastal areas from central California north, although MOG are relatively rare except for in protected areas. The distribution of this zone is mostly limited to the coast and closely related to the occurrence of summer fog, extending deeper inland along river valleys and transitioning to grasslands and woodlands in drier uplands. In addition to coast redwood, common tree species include Sitka spruce, grand fir, western redcedar, and western hemlock in coastal areas, and Douglas-fir and tanoak farther inland where there is less fog. Low- and moderate-severity wildfire was relatively frequent historically as a result of burning by American Indians, particularly in warmer inland areas and to the south. Winter storms are an important component of the disturbance regime and are often associated with high winds, landslides, and flooding.

More fog-free days during the summer could have negative effects on growth by increasing vapor pressure deficits. The effects of increasing summer moisture deficits may be greatest on western redcedar and western hemlock that occur in the southern part of their range. Warmer, drier conditions in the summer will also contribute to drier fuel conditions that could facilitate high-severity fires. These fires would potentially cause high mortality in all conifer species in MOG forests, although redwood can sprout vigorously.

## Douglas-Fir/Tanoak Forest

Douglas-fir/tanoak forests are common at low to middle elevations in the Klamath Mountains of northern California. Douglas-fir is dominant, but tanoak and other hardwood species including Pacific madrone, bigleaf maple, chinkapin, and multiple species of oak (e.g., canyon live oak, California black oak, Oregon white oak) may be present. Frequent, low- and mixed-severity fire was an integral art of the development of MOG Douglas-fir/tanoak forests prior to European colonization. Topography played an important role in the distribution and abundance of species as well as patterns of fire severity.

Fire exclusion and drought have increased the susceptibility of Douglas-fir/tanoak forests to high-severity fire. MOG trees are vulnerable to mortality and decreased growth from competitive effects associated with increased forest density. Hardwood species can resprout following high-severity fire but may be top-killed, resulting in loss of large-tree dominance. Invasions of nonnative annual grasses may increase fire frequency and affect native plant communities in MOG forests.

Douglas-fir is vulnerable to mortality from drought and beetles, particularly in warmer, drier topographic settings at low elevations. Tanoak has suffered extensive mortality from sudden oak death, resulting elevated levels of large woody fuels that can increase the intensity of fire following infection and mortality. The interaction of these multiple stressors with a warmer climate will increase the susceptibility of this forest type in the future.

## Foothill Forest and Woodland

Foothill forests and woodlands occur at the lowest elevations around valley margins and the foothills of larger mountain ranges. Foothill forests often intermingle with meadows and chaparral at the low end of their elevational distribution and transition to conifer-dominated forest types at the upper end. Several oak species are found in this forest type, including coast live oak, interior live oak, blue oak, canyon live oak, black oak, and Oregon white oak. Gray pine, knobcone pine, and Coulter pine are the most common conifers. All dominant tree species are generally drought tolerant.

Frequent, low-severity fire historically played a major role in the development of MOG foothill forests and woodlands. Some MOG foothill forest and woodlands are still abundant, particularly those dominated by blue oak, but fire exclusion and grazing have altered their structure and composition by promoting increased densities of small trees and conifer encroachment in places.

MOG foothill forest and woodlands are at risk of high-severity fire and drought-related mortality from increased density and competition with smaller trees. Although oaks will resprout following fire, high-severity fire may top-kill large trees that are an important component of MOG structure. Invasions of nonnative annual grasses may increase fire frequency and affect native plant communities in MOG forests and woodlands. Most dominant species are relatively resistant to native insects and pathogens, but sudden oak death has the potential to infect and kill large coast live oak, black oak, and canyon live oak trees.

## Subalpine/Red Fir/Shasta Red Fir Forest

Subalpine, red fir, and Shasta red fir forests occur at high elevations in mountainous landscapes. Red fir and Shasta red fir forests are generally located in more productive environments than subalpine forests but share many of the same climatic conditions. Western white pine, whitebark pine, lodgepole pine, and mountain hemlock are also common; Brewer spruce, limber pine, and foxtail pine are less common. Wildfire was moderately frequent but highly variable and predominantly low and moderate severity

historically. Current MOG forests have higher canopy cover and density of small trees than prior to fire exclusion, especially in red fir and Shasta Red fir forests.

Loss of snowpack will increase drought stress during the growing season while higher temperatures will increase water demand, especially later in the growing season. Higher temperatures and longer growing seasons will likely increase the frequency and extent of fire, insect outbreaks, and pathogens. MOG red fir and Shasta red fir have recently experienced significant tree morality from the combined effects of drought, insects, and pathogens. Lodgepole pine is susceptible to mountain pine beetles, and western white pine and whitebark pine are susceptible to the invasive white pine blister rust, especially in moister landscape positions.

## Ponderosa Pine Woodland and Forest

MOG ponderosa pine woodlands and forests are comprised mostly of ponderosa pine and multiple species of shrubs and perennial grasses. Frequent low-severity fire was common prior to European colonization but was largely absent during the past century. Fire exclusion, grazing, and high-grade logging of the largest trees have altered the structure of MOG forests which currently have an increased density of small trees and a reduced large-tree component.

MOG forests are currently vulnerable to large patches of high-severity fire and outbreaks of insects including mountain pine beetle and pine butterfly. Increased density also makes MOG forests susceptible to drought-related mortality as temperatures increase and acute summer droughts become more frequent and intense. A recent (2010–2016) large-scale mortality event in the Sierra Nevada (>100 million trees killed) corroborates the synergistic effects of drought and insects. Invasions of nonnative annual grasses may increase fire frequency and affect native plant communities in MOG forests and woodlands.

## Mixed Conifer Forest

Mixed conifer MOG forests occur across a broad range of moisture conditions at middle elevations in dry forest landscapes in the Pacific Southwest region. Ponderosa pine is a common and dominant early-seral species. Jeffrey pine, sugar pine, and western white pine may also be present. Giant sequoia is found in scattered stands on the western slope of the Sierra Nevada. Frequent wildfire in both dry and moist mixed conifer forests maintained the dominance of large trees of the drought- and fire-resistant sequoias. Fire exclusion and high-grade logging of the largest trees of all species altered the structure and composition of mixed conifer MOG forests. Current basal area and density are much higher than there were historically because of ingrowth of shade-tolerant cohorts of white fir, incense cedar, and Douglas-fir.

Large patches of high-severity wildfire are a primary vulnerability in mixed conifer MOG forests, and increased frequency and extent of fire in the future will favor the fire-tolerant species ponderosa pine and Douglas-fir. Increased frequency and extent of droughts will potentially affect all species, making them more susceptible to secondary factors such as

insects. Sugar pine and western white pine are affected by the invasive white pine blister rust. Mortality may be prominent in MOG forests with high stem densities, and firs may be especially susceptible. Drought-tolerant species such as ponderosa pine (although this species is susceptible to bark beetles) and Douglas-fir may be "winners" in the long term, comprising a greater proportion of future MOG forests. Mortality and altered species distribution and abundance will be greater where soil moisture is relatively low—south aspects, steep slopes, and lower elevations.

# Rocky Mountain Region

Increasing air temperature, through its influence on soil moisture, is expected to cause gradual changes in the abundance and distribution of tree species throughout the Rocky Mountain Region, with more drought-tolerant species becoming more competitive. The earliest changes will be at ecotones between lifeforms (e.g., upper and lower treelines). Ecological disturbance, including wildfire and insect outbreaks, will be a primary facilitator of vegetation change, and future forest landscapes may be dominated by younger age classes and smaller trees. High-elevation forests will experience declines in snowpack and will be especially vulnerable to increased disturbance frequency. Increased abundance and distribution of nonnative species, as well as past land uses, create additional stress for regeneration of native forest species.

Forest vegetation in the Rocky Mountain Region is diverse, ranging from mixed conifer forests on high mountains in Colorado to semiarid ponderosa pine forests in South Dakota, to whitebark pine woodlands in Wyoming. At low elevations, MOG forests are relatively uncommon because of a long history of logging, although some MOG forests can still be found in wilderness areas and other protected lands. At high elevations MOG forests are more common because they are less accessible and were less affected by logging. However, mountain pike beetles have caused extensive mortality in lodgepole pine forests over the past 30 years. The effects of climate change are summarized for seven forest types:

- Pinyon-juniper forest
- Ponderosa pine forest
- Mixed conifer forest
- Lodgepole pine forest
- Subalpine forest
- Quaking aspen forest
- Riparian woodland

## Pinyon-Juniper Forest

Pinyon-juniper forests, comprised of two-needle pinyon pine and three different juniper species, are found primarily at lower elevations in southern and western Colorado. Drought can reduce the vigor of pinyon pine, increasing their susceptibility to bark beetle outbreaks that can cause extensive tree mortality. Recent drought-provoked outbreaks in Arizona and Nevada killed as much as 90 percent of the dominant overstory pinyon pines. Juniper species

are typically more drought tolerant than pinyon pine but can also be stressed by long droughts. Both species are especially susceptible to drought-induced mortality on the hottest and driest landscape positions.

Pinyon pine and juniper are fire intolerant. Therefore, an increase in the frequency and extent of wildfire will be a major stressor in the future, although the fire effects will vary depending on stand structure and fuel loading. Forests with high stem densities and high fuel loadings are conducive to crown fires and mortality of most of the MOG trees, whereas forests with low stem densities and low fuels may not generate flames high enough to propagate crown fires.

## Ponderosa Pine Forest

Ponderosa pine forests are distributed mostly at lower elevations, often at lower treeline, extending into the lower distribution of mixed conifer forests. Ponderosa pine is often associated with subdominant Gambel oak, and is mixed with shrubs (e.g., sagebrush) and grasses at the lowest and driest extent of its distribution. Large areas of MOG are uncommon in this forest type, although stands or small groups of large trees are relatively common where logging has not occurred for several decades.

Ponderosa pine has a deep taproot, which allows it to tolerate drought. However, several consecutive years of drought can weaken trees enough to make them susceptible to lethal bark beetle outbreaks. If droughts occur more frequently, early effects on ponderosa pine can be expected in the driest landscape positions (e.g., south aspects, steep slopes). Historically, ponderosa pine forest had a high-frequency/low-intensity fire regime; even relatively small trees often survived fire. However, increased wildfire in the future may be a stressor in areas where high fuel loadings can propagate crown fires.

## Mixed Conifer Forest

Mixed conifer forests are comprised of a broad range of conifer and some hardwood species at mid elevations in the Southwest. Dominant species include Douglas-fir, ponderosa pine, white fir, Rocky Mountain juniper, and blue spruce; subalpine fir and Engelmann spruce are found in colder areas. Mixed conifer encompasses a significant amount of MOG forest where logging and recent disturbances have not been a factor. Patches of quaking aspen are commonly found in mixed conifer forests, and although it is often considered an early-seral species, it can achieve MOG conditions in the absence of disturbance and competition from conifers.

Increased frequency and extent of droughts will potentially affect all species, making them more susceptible to secondary factors such as insects. Mortality may be prominent in MOG forests with high stem densities; spruces and firs may be especially susceptible. Drought tolerant species such as ponderosa pine (although this species is susceptible to bark beetles) and Douglas-fir may be “winners” in the long term, comprising a greater proportion of future MOG forests. Mortality and altered species distribution and abundance will be greater where low soil moisture is prevalent—south aspects, steep slopes, and lower elevations. Historically, this forest type experienced mostly low-severity and mixed-severity wildfire. Increased

frequency and extent of fire in the future will tend to favor the fire-tolerant species ponderosa pine and Douglas-fir.

## Lodgepole Pine Forest

Lodgepole pine tolerates a wide variety of climatic and soil conditions, achieving its best growth on gentle slopes and in basins with well-drained soils. This species is often found in nearly pure stands but intergrades with mixed conifer and subalpine forests in many locations. Because lodgepole pine often germinates prolifically following wildfire, stands tend to be of uniform age and can achieve MOG conditions over time in the absence of insects and fire.

Old, low-vigor, high-density lodgepole pine stands are susceptible to mountain pine beetles. Beetle populations are stimulated by higher temperatures, spreading from stressed trees to adjacent healthy trees in large outbreaks, and will be a major stressor in a warmer climate. Stimulated by recent warming, beetles have killed lodgepole pine forests across large landscapes in the past 30 years, including MOG stands. Lodgepole pines are relatively fire intolerant and have serotinous cones that disperse seeds quickly after a wildfire passes. Therefore, it is expected that this species will persist in a warmer climate, but more frequent wildfire combined with increased beetle outbreaks will make it difficult to achieve MOG conditions.

## Subalpine Forest

Subalpine forests occupy a large portion of the highest elevations where tree species exist in the region. Engelmann spruce and subalpine fir are the dominant species; blue spruce and lodgepole pine are present in cooler, wetter sites, and limber pine and Rocky Mountain bristlecone pine are present on more exposed sites. MOG stands that have not been subject to logging are common, especially in wilderness areas.

Where adequate soil moisture is available, higher temperature and a longer growing season may increase (or at least maintain) growth and productivity for subalpine species, especially at the highest elevations. However, at lower elevations within the subalpine zone and other locations where snowpack decreases significantly, low soil moisture may decrease growth and subject MOG trees to stress during the growing season. This could in turn make these forests more susceptible to insects, especially spruce beetle and spruce budworm, especially in dense, older forests.

None of the common species in subalpine forests are fire tolerant. As fire frequency and extent increase in the future, it is likely that wildfire will increasingly spread from mixed conifer forests into subalpine forests, killing large areas of MOG subalpine forest. The potential for post-fire regeneration will be variable, and lower-elevation tree species may displace spruce and fir in the lower portion of the subalpine zone. Whitebark pine (found only in Wyoming) will be particularly susceptible to a stress complex of white pine blister rust and climate-related increases in mountain pine beetle outbreaks and wildfire.

## Quaking Aspen Forest

Quaking aspen is widely distributed in the region, often embedded with conifer forests, ranging from dry, high-elevation sites to poorly drained meadows. Although it is often considered an early-seral species, it can achieve MOG conditions in the absence of disturbance and competition from conifers. Aspen is susceptible to several insect and pathogen species.

There has been considerable discussion about "aspen decline" over the past 20 years. It appears that mortality has been highest in the driest landscape positions—exposed sites and south-facing slopes. A warmer, drier climate may facilitate additional mortality, first in the driest locations, then perhaps elsewhere. Aspen can be top-killed by wildfire but sprouts vigorously. With increased wildfire frequency, aspen may exist primarily in younger stands that never achieve MOG structure.

## Riparian Woodland

Riparian woodlands contain several hardwood species mixed with other herbaceous plants near streams and other water bodies. Riparian areas are often embedded within conifer and aspen forests. Species composition varies depending on local hydrology and topography. MOG trees in riparian areas provide habitat for many birds, mammals, and other fauna. Most of the hardwood trees tend to be short-lived but regenerate quickly by seed or sprouting following disturbances. Many riparian woodlands have a significant component of nonnative invasive species that are tolerant of saline conditions and low soil water, especially saltcedars and Russian olive, that can greatly reduce water availability for native species. These invasives, which are an ongoing stressor, will likely increase in a warmer climate.

If temperature and drought frequency increase as projected, the hydrology of riparian woodlands will be altered relatively quickly. This will decrease the abundance and diversity of native hardwood species that require a reliable water supply during the growing season, in some cases killing stressed MOG trees. In addition, drier conditions in riparian areas may reduce fuel moisture in riparian woodlands, making them more susceptible to wildfire that spreads from adjacent vegetation. These fires will likely kill many of the MOG trees, although some species can sprout quickly.

# Pacific Southwest Region

Higher temperature, independent of other climate-related factors, is expected to create considerable stress for many forest landscapes in the Pacific Southwest Region, especially on south and west aspects. Many forests in this region are already subjected to periods of low water availability, and increasing temperature will exacerbate the demand for water. Multi-year droughts, which have been common in the Southwest over the past 20 years, provide an additional stress that will likely become more common in the future. This will affect most mid- to low-elevation forests, ranging from MOG trees to regeneration. This is expected to

cause a gradual change in the distribution and abundance of dominant forest species, and in some cases will facilitate a transition from forests to nonforest vegetation.

Insect outbreaks are also expected to be significant stressors, often being the ultimate cause of mortality in drought-stressed forests. An increase in the frequency and extent of wildfire will be an additional stressor, especially where fuel loadings are high, often killing MOG trees and inhibiting regeneration. Nonnative plant species, especially annual grasses (e.g., cheatgrass) will likely continue to expand, potentially displacing native species and altering fire regimes. A combination of stressors (stress complexes), exacerbated by climate, may accelerate the rate of change in forest ecosystems, reducing productivity and carbon storage. Declining snowpack will decrease soil moisture, contributing to altered distribution of montane forest species.

At low to mid elevations, MOG forests comprised of large conifer species (e.g., ponderosa pine) are uncommon because of a long history of logging, although some MOG forests can still be found in protected lands. MOG stands can often be found at low to mid elevations where forests contain woodlands (e.g., oaks) and conifer forests (e.g., pinyon pine) with low commercial value. At high elevations, MOG forests are more common because they are less accessible and were less affected by logging. The effects of climate change are summarized for six forest types:

- Pinyon-juniper forest
- Ponderosa pine forest
- Mixed conifer forest
- Subalpine forest
- Oak woodland
- Riparian forest

## Pinyon-Juniper Forest

Pinyon-juniper forests are extensive at lower elevations in the Southwest. Multiple pinyon pine and juniper species are often mixed with grasses, sagebrush, and evergreen shrubs at the lowest extent of their distribution, and with oaks and ponderosa pine at higher elevations. Drought can reduce the vigor of pinyon pine, increasing their susceptibility to bark beetle outbreaks that can cause extensive tree mortality. Recent drought-provoked outbreaks in Arizona and Nevada have killed as much as 90 percent of the dominant overstory pinyon pines in some places. Juniper species are typically more drought tolerant than pinyon pine but can also be stressed by long droughts, and both species are susceptible to drought-induced mortality on hot, dry sites.

Pinyon pine and juniper species are fire intolerant. Therefore, an increase in the frequency and extent of wildfire could become a major stressor in the future, although fire effects will vary depending on stand structure and loading. Forests with high stem densities and high fuel loadings are conducive to crown fires and mortality of most of the MOG trees, whereas forests

with low stem densities and low fuels may not generate flames high enough to propagate crown fires, allowing MOG trees to survive.

## Ponderosa Pine Forest

Ponderosa pine forests lie between pinyon-juniper and mixed conifer forests, both of which contain a significant component of ponderosa pine. At the lowest extent of its distribution, ponderosa pine is often associated with subdominant Gambel oak and evergreen oak species, as well as shrubs (e.g., sagebrush) and grasses. MOG trees are not widespread in this forest type, although stands or small groups of large trees are relatively common where logging has not occurred for several decades.

Ponderosa pine has a deep taproot that allows it to tolerate drought. However, several consecutive years of drought can weaken trees enough to make them susceptible to lethal outbreaks of bark beetles, which has occurred recently in the Sierra Nevada of California. If droughts occur more frequently in the Southwest, early effects on ponderosa pine can be expected in the driest landscape positions (e.g., south aspects, steep slopes). Historically, ponderosa pine forest had a high-frequency/low-intensity fire regime; even relatively small trees often survived fire. However, increased wildfire in the future may be a stressor in areas where high fuel loadings can propagate crown fires.

## Mixed Conifer Forest

Mixed conifer forests are comprised of a broad range of conifer and some hardwood species at mid elevations in the Southwest. Dominant species include Douglas-fir, ponderosa pine, white fir, blue spruce, corkbark fir, and southwestern white pine; subalpine fir and Engelmann spruce are found in colder areas. Mixed conifer forests encompass a significant amount of MOG forest where logging and recent disturbance (e.g., fire and insects) have not been a factor. Patches of quaking aspen are commonly found in mixed conifer forests, and although it is often considered an early-seral species, it can achieve MOG structure in the absence of disturbance and competition from conifers.

Increased frequency and extent of droughts will potentially affect all species, making them more susceptible to secondary factors such as insects. Mortality may be prominent in MOG forests with high stem densities; spruces and firs may be especially susceptible. Drought-tolerant species such as ponderosa pine (although this species is susceptible to bark beetles) and Douglas-fir may be “winners” in the long term, comprising a greater proportion of future MOG forests. Mortality and altered species distribution and abundance will be greater where lower soil moisture is more likely—south and west aspects, steep slopes, and lower elevations. Increased frequency and extent of wildfire in the future will also favor fire-tolerant ponderosa pine and Douglas-fir.

There has been considerable discussion about “aspen decline” over the past 20 years. It appears that mortality has been highest in the driest landscape positions—exposed sites and south-facing slopes. A warmer, drier climate may facilitate additional mortality, first in the driest locations, then perhaps elsewhere. Aspen can be top-killed by wildfire but sprouts

vigorously. With increased fire frequency, aspen may exist primarily in younger stands that never achieve MOG structure.

## Subalpine Forest

Subalpine forests occupy the highest elevations where tree species exist in the region. Engelmann spruce and subalpine fir are the dominant species, with blue spruce and lodgepole pine present in cooler, wetter sites; species such as limber pine and southwestern white pine are present on more exposed sites. MOG stands that have not been subject to logging are relatively common, especially in wilderness areas.

Where adequate soil moisture is available, higher temperature and a longer growing season may increase (or at least maintain) growth and productivity for these species, especially at the highest elevations. However, at lower elevations within the subalpine zone and other locations where snowpack decreases significantly, low soil moisture may decrease growth and subject MOG trees to stress during the growing season. None of the common species in subalpine forests are fire tolerant. As fire frequency and extent increase in the future, it is likely that wildfire will increasingly spread from mixed conifer and ponderosa pine forests into subalpine forests, killing large areas of MOG subalpine forest. The potential for post-fire regeneration will be variable (but reliable for lodgepole pine), and lower-elevation tree species may displace subalpine species over time.

## Oak Woodland

Gambel oak, a deciduous species, and several evergreen oak species are broadly distributed at lower elevations, often on drier aspects mixed with pinyon-juniper and ponderosa pine forests. Oak woodlands have experienced low regeneration throughout the region during the extensive drought of the past 20 years or so. Because the frequency and duration of drought are expected to increase in the future, poor regeneration is expected to continue, and MOG oaks may experience mortality in locations where low soil moisture is persistent. Oaks will persist where microclimate (e.g., north aspects), poorly drained soils, and adjacency to riparian areas provide sufficient moisture for long-term tree growth.

Climate change is expected to increase the frequency and extent of wildfire throughout the Southwest. Oak woodlands often have high loadings of very dry fuels, so when fires occur, they will be of high intensity, top-killing most or all trees including MOG oaks. Many oak species sprout vigorously after fire, but the MOG structure will be lost for several decades. In some locations, fire frequency may be so high that MOG structure will rarely develop.

## Riparian Woodland

Riparian woodlands contain several hardwood species (e.g., Fremont cottonwood, Arizona sycamore, boxelder, willows, and sometimes conifers). Most of the hardwood trees tend to be short-lived but regenerate quickly by seed or sprouting following disturbances. Many riparian woodlands have a significant component of nonnative invasive species, which are an ongoing stressor, and will likely spread in a warmer climate.

If temperature and drought frequency increase as projected, the hydrology of riparian woodlands will be altered relatively quickly. This will decrease the abundance and diversity of native hardwood species that require a reliable water supply during the growing season, in some cases killing MOG trees that are highly stressed. In addition, drier conditions may reduce fuel moisture in riparian woodlands, making them more susceptible to wildfire that spreads from adjacent vegetation. These fires will likely kill many of the MOG trees, although some species can sprout vigorously.

# Literature Cited

## Appendix 5


Anderson, S.M.; Cleland, D.T.; Vaughan, R.E.; Laing, L.E.; Reynolds, K.M.; Spencer, L.A.; Schrader, B.; Tkacz, B. Darbyshire, R.; Cleveland, A. 2020. Terrestrial condition assessment, version 2: Improvements to assessing ecological condition on National Forest System lands. Ecological Society of America, Annual Meeting.

Blankenship, K.; Swaty, R.; Hall, K.R.; Hagen, S.; Pohl, K.; Shlisky Hunt, A.; Patton, J.; Frid, L.; Smith, J. 2021. Vegetation dynamics models: a comprehensive set for natural resource assessment and planning in the United States. Ecosphere 12(4): e03484.

Cleland, D.; Reynolds, K.; Vaughan, R.; Schrader, B.; Li, H.; Laing, L. 2017. Terrestrial condition assessment for national forests of the USDA Forest Service in the continental US. Sustainability, 9(11), 2144 p.

Clifford H.T. 1959. Seed dispersal by motor vehicles. Journal of Ecology 47:311–315.

Forman, R.T.T.; Sperling, D.; Bissonette, J.A.; Clevenger, A.P.; Cutshall, C.D.; Dale, V.H.; Fahrig, L.; France, R.; Goldman, C.R.; Heanue, K.; Jones, J.A.; Swanson, F.J.; Turrentine, T.; Winter, T.C. 2003. Road ecology: science and solutions. Island Press, Washington, D.C. 481pp.

Housman, I.W.; Campbell, L.S.; Heyer, J.P.; Goetz, W.E.; Finco, M.V.; Pugh, N.; Megown, K. 2022. Landscape Change Monitoring System Methods Version 2021.7. GTAC-10252-RPT3. Salt Lake City, UT: U.S. Department of Agriculture, Forest Service, Geospatial Technology and Applications Center. 27 p.

Miller, J.R.; Joyce, L.A.; Knight, R.L.; King, R.M. 1996. Forest roads and landscape structure in the southern Rocky Mountains. 1996. Landscape Ecology 11:115–127.

Nelson, M.L.; Brewer, C.K.; Solem, S.J., eds. 2015. Existing vegetation classification, mapping, and inventory technical guide, version 2.0. Gen. Tech. Rep. WO–90. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 210 p.

Patterson, M.S.; Archer, V.; Anderson, S.; Connolly, S.; Rounds, E.; Love, T.; Fish, H. 2022. Developing a first approximation of a national timber suitability layer. https://apps.fs.usda.gov/gtac/publications/2022/developing-first-approximation-national-timber-suitability-layer

Reynolds, K.M.; Hessburg, P.F. 2014. An overview of the ecosystem management decision-support system. Making transparent environmental management decisions: applications of the ecosystem management decision support system, pp.3-22.

Swaty, R.; Blankenship, K.; Hall, K.R.; Smith, J.; Dettenmaier, M.; Hagen, S. Assessing ecosystem condition: use and customization of the vegetation departure metric. *Land* 2022, *11*, 28. https://doi.org/10.3390/land11010028

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2023. Fiscal Year 2024 Budget Justification, 2024 USDA Explanatory Notes—Forest Service. https://www.fs.usda.gov/sites/default/files/FS-FY24-Congressional-Budget-Justification.pdf

Watkins, R.Z.; Chen, J.; Pickens, J.; Brosofske, K.D. 2003. Effects of forest roads on understory plants in a managed hardwood landscape. Conservation Biology 17:411–419.

Winthers, E.; Fallon, D.; Haglund, J.; DeMeo, T.; Nowacki, G.; Tart, D.; Ferwerda, M.; Robertson, G.; Gallegos, A.; Rorick, A.; Cleland, D.T.; Robbie, W. 2005. Terrestrial ecological unit inventory technical guide. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office, Ecosystem Management Coordination Staff. 245 p.

# Appendix 7

Anderegg, W.R.; Chegwidden, O.S.; Badgley, G.; Trugman, A.T.; Cullenward, D.; Abatzoglou, J.T.; Hicke, J.A.; Freeman, J. and Hamman, J.J. 2022. Future climate risks from stress, insects and fire across US forests. Ecology letters, 25(6), pp.1510–1520.

Dillon, G.K.; Scott, J.H.; Jaffe, M.R.; Olszewski, J.H.; Vogler, K.C.; Finney, M.A.; Short, K.C.; Riley, K.L.; Grenfell, I.C.; Jolly, W.M.; Brittain, S. 2023. Spatial datasets of probabilistic wildfire risk components for the United States (270m). 3rd Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2016-0034-3

# Appendix 8

Costanza, J.K.; Koch, F.H.; Reeves, M.; Potter, K.M.; Schleeweis, K.; Riitters, K.; Anderson, S.M.; Brooks, E.B.; Coulston, J.W.; Joyce, L.A.; Nepal, P.; Poulter, B.; Prestemon, J.P.; Varner, J.M.; Walker, D.M. 2023. Disturbances to Forests and Rangelands. In: U.S. Department of Agriculture, Forest Service. 2023. Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: 5-1–5-55. https://doi.org/10.2737/WO-GTR-102-Chap5.

Coulston, J. W.; Brooks, E.B.; Butler, B. J.; Costanza, J.K.; Walker, D.M.; Domke, G.M.; Caputo, J.; Markowski-Lindsay, M.; Sass, E.M.; Walters, B.F.; Guo, J. 2023. Forest Resources. In: U.S. Department of Agriculture, Forest Service. 2023. Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO- 102. Washington, DC: 6-1–6-38. https://doi.org/10.2737/WO-GTR-102-Chap6.

Joyce, L.A.; Coulson, D. 2020. Climate Scenarios and Projections: A Technical Document Supporting the USDA Forest Service 2020 RPA Assessment. Gen. Tech. Rep. RMRS-GTR-413.

O'Dea, C.B.; Langner, L.L.; Joyce, L.A.; Prestemon, J.P.; Wear, D.N. 2023. Future Scenarios. In: U.S. Department of Agriculture, Forest Service. 2023. Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: 3-1–3-13. https://doi.org/10.2737/WO-GTR-102-Chap3.

Oswalt, S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A. 2019. Forest Resources of the United States, 2017. Gen. Tech. Rep. WO-97. Washington, DC.

Live version as of 2/20/2025

The requested page could not be found.

# EXHIBIT Q

Live version as of 2/20/2025

U.S. DEPARTMENT OF AGRICULTURE

# ACTION PLAN FOR CLIMATE ADAPTATION AND RESILIENCE



In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at
(800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at How to File a Program Discrimination Complaint and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

August 2021

# Contents

**A Message from Secretary Vilsack** ..... 1

**I. Introduction** ..... 2

**II. Climate Vulnerabilities** ..... 3

**III. USDA's Adaptation Actions** ..... 14

**IV. Enhancing Climate Literacy in USDA's Workforce** ..... 26

**V. USDA Actions for Climate-Ready Sites and Facilities** ..... 28

**VI. USDA Actions to Ensure a Climate-Ready Supply of Products and Services** ..... 29

**VII. Next Steps** ..... 31

**Appendix: USDA Departmental Regulation 1070-001: Policy Statement on Climate Adaptation** ..... 32

# A Message from Secretary Vilsack

Dear Reader,

As evidenced by the historic drought in the western United States, vast wildfires, and soaring temperatures across the country, climate change is already on our doorstep, and America's producers are on the front lines. We are operating in new territory, and the changing climate creates immense uncertainty and threatens the resilience of the American agriculture and forestry sectors. Not only does climate change have a direct impact on a producer's ability to plan and manage risk, it has wider impacts on the natural systems we rely on to support production of food and fiber, keep our waters clean, and maintain cultural resources.

As the "People's Department," USDA is preparing to help communities across the United States, both rural and urban, plan for and build resilience to the impacts of climate change. Answering President Biden's call for a whole-of-government approach to climate, USDA is taking a whole-of-Department approach to address the challenges and opportunities posed by climate change. In USDA's recent Climate-Smart Agriculture and Forestry Strategy: 90-Day Progress Report, we laid out our mitigation strategy to ensure that farmers, ranchers, and landowners can seize on these opportunities and contribute to greenhouse gas emissions reductions and sequestration. Alongside those actions, we must make sure that we provide producers, landowners, and communities with the tools to manage risk and adapt to this changing reality.

This Action Plan for Climate Adaptation and Resilience outlines how USDA will provide relevant information, tools, and resources to its stakeholders and target programs and activities to increase resilience to climate impacts. USDA will prioritize equity, promote environmental justice through a focus on healthy communities, and target adaptation actions with co-benefits for climate mitigation, conservation, and sustainability.

In addressing the climate crisis, the USDA research enterprise will develop innovative tools and practices for farmers and land managers of the future. USDA will tailor its climate outreach and assistance to be regionally specific through its vast field operations and innovative partnerships and enhance department-wide coordination through its ten regional Climate Hubs. Building climate literacy across all levels will enable USDA staff to best serve its stakeholders in the decades ahead.

Our plan will serve as the foundation for iterative climate adaptation across the Department. Taking these steps to prepare American farmers, ranchers, forest landowners, resource managers, and communities for the effects of climate change will help ensure that our agriculture and forestry sectors continue to provide healthy food and fiber for America and the world, and that we conserve our soil, air, and water for generations to come.

Sincerely,



Secretary Tom Vilsack



## I. INTRODUCTION

On January 27, 2021, in Executive Order (E.O.) 14008 Tackling the Climate Crisis at Home and Abroad, President Biden laid out a vision for a United States government-wide approach and a set of coordinated domestic actions to address the risks and opportunities posed by climate change. One of these actions directs the U.S. Department of Agriculture (USDA) to submit an action plan of steps to bolster adaptation and increase resilience to the impacts of climate change across our mission and operations.

Climate change poses a significant risk to agriculture, forests, and grasslands across the United States and the communities that support and depend upon them. This risk is disproportionately high for disadvantaged communities, including Tribal nations, low-income, and minority communities. USDA is unique among federal departments in the breadth of its Mission Areas and its reach across the United States to urban, rural, and Tribal communities. Steps to reduce the vulnerability and increase the adaptive capacity of American farmers, ranchers, forest owners, and other stakeholders to climate change are needed to maintain competitiveness and sustainability in the coming decades. Through climate change adaptation planning, USDA will increase the resilience of these sectors and communities to climate change.

Agricultural producers and forest landowners have extensive experience dealing with uncertain conditions, yet climate change is producing new challenges. Adaptation actions by USDA and our stakeholders can reduce the impacts of climate change while creating opportunities or co-benefits for mitigation, sustainable production, and conservation. The co-benefits of adaptation actions may also stretch as far as the social welfare of rural and urban communities by improving economic opportunities, infrastructure, and equity. The research and development necessary to support agricultural and forestry climate adaptation have the potential to spur new tools, practices, and technologies that may underpin the future of these sectors.

USDA last undertook extensive climate adaptation planning in 2014 in response to E.O. 13653 Preparing the United States for the Impacts of Climate Change. In that plan, USDA laid out a vision for how to integrate consideration of climate change into agency operations and overall mission objectives in the context of USDA's strategic goals. USDA provided progress and strategic updates to its climate adaptation planning via USDA's annual Strategic Sustainability Performance Plan, most recently in 2017.

FY 2021 is a transition year for USDA as its leadership develops a 2022-2026 USDA Strategic Plan, to align with the Biden-Harris Administration's priorities, which include addressing climate change. At the same time, USDA is tracking key performance indicators (KPIs) for the 2018-2022 Strategic Plan. A draft of the new goals was provided to the Office of Management and Budget (OMB) in June 2021. From June to September 2021, a cross-departmental working group will establish KPIs to gauge progress towards specific performance goals that are in alignment with the new strategic plan. A full draft strategic plan will be provided to OMB in September 2021. USDA's 2021 Annual Performance Report and 2023 Annual Performance Plan, due to OMB in November

2021, will close the 2018-2022 performance cycle's KPIs and, where possible, reflect the new draft KPIs. Finally, for FY 2021, USDA's Risk Profile will be updated to incorporate risks and risk mitigation strategies that reflect the Biden-Harris Administration's priorities, like climate change, where possible.

The complete package of this USDA Action Plan for Climate Adaptation and Resilience includes:

- This Action Plan for Climate Adaptation and Resilience that builds on prior adaptation plans,
- An update to USDA Departmental Regulation 1070-001 USDA Policy Statement on Climate Change Adaptation, and
- Identification of the Director of the Office of Energy and Environmental Policy (OEEP) in the Office of the Chief Economist (OCE) as the senior agency official responsible for carrying out the climate adaptation activities described in this Plan.

This Plan, which aligns with guidance from the White House Council on Environmental Quality (CEQ), includes:

- Five vulnerabilities due to climate change that USDA has identified and must address;
- Five actions USDA will implement in its mission, programs, operations, and management in anticipation of and in response to a changing climate;
- A description of efforts to enhance the climate literacy of USDA's workforce; and
- Descriptions of how climate adaptation and preparedness is built into management and decision-points for USDA climate-ready sites, facilities, products, and services.

## II. CLIMATE VULNERABILITIES

Climate change presents many challenges to USDA and its stakeholders. The five vulnerabilities below build on prior vulnerability assessments of the Department and draw from our best understanding of the threats posed by climate change and its impacts in the Fourth National Climate Assessment. The potential climate impacts to agricultural productivity, water quantity and quality, vulnerable communities, public lands and infrastructure, and as a result of extreme events will have broad Department-wide effects. For each vulnerability, we describe the threat and propose adaptation actions to address it. Some of these actions overlap with the cross-cutting actions outlined in section III, while others specifically target the vulnerabilities described below.

### 1. Decreased agricultural productivity

Climate change threatens growth in agricultural productivity through direct effects such as changes in temperature and precipitation patterns, and secondary effects, such as increased pest and disease pressures, decline in pollinator health, reduced crop and forage quantity and quality, and infrastructure damage. Agricultural productivity is additionally threatened by impacts to water supply and increased frequency and intensity of extreme weather events, which are described in more detail in Vulnerabilities #2 and #4. Agricultural productivity is vulnerable to the impacts of climate change via:

- **Crop and livestock production.** With variation at local, regional, and continental scales, climate change is projected overall to impact crop production by reducing both quantity and quality of yields, altering optimal growing season periods, and increasing likelihood of crop failure and damage. Similarly, livestock production will be impacted by reducing the quantity and quality of pasture and forage, lowering the yield of feed grain, affecting livestock health, and fostering the spread and resilience of pathogens and parasites that affect livestock development.



- **Reduced soil quality.** Agricultural, forest, and grassland soils are sensitive to long term changes in temperature and precipitation, management practices, and multiple uses like recreation. The interactive effects of these stressors can increase erosion rates, reduce soil quality, and alter soil composition that supports plant growth. Additionally, increases in temperature, changes in moisture levels, and disturbances like wildfire, pests, and disease can release carbon stored in soil organic matter.
- **Pest and disease pressure.** Climate change may expand or shift the range of a pest, pathogen, or vector organism, increasing its ability to establish in areas not previously considered at risk, elevating the risks to agriculture and forestry. Climate change may also lead to changes in wildlife migratory patterns, diseases, disease life cycles, predator-livestock interactions, and mass mortality events. These increased pressures may impact the Animal and Plant Health Inspection Service's (APHIS) ability to monitor for animal and plant pests and diseases in traded and domestically produced goods.
- **Pollinator health.** Pollinator health, which is essential to successful crop production and highly correlated with floral landscapes, is threatened by climate-driven temperature and rainfall extremes. Areas vulnerable to climate change include the commercial beekeeping industry, non-managed pollinator populations, and the subsequent threats to specialty crop industries.
- **Crop insurance.** Agricultural producers purchase crop insurance for protection against numerous production and price risks, which can include climate and weather-related losses from hurricanes, flood, drought, hail, and wildfires. Forecasts of more rapid changes in climatic conditions have raised concerns that these risks will increase relative to historical conditions. In addition to implications for landowner decisions regarding land use, crop mix, and production practices, changing agricultural risks could affect the performance of the Federal Crop Insurance Program (FCIP), managed by the Risk Management Agency (RMA). Economic Research Service (ERS) analysis suggests that even with some adaptation actions taken by producers, climate change could lower domestic production of major commodities, leading to higher prices, higher premiums and, consequently, higher FCIP subsidies. Without adaptation actions on the part of farmers, these potential cost increases are likely to be even greater.

In response to the threats and impacts to agricultural productivity described above, USDA has identified several key adaptation actions:

- **Increase implementation of on-farm adaptation strategies and practices.** The Farm Service Agency (FSA) and the Natural Resources Conservation Service (NRCS) can leverage existing programs to support farmers, ranchers, and landowners in understanding the vulnerabilities of their operations to a changing climate and implementing adaptive practices and management strategies. NRCS programs, such as the Conservation Stewardship Program (CSP) and Environmental Quality Incentives Program (EQIP), and initiatives, such as the Soil Health Initiative, can

provide financial and technical assistance and resources for implementing practices, like cover crops, reduced and no tillage, and improved irrigation systems, that contribute to more resilient landscapes. FSA loan programs, including Operating Loans, the Farm Ownership Loan Program, and the Conservation Loan Program, can also provide funds for a wide range of purposes, including short-term equipment or operating needs or long-term infrastructure enhancements to support increased resilience. USDA agencies will continue to evaluate and modify existing programs, like the Conservation Reserve Program (CRP), the Emergency Conservation Program (ECP), and the Emergency Forest Restoration Program (EFRP), for climate risks and adaptation opportunities. In administering disaster-related programs, USDA will aim to build resilience and adaptive capacity to future shocks whenever possible. Barriers to scaling up the adoption of adaptation practices include high costs of implementation, insufficient incentives, and need for additional technical assistance to aid decision-making and implementation.

- **Support active landscape-scale management and disturbance responses.** Supporting healthy landscapes starts with ensuring that whole ecosystems are managed at the landscape scale, considering multiple components, interactions, and timescales. For example, the Forest Service's (FS) Burned Area Emergency Response (BAER) teams assess post-wildfire disturbances and implement short-term treatments to stabilize soils to minimize threats to built and natural infrastructure, helping to ensure long-term ecosystem integrity. On private working lands, NRCS's area-wide and watershed planning processes bring together state agencies, soil and water conservation districts, regional planning commissions, counties, and other governmental entities to coordinate long-term resource management at the landscape level. Current barriers include capacity to translate science into practice and ensuring sufficient workforce and public education around these topics.
- **Improve access to climate data and tools.** Improved access to climate and climate-related data can help producers better understand changing conditions and adjust their management decisions accordingly. The USDA Climate Hubs play a pivotal role in developing and curating data and tools for producers and the public. USDA's Office of the Chief Economist (OCE) will continue to partner with the National Drought Mitigation Center (NDMC) to improve their capacity to provide actionable information to the public and record observed drought impacts.
- **Enhance systems for monitoring and mitigating vector and disease spread.** APHIS and FS will improve current monitoring systems and responses to vector and disease spread, incorporate state-of-the-art modeling to inform surveillance, develop early warning systems, and identify better options for vector control and animal protection. APHIS will also evaluate its regulatory framework for biotechnology and genome editing as use of these technologies increases to support the development of climate-adapted crops and livestock.
- **Continue research into climate impacts on agricultural productivity and adaptation strategies and practices.** Further research is needed to understand the full range of potential impacts, inform implementation of adaptation strategies, and identify barriers to access. The Agricultural Research Service (ARS) and the National Institute of Food and Agriculture (NIFA) support research on adaptation strategies, including adapted cultivars and crops, enhanced water and input-use efficiency, optimal production efficiency, and improved resistance to diseases and pests. ARS's Long-Term

Agroecosystem Research (LTAR) sites will continue landscape and regional-scale approaches to investigate sustainable intensification of U.S. agriculture. The Office of the Chief Scientist (OCS) will continue to coordinate research into pollinator health, including changes in plant pollen ranges, co-benefits of resilient plant species to pollinators and carbon sequestration, co-location of pollinator habitat with renewable energy sites, and practices to address increased stress on pollinator health.

- **Provide climate-smart risk management products.** New and continuing actions that RMA will take to help producers manage climate-related production risks include:
  - Evaluation and monitoring of climate risks to the FCIP and update of program parameters, like earliest and final planting dates and sales closing dates, based on these analyses;
  - Implementation of state-funded incentives to encourage cover crop planting;
  - Use of the Whole Farm Revenue Protection product to support farmers who use crop diversification to reduce risk;
  - Continued insurance coverage for crops that accommodate new agronomic practices that minimize water use;
  - Implementation of procedures that facilitate access to insurance coverage to accommodate climate-driven shifts in production areas;
  - Application of recently revised premium rating methodology so that rates more quickly reflect changes in risk; and
  - Monitoring of premium rating methodology, loss adjustment standards, underwriting standards, and other insurance program materials to ensure they are appropriate for new production regions or practice changes within regions.

  In parallel with these efforts, the Climate Hubs will continue to provide information and tools to support producers' capacity to manage for impacts to crop insurance, such as the AgRisk Viewer, a decision-support tool that provides historic crop insurance data to assess climate risk.

Many of the actions described above are in-progress or positioned to begin soon through coordinated Department-level efforts and creative applications of existing USDA resources and programs. Additional investments directed towards these efforts will enable USDA to more effectively address actions that rely on new data or expertise or require significant program enhancements. In the near-term, progress can be measured using existing systems that correlate well with target outcomes, like data from the North American Long-Term Soil Productivity study, led by Forest Service Research & Development (FS R&D). Agency record-keeping can also support progress measurement, including loan funds use, technical and financial assistance disbursed, and programmatic changes or additional investments made considering assessed climate risks.

## 2. Threat to water quantity and quality

Climate change impacts on the water cycle are resulting in earlier snowmelt, reduced water supply, more intense and frequent drought, degraded water quality, excess soil moisture, and greater flooding, all of which will alter crop and animal production and quality and management of forest and rangeland systems. In 2021, producers in areas like the Klamath River Basin and the Colorado River Basin are again experiencing severe drought conditions resulting in historically low water allocations. Key threats and impacts related to water supply include:

- **Water quantity and drought.** With climate change, producers are confronting greater intra- and interannual variability in the distribution, quantity, and timing of precipitation. Drought has become more

persistent and widespread with impacts on soil moisture and health, groundwater recharge, runoff, and ultimately agricultural productivity. Changes in snowpack also impact water supply and seasonal runoff timing. These changes in the water supply have the potential to drastically shift the geographic distribution of agriculture and exert greater pressure on finite groundwater resources.

- **Water quality.** Precipitation extremes can cause excessive runoff and soil erosion, which lead to field production issues and downstream impacts on quality of water resources, including eutrophication and hypoxia.
- **Riparian and aquatic ecosystems.** Changes in climate and the water cycle are affecting aquatic and riparian ecosystem structure and function, potentially resulting in loss of at-risk species, new species being put at risk, the introduction of additional or expansion of existing invasive species, and the establishment of new diseases and pathogens.
- **Forest resilience.** Declines in forest health because of drought, excess soil moisture and flooding will lead to increased vulnerability to disasters (see Vulnerability #4) such as wildfires, severe storms, and forest insect and pathogen outbreaks. These disasters will impact communities through decreases in ecosystem health and delivery of ecosystem services.

Priority actions that can be taken to respond to these risks to water quantity and quality include:

- **Target existing programs to support water issues.** Projected changes in water availability will require programmatic shifts that specifically integrate climate adaptation and resilience-building. FSA currently delivers several assistance programs for producers who have experienced hardships due to water-related impacts including the Noninsured Crop Disaster Assistance Program (NAP), the Emergency Conservation Program (ECP), the Tree Assistance Program (TAP), the Livestock Forage Program (LFP), and ad hoc programs like the Quality Loss Adjustment program (QLA). USDA will evaluate the existing programs within legislative authority to ensure that coverage or grazing periods accurately represent when threats to water quantity and quality could occur. For example, FSA programs could adapt to support water quantity and quality issues by broadening support to annual cropping systems that increase water use efficiency. NRCS's Regional Conservation Partnership Program (RCPP) and EQIP can provide financial and technical assistance to the irrigated agricultural sector in support of additional water storage infrastructure and soil enhancing practices.



- **Build resilience by enhancing soil health.** Through a variety of conservation practices, soils can be enhanced to promote water infiltration and be less prone to surface runoff and downstream flooding. Building soil health is a slow process that can take a number of years and requires changes in cropping systems and management practices. Programs like EQIP, RCPP, and the Soil Health Initiative help promote practices such as cover crops, reduced tillage, and prescribed grazing that can improve soil health and

build more resilient landscapes. Adaptation Action #1, below, further highlights the impact that improvements to soil health can make on long-term sustainability.

- **Use a landscape approach in addressing water issues.** Successful adaptation will require an integrated, landscape scale approach, including managing water resources across private and public lands, restoring terrestrial and aquatic ecosystems to enhance their resilience to climate stressors, and addressing the effects of pathogens and invasive species. Heterogeneous land cover makes developing resilience strategies for water resources on this scale complicated and requires participation, cooperation, and coordination of diverse stakeholders.
- **Explore innovative technology and approaches.** Drought-adapted varieties, dynamic and data-driven irrigation technology, and increasingly efficient delivery, storage, and recycling of water will be important adaptation tools. Improved and integrated climate, groundwater, and surface water measurements and modeling will help predict vulnerability in water availability and identify priority areas for reduced water use. Innovative translation of water management research and technology to on-field realities through extension and education will be essential to support user adoption and alleviate producer and land manager concerns.
- **Invest in water management infrastructure and adaptive irrigation systems.** Investing in additional water storage infrastructure, such as new reservoirs and managed aquifer recharge, and increasing the ability of water-related infrastructure to survive extreme events, can help irrigated agriculture adapt to a variable future and expand availability of seasonal runoff. In traditional rainfed agricultural regions, producers may adapt to more variable growing season precipitation by beginning to irrigate or practicing supplemental irrigation. Barriers to these actions include the need to address the ecosystem impacts of dams, the relative lack of institutions to guide the development of managed aquifer recharge, and the high cost to build on-farm irrigation infrastructure.
- **Leverage existing federal coordination mechanisms.** USDA will continue to play a leading role in existing interagency drought coordination networks including the National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System (NIDIS) and National Drought Resilience Partnership (NDRP). OCE and NDMC will continue to leverage their partnership to support Climate Hub projects that provide useful and usable drought products to end users. Moreover, the Climate Hubs will continue supporting NIDIS in their regional Drought Early Warning Systems (DEWS). A Drought Learning Network (DLN) was jointly developed by the Climate Hubs, NDMC, and NIDIS, and allows stakeholders to share experiences in preparing for, responding to, and recovering from drought.

Many current USDA programs are well-suited to address these water-related threats and can provide a strong foundation for completing the necessary actions. It will also take new and reinforced partnerships within federal government and with Tribes, states, non-governmental organizations (NGOs), and businesses to tackle the significant challenge of addressing the long-term sustainability of the Nation's water supply. Much of this work will take years to complete and therefore requires five- or ten-year timelines to measure progress. USDA's National Agricultural Statistics Service (NASS) data on the market value attributable to irrigated farms and irrigated land, which is collected in the Census of Agriculture, will be used to assess the efficacy of future adaptation efforts in the irrigated agricultural sector. U.S. Geological Survey's (USGS) water use reports, which are released at 5-year intervals, will serve as another useful

tool to measure changes in water use over time. Improvements in monitoring, infrastructure, and research could be realized with additional investments to further minimize the climate risks to water for soil and forest ecosystems.

## 3. Disproportionate impacts on vulnerable communities

Socially disadvantaged, low-income, minority, and rural populations as well as American Indians, Alaska Natives, and sovereign Tribal governments are more likely to be vulnerable to the impacts of climate change. These communities' ability to adapt to a changing climate is often limited by financial, social, and other constraints. Climate change is likely to disproportionately impact these communities via several pathways:

- **Health.** Many communities who are exposed to the impacts of climate change are already burdened by air and water pollution and other environmental health hazards. Health risks of climate change may compound existing health issues in Tribal and Alaska Native communities, including risks from the loss of traditional food and practices, community displacement, new infectious diseases, and other effects of climate change.
- **Food.** Climate change poses risks for the U.S. food system, including production risks (as described in Vulnerability #1), transport and trade vulnerabilities, the potential for increased food loss and waste, and diminished food safety. These vulnerabilities challenge USDA's mission to provide leadership on food, nutrition, and related issues.
- **Ecosystem services and livelihoods.** Climate change threatens ecosystem services that many communities depend on including clean air and water, subsistence foods, medicine, fiber, fuel, and cultural services, such as cultural heritage and identity, spiritual, aesthetic, and educational values, and recreation and tourism opportunities. Rural communities, many of whose livelihoods are tightly tied to the agriculture and forestry sectors, and migrant workers, who provide a large share of agricultural labor in some regions, are particularly vulnerable to climate change impacts.
- **Extreme weather event impacts.** As described further in Vulnerability #4, the impacts of extreme weather events influenced by climate change are expected to have a disproportionate impact on populations lacking resources to cope with economic and environmental shocks and uncertainty. Communities in risk-prone areas can face cumulative exposure to multiple pollutants and climate event impacts. Without action, the adverse effects of extreme weather events, severe wildfire, flooding, drought, and invasive species on these populations and Tribal communities will only intensify.

USDA actions to help the most vulnerable communities adapt to climate change will include:

- **Increase equity and environmental justice awareness, skills, and abilities of USDA staff.** USDA will take additional steps to educate its staff on environmental justice, including disproportionate impacts from climate change, and how it relates to USDA agencies, programs, and activities. This will



enable the Department to assess its current and future activities, identify areas and strategies for improvement, and develop metrics to ensure progress in supporting communities most vulnerable to the impacts of climate change.

- **Engage meaningfully with impacted and vulnerable communities.** The Department will leverage existing relationships and build off past and on-going Tribal consultation and stakeholder engagement processes, including those recently initiated to seek input on the Department's climate-smart agriculture and forestry strategy. As the Department and individual agencies continue to develop adaptation and environmental justice strategies, they should engage directly with environmental justice leaders and communities impacted by climate change to understand vulnerabilities and risks, identify barriers to and resources for adaptation, and collaboratively develop solutions and responses, including through participatory adaptation planning.
- **Evaluate programs and activities for risks to communities.** In carrying out actions to address climate risks, USDA should develop robust processes to ensure disproportionately high impacts and maladaptation are avoided or mitigated. FS has developed guidance for incorporating analysis and consideration of impacted communities during Land Management Planning and National Environmental Policy Act (NEPA) processes and has established a robust Urban Forestry program to address environmental justice issues in urban areas. Evaluating risks to vulnerable communities may involve leveraging new and updated vulnerability assessments and existing and emerging tools, such as the proposed Climate and Economic Justice Screening Tool, to identify communities at risk.
- **Provide assistance and resources.** USDA will continue work to ensure its programs and resources are distributed equitably and are accessible to those most at risk of climate change impacts and in need of adaptation support. Several USDA programs have special provisions or dedicated funding for historically underserved producers—which may include socially disadvantaged, beginning, limited resource, and veteran farmers and ranchers—who are among the most vulnerable to impacts. Activities to integrate environmental justice and equity into existing programs will require removing barriers to participation, establishing trust, transparency, and accountability, identifying opportunities for broader inclusivity, and targeting education and outreach. Additional areas for advancing equity and environmental justice are described within USDA's Climate-Smart Agriculture and Forestry Strategy: 90-Day Progress Report.

Ensuring environmental justice and equity is an ongoing activity for USDA. The actions presented here can build on recent outreach efforts that have resulted in increases in program participation by historically underserved producers. Agencies will need to prioritize environmental justice in their planning and budget processes and when implementing new programs and policies. Indicators of success will be identified in coordination with the White House Environmental Justice Interagency Council's forthcoming performance metrics.

## 4. Shocks due to extreme climate events

Climate change is causing more frequent and intense disruptive events including hurricanes, floods, drought (see Vulnerability #2), and fires, which can have significant impacts on agriculture and forestry. Rural and vulnerable communities will be disproportionately impacted by these events while lacking the resources to adequately prepare for and respond to them. Key areas of impact associated with extreme climate events include:



- **Hurricanes, floods, and other extreme weather events.** Extreme weather events are not new, but recent increases in frequency and severity of these events, like hurricanes, floods, tornadoes, hail, and other severe storms, have negatively affected working lands. Hurricanes and floods are expected to increasingly affect U.S. agriculture and forests leading to crop loss and production delays, degradation of soil and water resources, damage to infrastructure, alteration of forest health and productivity, and impacts to community health and safety. As hurricanes become more frequent and severe, wind, rain, and debris damage to buildings, power grids, and telecommunications will be increasingly common. Landslides, stream washouts, and downed trees can threaten water quality and community and animal safety, and frequently require targeted restoration and salvage efforts.
- **Wildfire.** Climate change is expected to continue to alter fire regimes, increasing the frequency and extent of wildfire. As the wildland-urban interface expands, wildfire presents increased risks to human health and infrastructure. Severe wildfire can leave forests in need of reforestation and restoration and heighten the risk of secondary disturbances such as erosion, landslides, and invasive species.
- **Vulnerability of rural communities.** As mentioned in Vulnerability #3, rural communities are particularly vulnerable to extreme weather events due to a greater direct dependence on agriculture, forestry, and outdoor recreation for income and employment, existing challenges with infrastructure and connectivity, and limited capacity to prepare and respond to these events. Severe weather events threaten ongoing rural development efforts, negatively impacting projects, destroying properties, delaying construction, and disrupting revenue for existing loans. Increasing climate variability will result in increasing uncertainty in agricultural and forest industries in rural communities, likely leading to long-lasting shifts in community structure and composition. Current declining trends in population and employment tend to also reduce resources available to local government and community associations to deal with climate change variability.

In addition to the resilience-building actions described in Vulnerabilities #1 and #2, further actions can be taken to adapt to the risks from extreme climate events:

- **Update vulnerability assessments.** With the support of the USDA Research, Education, and Economics (REE) agencies and FS R&D, in 2015 the Climate Hubs conducted vulnerability assessments for each of their ten regions based on the Fourth National Climate Assessment. Likewise, FS engaged in science management partnerships to develop vulnerability assessments in over 100 national forests and grasslands, including other public and private lands, with applications in land management and project plans. The Hubs will update their vulnerability assessments for the forthcoming Fifth National Climate Assessment and continue to support the development of

more place-based assessments that identify climate-smart practices to build resilience.

- **Use monitoring tools to build resilience.** NASS has developed a series of geospatial agricultural monitoring portals that can be used to identify and quantify impacts from extreme climatic events. These portals can provide near real-time updates on major storm disaster events, crop condition and soil moisture, decision-support system capabilities, and annual planted crop area to inform agricultural adaptation strategies. Examples of these NASS portals and other USDA-supported decision-support tools include:
  - NASS Disaster Analysis Program, which captures impacts from major storm events,
  - The joint vegetative condition and soil moisture monitoring portal,
  - AgroClimate, a weather and climate-based decision support system for agriculture, and
  - After Fire: Toolkit for the Southwest, a resource to assess post-fire risks.
- **Build forest and grassland resilience through management, planning, and responses.** Active management to build resilience to wildfire, insects, and disease is a high priority for the FS. USDA's Climate-Smart Agriculture and Forestry Strategy: 90-Day Progress Report and Adaptation Action #1, below, discuss these efforts further. Specific actions related to extreme events include development of information on disaster preparedness and response, support for forest products and markets for salvage and small-diameter timber, and support for post-disturbance emergency stabilization and rehabilitation. Wildfire and hurricanes can provide opportunities to increase climate resilience through species selection and soils restoration in disturbed areas. Barriers to implementation include underdeveloped markets and feedstock sources that slow use of hurricane salvage and small-diameter timber.
- **Strengthen disaster assistance and relief programs.** In addition to assistance programs mentioned in Vulnerability #2 (NAP, ECP, TAP, LFP, and QLA), FSA offers the Livestock Indemnity Program (LIP), Emergency Assistance for Livestock, Honeybees and Farm-raised Fish (ELAP), and Wildfire and Hurricane Indemnity Program and Program Plus (WHIP and WHIP+) to help producers cope with impacts of extreme events and natural disasters. FSA also provides Emergency Loans for producers who might otherwise be forced to terminate operations, and Disaster Set-Aside options, which allow direct loan borrowers to forego an installment until the end of the loan term to reduce short-term financial strain due to a disaster.
- **Enhance the adaptive capacity of rural communities.** Resilience to extreme events and other climate impacts will require increasing local capacity to make adaptive improvements to community resources and expanding options for economic opportunities. USDA's Climate-Smart Agriculture and Forestry Strategy: 90-Day Progress Report highlights ways in which USDA can support new and better for markets for agriculture and forestry products while simultaneously building the resilience of rural communities. Examples of actions include supporting participation in voluntary carbon markets, renewable energy development and energy efficiency activities, and loans and grants to expand broadband access.

Many measures to build resilience to extreme events are long term investments whereas some programs will have distinct timelines triggered by the occurrence of such events. For example, while loan assistance is on-going, Emergency Loan and Disaster Set-Aside assistance is only available after a declared disaster. The level of support proposed in the FY 2022 budget and other

mechanisms will be used to address the backlog of National Forest System (NFS) restoration projects and enhance current work on risk identification, vulnerability assessment, adaptation planning, and disaster preparedness and recovery. Program records, including FSA's loan disbursement records and NRCS's reporting on conservation and investments, can be used to track activities. Progress on NFS lands will be monitored through the FS Climate Scorecard and the number of acres restored.

## 5. Stress on infrastructure & public lands

The increasing frequency, severity, and extent of disturbances with climate change can have far-reaching consequences on natural and built infrastructure on public lands. Changes in flood frequency, wildfire intensity, sea level, and extreme precipitation events can cause damage to low-elevation infrastructure, threaten utilities and air quality, endanger coastal communities, and increase erosion and landslides. For the NFS, in the absence of any climate adaptation action, reforestation and restoration needs will continue to increase, ecosystem services will be lost or diminished, aging infrastructure will deteriorate, and social and economic benefits will be disrupted. Roads and bridges damaged or lost because of increased flooding can limit access to Federal lands, create safety hazards, and reduce the availability of water resources. Actions USDA can take regarding built infrastructure and forest resilience include:

- **Increase resilience of built infrastructure.** Infrastructure must be upgraded, or newly designed, to withstand increasing extreme events and disturbances. The FS is using decision support tools and climate change vulnerability assessments to identify when and where to relocate or decommission vulnerable infrastructure and improve transportation infrastructure to reduce erosion and sedimentation. Other adaptation actions include improving streamflow forecasting and expanding streamflow and snowpack monitoring networks to help managers respond to extreme events and ensure water allocation downstream. Barriers to implementation include funding to upgrade existing infrastructure and uncertainty in future flood projections.
- **Address forest restoration needs.** FS will need to increase the pace of restoration to address 1 to 4 million acres of restoration needs on national forests as described in the FS reforestation strategy. This action will require the use of planning tools and decision-making frameworks to enable collaborative planning and implementation of large restoration treatments across management boundaries.
- **Build resilience to severe wildfires and their effects.** Building resilience to wildfire necessitates the accelerated use of prescribed fire and the strategic implementation of hazardous fuel treatments to reduce wildfire impacts. Following severe wildfires, FS will prioritize public safety, forest rehabilitation, and slope stabilization. Rural Development (RD) and FS will work together to identify opportunities to link post wildfire restoration efforts with bioenergy generation. Barriers to implementing this action include limited





capacity and competing priorities during periods of widespread wildfire activity, State and local air quality compliance for prescribed fires, and public resistance to wildfire and fuels management.

Addressing the growing reforestation and restoration backlog over the next 10 years will require a four-fold increase in planting and a 30 percent increase in certification of natural regeneration, resulting in 3.6 million acres reforested. Given the importance of forest health and resilience to the long-term sustainability of forest landowners and surrounding communities, these efforts are described in further in Adaptation Action #1 below. For infrastructure like roads, bridges, and facilities, their long service life means that adaptation will be a long-term effort. Long-term monitoring will help detect potential climate change effects and evaluate the effectiveness of adaptation options. Existing FS monitoring efforts include the Climate Scorecard (biennially through 2025), the Key Performance Indicator for Terrestrial Condition Assessment (annually for all NFS lands), the Watershed Condition Framework, Biennial Monitoring Reports, and Forest Inventory and Analysis.

Already, the Great American Outdoors Act (GAOA) is being leveraged to develop more resilient infrastructure. In March 2021, USDA announced investment via GAOA's National Parks and Public Land Legacy Restoration Fund, which will enable implementation of more than 500 infrastructure improvements across national forests and grasslands. The Forest Service also continues to use Land and Water Conservation Fund (LWCF) programs to strategically conserve forests on private and public lands. Future investments to address the reforestation backlog and wildfire risk could be targeted towards nurseries and natural infrastructure, accelerated project planning, building expertise, and improving management strategies to build resilience to wildfire. Continued and expanded cross-boundary collaboration with other federal agencies, Tribes, states, and partners will help achieve the requisite scale of response.

## III. USDA'S ADAPTATION ACTIONS

Building on the vulnerabilities identified above, USDA will take cross-cutting adaptation actions to prepare the American agriculture and forestry sectors and rural and urban communities to be resilient in a changing climate. These actions aim to bridge the gap between innovative science and technology for climate adaptation and preparedness and in-field and on-site practices to build soil and forest health. These actions will reduce producers' vulnerability to climate change through increased access to relevant climate data and expanded education and outreach efforts.

The Fourth National Climate Assessment outlines the key challenges associated with adaptation planning for USDA consideration. The first challenge is that adaptation planning must be a sustained, iterative process. Mainstreaming the climate preparedness thought process rather than making it an additive step in decision-making will lead to greater success. Secondly, it is essential that USDA considers both current and projected climate change and variability in its planning and decision-making. Supporting climate literacy within the USDA workforce, as discussed later in this Plan, can support this new mode of thinking.

A third challenge is ensuring that climate adaptation actions are not limited to the stages of awareness, assessment, and planning but are implemented, monitored, and re-evaluated, which will require sustained attention and measures of success. Finally, the impacts of climate change on USDA and its stakeholders will vary regionally and locally, requiring climate adaptation actions at relevant scales.

USDA proposes adaptation actions to:

1. Build resilience across landscapes with investments in soil and forest health;
2. Increase outreach and education to promote adoption and application of climate-smart adaptation strategies;
3. Broaden access to and availability of climate data at regional and local scales for USDA Mission Areas, producers, land managers, and other stakeholders;
4. Increase support for research and development of climate-smart practices and technologies to inform USDA and help producers and land managers adapt to a changing climate; and
5. Leverage the USDA Climate Hubs as a framework to support USDA Mission Areas in delivering adaptation science, technology, and tools.

## 1. Build resilience to climate change across landscapes with investments in soil and forest health

Economic vitality and quality of life throughout America depends on healthy, climate-adapted agricultural and forest systems. Proactive investments in soil and forest health will build resilience to climate change into these systems. This action includes efforts to build resilience via conservation practices, improved water management and efficiency, climate-informed reforestation and forest management, and ecosystem restoration and management. Enhancing soil and forest health will protect ecosystem functions that support the long-term resilience of working lands and forests and enable producers to successfully and sustainably enhance productivity to meet growing global demand in a changing climate.

Climate change threatens to increase the degradation of soil and water resources, including via increases in extreme precipitation events that lead to soil erosion, degraded water quality in lakes and streams, damage to infrastructure, and diminished crop production. On forest land, a combination of acute disturbances and shifts due to gradual climate change are expected to alter forest structure, function, productivity, and health, which will decrease the ability of forests to provide important ecosystem services. The rate at which restoration services are needed across the landscape is currently outpacing the capacity of land management agencies and their partners.

A variety of conservation management practices to restore soil structure and hydrologic function of agricultural landscapes can be adopted to improve resilience, including no till and reduced till, cover crops and crop rotations, improved nutrient management, agroforestry practices such as windbreaks and buffers, and prescribed grazing. These practices help to reduce erosion and



increase organic matter in the soil, which improve water holding capacity and water infiltration, thereby increasing resilience to drought, heavy precipitation, and extreme temperatures. Current adoption of these practices varies by practice, region, and crop. For example, U.S. farmers have rapidly expanded their use of cover crops, a 50 percent increase from 2012 to 2017, yet their use spans only 5 percent of total harvested cropland. Active forest management, including thinning forests and treating fire-deficient landscapes by prescribed burning, and climate-smart reforestation can increase resilience and reduce risks of wildfire, insect, and disease related mortality.

Many of these practices provide co-benefits for climate change mitigation via enhanced soil carbon sequestration and reduced emissions and for water quality and quantity through reduced erosion and runoff. Improvements in forest health can mitigate emissions from increased wildfire, increase soil carbon sequestration, mitigate risks to communities in the wildland-urban interface, and maintain other valuable forest ecosystem services.

Recent and ongoing USDA activities to promote resilience via enhanced soil and forest health include:

- Creation of The Adaptation Workbook, which producers can use to assess threats and document management choices to minimize climate change impacts to their operations. The workbook uses menus of adaptation strategies and approaches for forests, urban ecosystems, forested watershed and water resources management, agriculture and working lands, and recently published menus focusing on Tribal perspectives, forest carbon, and recreation. The workbook has been used to generate hundreds of adaptation demonstration projects using real-world examples of forest and farm management.
- Curation and continued growth of an online compendium of nearly 500 adaptation approaches with numerous associated examples on the FS Climate Change Resource Center (CCRC).
- Awards through NIFA's Agriculture and Food Research Initiative (AFRI) to fund 14 Soil Health grants and 7 Signals in Soil grants, an interagency program with the National Science Foundation (NSF).
- Investment in NRCS's Conservation Innovation Grants (CIG) to support the development of innovative tools, approaches, practices, and technologies to further natural resource conservation on private lands. The Soil Health Demonstration Trial, part of the CIG On-Farm Conservation Innovation Trials, will focus extensively on implementation of conservation practices and systems that improve soil health.
- Commitment of NRCS resources to fund 85 locally driven, public-private partnerships via the Regional Conservation Partnership Program (RCPP) to address climate change, improve water quality, combat drought, enhance soil health, support wildlife habitat, and protect agricultural viability.
- Encouraging enrollment in the Conservation Reserve Program (CRP) with new incentives and other adjustments to payments and a focus on the program's role in climate change mitigation. CRP provides annual payments to producers in exchange for removing environmentally sensitive lands from production and implementing practices to improve soil health and provide other benefits. In addition to general and continuous CRP sign-up, FSA offers CRP Grasslands and pilot programs focused on soil health and clean water, such as Clean Lakes, Estuaries and Rivers 30-year contracts (CLEAR30). FSA administers CRP on behalf of the Commodity Credit Corporation.
- Investments in the FS and NRCS's Joint Chiefs' Landscape Restoration Partnership, which includes projects to mitigate wildfire risk, improve water quality, and restore healthy forest ecosystems on public and private lands.

- Release of a new fire mapping tool, Southeast FireMap, to enable resource managers to improve their approaches to managing wildfire risk and fire management needs through targeted prescribed burns and training.

Building on the efforts described above and in conjunction with the objectives of the Climate-Smart Agriculture and Forestry Strategy: 90-Day Progress Report, USDA will use strategic investments to carry out climate-informed forest management and restoration activities, provide wildfire mitigation response, incentivize and scale up voluntary adoption of soil and forest health enhancing practices, and support markets that value the enhanced resilience of producers and ecosystems. Climate-adaptation practices will need to fit the geographic context and align with the interests of farmers and land managers. This is especially important because implementation costs are usually incurred on shorter timescales than the soil and forest health benefits are realized. A combined effort from NRCS, FSA, FS, USDA research agencies, the Climate Hubs and other USDA agencies will be essential to implement these actions effectively and address these challenges.

NRCS will play a key role by providing technical and financial assistance to farmers to implement and incentivize conservation practices through several existing programs and initiatives, including EQIP, CSP, RCPP, CIG, and the Soil Health Initiative. The backbone of NRCS data for designing assistance is the National Cooperative Soil Survey Program, which provides information on soil and ecological site resources of farms and ranches across the United States. FSA aims to increase enrollment in CRP by 4 million acres or more over the coming year, with the long-term goal to establish valuable land cover to improve water quality, soil health and carbon sequestration, and prevent soil erosion and loss of wildlife habitat. REE agencies and other programs, like the National Agroforestry Center, will provide the science and innovations that will underpin the management choices taken by the program



agencies, as described in Adaptation Action #4.

FS will scale up its activities to accelerate the strategic implementation of hazardous fuel treatments and prescribed fire to reduce wildfire risks and to increase forest restoration and reforestation. To significantly reduce the risk of high intensity wildfire, over the next 10 years, the FS will need to treat an additional 20 million acres of NFS land and 30 million acres of other Federal, State, Tribal and private land, especially in the Western United States. These goals are consistent with the recommendations outlined in USDA's Climate Smart Agriculture and Forestry Strategy: 90-Day Progress Report and current

budget priorities. A number of FS programs and initiatives will be engaged to build resilience on forests and grasslands including the Forest Legacy Program, which supports easements and land purchases for private-land conservation, as well as the Community Forest Program (CFP), Forest Stewardship Program (FSP), Sustainable Forestry African American Land Retention Program (SFLR), and Urban and Community Forestry (UCF) Program. Planning and decision-making in these programs and management activities will be based on climate-smart principles informed by FS R&D and the Climate Hubs.

The Climate Hubs will support efforts to build soil and forest health through ongoing work to empower land managers to incorporate climate adaptation into their land management planning. Further details of the Hubs' outward and inward-facing efforts are included in Adaptation Actions #2 and #5, respectively.

*Scope, Performance, and Resources*

- This action will work to build resilience across diverse landscapes at local to national scales, with a particular emphasis on supporting producers and land managers most vulnerable to climate change impacts. While conservation practices are often implemented at the field, farm, and stand levels, conservation planning can also be coordinated at the area and watershed levels. Large-scale forest treatment and restoration often spans management boundaries.
- USDA will track and estimate benefits of soil health practices using national survey data and program data. These data can be used to estimate soil carbon benefits and other co-benefits of soil health practices. USDA is planning to improve conservation data collection and reporting by implementing new surveys, which will provide more information on the adoption and benefits of soil health practices.
- FS will use its Climate Scorecard, particularly the Adaptation element, to monitor progress.
- Active forest management treatments to reduce wildfire risk on Federal, State, Tribal and private lands will require cross-government coordination.
- The President's FY 2022 Discretionary Funding Request includes significant investments within FS, NRCS, and other USDA agencies to enhance soil and forest health and resilience on public and private lands, including through support for voluntary conservation on working lands and for high-priority hazardous fuels and forest resilience projects.

## 2. Increase outreach and education to promote adoption and application of climate-smart adaptation strategies

The Nation's farmers, foresters, and ranchers face increased vulnerability of their operations to extreme weather and long-term changes in climate. Low-income, minority, and Tribal communities as well as small-scale, beginning, young, underrepresented, and underserved farmers and foresters will bear the brunt of negative climate change impacts, made more difficult by lack of accessible and useful information sources. Maladapted agriculture and forestry sectors could lead to a less diverse and resilient food system, degraded natural resources, and missed economic opportunities.

The goal of this action is to promote adoption and application of climate-smart adaptation strategies. USDA's Climate Hubs and NIFA, in partnership with the Cooperative Extension Service, Historically Black Colleges and Universities, Tribal colleges, Hispanic Serving Institutions, additional university partners, NGOs, and others, can provide resources to farmers, ranchers, and forest landowners to increase awareness of and engagement in opportunities to address climate change. Investments in the Climate Hubs program will allow the network to scale up their efforts to

develop and deliver science-based, region-specific information and technologies. The Climate Hubs will strengthen partnerships to enhance support for science-based decision-making and facilitate knowledge sharing of climate risks, vulnerabilities, and adaptation strategies. NIFA will evaluate the inclusiveness of climate in its education and extension portfolio and leverage its resources to encourage stakeholders to partner with the Climate Hubs to develop and deliver resources to America's farmers, ranchers, and landowners. Together, the Climate Hubs and NIFA can strengthen the role of extension as a force multiplier in increasing adoption and application of climate-smart practices. With a presence in nearly all of the more than 3,000 counties of the United States, the Cooperative Extension System's network of agents and specialists will be essential to expanding the use of climate-smart strategies described in Adaptation Action #1.

Recent accomplishments by NIFA and the Climate Hubs towards this goal include:

- NIFA support for Cooperative Extension professionals who are actively engaged in the National Extension Climate Initiative (NECI), which promotes the recognition of the climate crisis, coordination and management of climate-smart agriculture and forestry outreach activities, and sharing of program materials;
- A NIFA solicitation for extension and education projects that include partnerships with the USDA Climate Hubs through AFRI's Foundational and Applied Science Request for Applications (RFA);
- Through the Climate Hubs, development of 11 curricula reaching 402 students, production of 118 in-person or virtual workshops with an estimated 7,800 participants, 214 presentations, and 439 engagements with Tribes or Tribal organizations in FY 2020.

The Climate Hubs are a focal point for outreach and education efforts around climate impacts and risk management on working lands. Moreover,



the Hubs act as conveners helping to gather information from Tribal and stakeholder groups to understand regional issues and deliver actionable, relevant information to enhance climate-informed decision making. While many of the Climate Hubs already engage with local communities, states, and Tribes, the Hubs' capacity to increase climate outreach and education could be enhanced through dedicated Tribal and state liaisons. In addition, the Climate Hubs can expand their reach into under-resourced and underserved communities through delivery of timely, relevant, and credible information, data, and tools. NIFA can leverage existing and new funding sources to support colleges and universities, especially minority-serving institutions, in developing partnerships with the Climate Hubs. NIFA will also increase consultations with community colleges and minority-serving institutions to ensure widely accessible climate education and outreach opportunities.

Implementation will be accomplished through an expansion of the USDA Climate Hubs program and establishment of NIFA funding opportunities to address this Adaptation Action. USDA intends to leverage opportunities for enhanced technology transfer and implementation of climate-smart practices by linking USDA staff with other federal climate change coordination efforts such as the Department of the Interior's Climate Adaptation Science Centers (CASCs), NOAA's Regional

Climate Centers and Regional Integrated Sciences and Assessments (RISAs), and U.S. Global Change Research Program (USGCRP) working groups.

The Climate Hubs will evaluate success based on activities including vulnerability assessments, adaptation planning and menus, jointly developing decision-support tools, building technology to support climate resilience, and stakeholder workshops/listening sessions. Key metrics for NIFA include number of RFAs published that include climate change language and projects funded that support climate outreach and education.

*Scope, Performance, and Resources*

- The USDA Climate Hubs are located at five ARS and five FS research stations comprising ten regions spanning the United States and its territories. The Climate Hubs support local, state, and regional efforts including cross-region and national initiatives when there are common interests or technology needs.
- The Climate Hubs are overseen at the national level by an Executive Committee (EC) comprised of senior program leaders from across the Department who provide leadership on action development, implementation, monitoring, evaluation, and oversight. The National Lead, a 2-year rotating position among ARS, FS, and NRCS, works through the EC to ensure national coordination to capitalize on synergies and efficiencies.
- New NIFA programmatic support for climate extension and education is expected in FY 2022. NIFA will need to balance climate with other priorities across its research, education, and extension portfolio. Additional National Program Leaders with social and behavioral science expertise will help develop effective climate outreach and education programs.
- The President's FY 2022 Discretionary Funding Request for the Climate Hubs will support an expansion of climate science tools and landowner awareness and engagement in climate adaptation practices.

## 3. Broaden access to and availability of climate data at regional and local scales for USDA Mission Areas, producers, land managers, and other stakeholders

Increasing access to and use of climate data, models, and decision support tools at the regional and local scales for producers, land managers, state and local policymakers, and USDA Mission Areas is a critical and ongoing priority for supporting timely responses to the impacts of climate change. This action necessitates organizing, streamlining, and coordinating data access points and online data delivery. Ensuring that climate adaptation strategies are accessible to all farmers, ranchers, forest landowners, and communities will require that USDA address internet access and other infrastructure or resource issues that limit access and use of climate data.

The Department aims to increase access to reliable climate data by supporting the collection and curation of scientific information on climate change and translating that information into user-friendly decision support tools, models, and recommendations to provide guidance on benefits and outcomes associated with agronomic decisions. To accomplish this goal, the Department must also provide equitable access to technical assistance and training for climate data end users.

Ways in which USDA already collects and provides data for improved resource management in a changing climate include:

- ARS's development of the Agricultural Collaborative Research Outcomes System

(AgCROS) database to provide data to the public research and development community and its Partnerships for Data Innovation (PDI) program to implement sensors and other data collection, integration, and sharing systems that will help farmers get the most from their limited resources;

- ERS's regular evaluation of its Agricultural Resources and Management Survey data products;
- NRCS, which delivers data on conservation practices and is modernizing its Plant List of Accepted Nomenclature, Taxonomy, and Symbols (PLANTS) database;
- FS's Forest Inventory and Analysis (FIA), which provides annual data on forests to assess sustainability of management practices, monitor forest health, productivity and carbon stock change, and predict the effects of climate change;
- NIFA with its AFRI Data Science for Food and Agricultural Systems program area that supports projects that harness data science to aid land managers in decision-making and a collaboration with the National Agriculture Library on an open data framework; and
- The Climate Hubs, which have improved the discoverability and usability of RMA crop insurance data for enhanced climate risk management with the AgRisk Viewer.

This action provides an opportunity to deliver credible science and user-friendly decision-making tools that can help producers and land managers apply climate change and weather-related information to their operations. Reliable data can inform planting decisions, farming practices, and business decisions. By improving current data access, this action enables USDA to provide support and incentives for agricultural data standards and to encourage partnerships with public and private data trusts. Additionally, this action presents the opportunity to create a USDA-wide open access agricultural, rangeland and forestry database to drive development of more advanced tools for producers and land managers.



The Department will identify existing or emerging issues with data access as well as opportunities for improvement, with a particular focus on access for low-income, socially disadvantaged and historically underserved communities. Consistent financial support will be key to ensure that the necessary infrastructure exists for data access. The lack of a cohesive and consistent cloud computing environment will restrict the ability to deliver spatial data sets, and Chief Information Officer restrictions on research and development application development may delay delivery of user-friendly climate dashboards and tools. Other challenges include the availability of temporally resolved geospatial imagery, the need for additional data science expertise, and the capacity to incorporate social and behavioral sciences to evaluate human dimensions of the food system. Data and decision-support tools need to be accessible to rural communities, which may be challenging with current broadband and internet infrastructure in some communities. Collaborations with federal funding agencies to provide research support will aid in understanding complex climate issues and allow the Department to craft models and decision-making products essential for the sustainability of economic and natural resource systems.

*Scope, Performance, and Resources*

- Increasing access to climate data is an ongoing priority in the Department, and a reasonable timeframe for achieving the goal will be FY 2021 through FY 2025. The first key milestone of this action will be leveraging new technologies and computing resources to effectively deliver additional climate data through online tools in FY 2022 and FY 2023.
- This action will require contributions and support from ARS, ERS, FS, NASS, NIFA, NRCS, and OCS.
- Maintaining current levels of delivery and data access will likely be possible with existing resources. Direction of additional investments and technical capacity towards this action could further improve data quality, timeliness of delivery and ease of access by users.
- Increased access to and consistency of climate data should be addressed at the national, regional, and local scales.
- Supporting information tools that provide resolution across multiple scales will be critical to allow users to adjust output based on their specific need.
- Increased availability of technical assistance to support climate data and tools, increased access and use of climate and climate-related data, feedback from user communities on the usefulness of information and data, and the reduction in gaps of science and science delivery for agriculture will serve as useful performance measures.
- USDA will work to better understand Tribe and stakeholder needs for climate data, particularly in underserved communities.
- The Department will coordinate with science agencies across the federal government, including the NSF, the Department of Energy, the National Aeronautics and Space Administration, and NOAA to ensure that federal climate-related data are accessible to those in the agriculture, rangeland, and forestry sectors.

## 4. Increase support for research and development of climate-smart practices and technologies to inform USDA and help producers and land managers adapt to a changing climate

USDA will continue to support and coordinate the efforts of its research agencies to develop innovations in climate-smart agriculture and forestry. Evaluating the efficacy of adaptive practices and technologies on working lands, including productivity synergies and tradeoffs and mitigation co-benefits on soil carbon storage and GHG emission reductions, is a research priority. Other key topics for climate research include improved fertilizer technologies, genetic studies to identify climate resilient plants and trees, and studies of the impacts of climate change on pollinator communities and vector-borne livestock diseases. Modeling efforts can project the affordability of climate-smart activities, infer adoption likelihood, and project pest and disease outbreaks under different climate change scenarios. USDA's long-term monitoring networks for snowpack, precipitation, and soil moisture provide data to investigate trends and develop management options.

The Department's research activities form the basis for validating existing climate adaptation options and identifying and developing new ones, while ensuring the actions are regionally relevant and economically viable. USDA's research integrates climate and socioeconomic change with production and land-management outcomes, while considering the secondary effects of climate's influence on pollinators, pests, diseases, invasive species, and extreme events such as flooding and drought. New scientific information and tools, contextualized and implemented locally, can help

land and resource managers increase the resilience of those systems and the communities that depend on them. To date, however, implementation has been slow. Increasing partner engagement, science co-production, and delivery will ensure that the best available science is understood and put into practice.

USDA's efforts to understand and minimize climate risks for its stakeholders have yielded important accomplishments, a few of which are highlighted here:

- In July 2020, USDA published a report documenting 20 Climate Indicators for Agriculture to support decision making and to understand the larger climate context of U.S. agriculture.
- NIFA currently supports approximately 400 active projects related to climate change representing an investment of approximately $200 million.
- Scientists at ARS are developing a Grand Challenge Synergy Project proposal "Creating pollinator landscapes and beekeeping practices for a changing climate," to synergize efforts across ARS and other federal and state agencies to find solutions to the climate change challenges experienced by pollinators. In May 2021, Project Leaders held a workshop to obtain perspectives from scientists and stakeholders and build collaborations required to generate and implement solutions to pollinator loss from climate change.
- FS has developed national and regional syntheses of climate effects on forests, agroforestry, non-timber forest products, forest and rangeland soils, invasive species, and the wildland urban interface and identified management opportunities and adaptation practices.
- In collaboration with ARS, NRCS, NDMC, and university partners, the Climate Hubs developed Grass-Cast to provide enhanced decision support to ranchers and grassland managers by estimating forage productivity during the growing season.



- FS's FIA program has successfully led to practical tools for forest carbon assessment and monitoring climate change effects on forest species composition and abundance.
- NRCS's Snow Survey and Water Supply Forecasting and Soil Climate Analysis Network data are used to manage water resources and plan for water shortages in the Western United States.

Managing competing research priorities will require a coordinated effort at the Department and agency levels. As described in Adaptation Action #3, translating experimental data into information and decision tools is a complex process that is required for the adoption of climate-smart practices and technologies. Evaluating the effectiveness, tradeoffs, and synergies of climate-smart practices will require a multidisciplinary systems approach.

USDA anticipates that existing organizational, administrative, and coordination capacity will rapidly and efficiently integrate many of the new research and development priorities outlined in this Plan. As described in Adaptation Actions #2 and #5, USDA will work through the Climate Hubs, extension, and other means to understand stakeholder needs and deploy new information, data, practices, tools, and technologies to private landowners and managers for implementation. Relationships with land-grant universities, technical service providers, and other cooperators will be leveraged to achieve this goal. Finally, USDA will use internal and interagency working

groups and review of existing funding authorities to identify research opportunities and increase support where appropriate for climate-smart research activities.

Many ongoing USDA research projects with climate adaptation applications will continue into the foreseeable future, for example:

- ARS has numerous climate adaptation research projects throughout its crop, animal, natural resource, and food nutrition programs.
- FS activities to increase support for applied climate science to develop and evaluate practices and technologies, engage in the development and co-production of science, and use social science to identify adoption barriers will be initiated in FY 2022 and continue at least through FY 2026.
- NIFA will support new Artificial Intelligence Research Institutes focused on climate change in FY 2022 and continue to support climate science in the AFRI Sustainable Agricultural Systems (SAS) RFA.
- FSA's evaluation of the soil benefits of the Conservation Reserve Program will undergo a significant expansion in FY 2021 and will continue for at least five years, with the potential to go beyond 15 years.

Existing monitoring efforts and those developed by USDA's research agencies during adaptation planning will be used to track the outcomes of science implementation and adaptation actions. These efforts will consider the outcomes of focused listening sessions, adaptation case studies, dissemination and training workshops, new tools and tool improvements, research partnerships and measures like adoption rates, publications, data usage, fellowships, and funding levels.

*Scope, Performance, and Resources*

- OEEP coordinates USDA's climate change activities, including execution of this Plan, through the monthly USDA Global Change Task Force (GCTF) and represents USDA to the interagency USGCRP. OCS provides Department-wide coordination of agricultural research, education, and extension needs.
- USDA's research spans field-scale practices, whole-farm or forest systems, regional monitoring networks, and national-scale analysis and assessment.
- Coordination is generally a national headquarters activity, while primary research activities largely occur in the field to capture diversity in environmental conditions, production types, and management.
- USDA will continue its participation in the USGCRP's Federal Adaptation and Resilience Group to ensure that climate-driven challenges are anticipated by new information, practices, technologies, and tools.
- Outside of the federal government, shared stewardship agreements between the FS and states will facilitate implementation of adaptive actions and support monitoring efforts.
- USDA agencies will increase consultations with Tribal communities to incorporate traditional ecological knowledge into climate-smart practices.
- Additional consultations with community colleges and minority-serving institutions will be used to make research opportunities under this effort widely accessible.
- International partnerships and dialogues allow USDA's expertise to improve global outcomes beyond U.S. borders.
- USDA research agencies are already or planning to realign personnel time and resources towards USDA's climate priorities. Additional investments would permit expansion of essential research efforts, climate-related program analysis, monitoring networks, and technology transfer.

## 5. Leverage the USDA Climate Hubs as a framework to support USDA Mission Areas in delivering climate adaptation science, technology, and tools

The Climate Hubs provide necessary USDA infrastructure to deliver climate adaptation science, technology, and tools to USDA agencies who, through their missions, support farmers, ranchers, and forest landowners. The Hubs were established in 2014 with the aim to develop and deliver science-based information and technologies to enable producers and natural resource managers to make climate-smart decisions and minimize risk to their operations. In January 2020, the Hubs completed a five-year review to assess their effectiveness and provided recommendations to inform a new, forthcoming, strategic plan. Over a five-year period (2014-2019), the Climate Hubs and partners hosted over 435 in-person workshops and training events and engaged over 16,000 stakeholders on critical climate issues and adaptation opportunities. The Hubs provided technical expertise through 237 webinars, podcasts, and other digital communication reaching over 17,000 people, and developed more than 25 web-based decision-support tools, including Grass-Cast and AgRisk Viewer.

To integrate climate-smart agriculture and forestry in USDA's mission, programs, operations, and management, USDA will take advantage of the Climate Hubs' unique position to work across organizational boundaries and engage their expertise and awareness of regional priorities. The Climate Hubs and USDA Mission Areas will work together within the three Hubs workstreams:

**Workstream 1: Science and Data Synthesis**

- The Hubs will promote coordination and joint production of resources and tools between USDA science and program agencies.
- Hubs' applied vulnerability assessments for fire, flood, drought, extreme temperatures, and hurricanes will be used to make recommendations to USDA Mission Areas to increase landscape and community resilience to extreme climate events.
- Using an adaptive management approach, the Climate Hubs plan, implement and monitor actions, analyze and synthesize results, and share their learning. USDA will use the Hubs' regional expertise and awareness of climate-smart agriculture and forestry successes to inform Mission Area management and decision-making.

**Workstream 2: Technology and Tool Development and Implementation Support**

- The Climate Hubs will leverage their co-production model to produce tools relevant to USDA agencies that use existing technologies and data.
- To promote co-production of tools and resources with stakeholders, the Hubs will pass back local and regional knowledge and climate adaptation needs to ensure that USDA's work is relevant and usable by farmers, ranchers, and landowners.

**Workstream 3: Outreach, convening, and training**

- The Hubs will provide a platform for USDA agencies to convene and work on common issues and expand their outreach.



- The Hubs will develop new partnerships and strengthen existing relationships with USDA agencies to enhance uptake of existing tools and jointly develop new products. Opportunities to partner with APHIS, FS, FSA, NRCS, RD, RMA, and other agencies will be sought.
- To build a practice of climate-thinking across USDA, the Hubs will integrate the best available science into messaging tools like research publications, gray literature, social and other media communications, and video and podcast products.
- To reach specific agency staff, the Climate Hubs will jointly develop and curate relevant educational modules, webinars, workshops, and trainings.

*Scope, Performance, and Resources*

- Resources to support the Hubs program are contained within the President's FY 2022 Discretionary Funding Request. These investments will allow the program to expand to meet growing demand from within and outside USDA.
- Indicators relevant to this action will include training or capacity building activities provided to USDA staff, an increase in intra-agency research or program collaborations, and development of tools, resources, and research to support Mission Area objectives. The Hubs will continue to track webinars, trainings, and other interactions with the public.
- The Climate Hubs report on their progress through quarterly reports to the Executive Committee, newsletters, and annual reports.
- The Climate Hubs have built strong relationships with external partners from local to national scales and across sectors, providing opportunities for collaboration with NGOs and other stakeholder communities to develop adaptation resources and tools to enhance USDA activities.
- The Climate Hubs will share climate adaptation science, tools, and technologies through partnerships with other federal climate service networks including the RISAs, CASCs, and NIDIS DEWS. The Hubs can assess how to adapt these interagency efforts for USDA use to increase efficiency and avoid duplication of efforts.

## IV. ENHANCING CLIMATE LITERACY IN USDA'S WORKFORCE

A climate-informed and capable workforce underpins the success of the adaptation actions outlined in the sections above. Enhancing climate literacy across USDA's workforce is an essential element of integrating climate preparedness into USDA's mission, programs, operations, and management. USDA has nearly 100,000 employees at more than 4,500 locations across the United States and abroad with a diverse range of roles, responsibilities, and backgrounds. To prepare USDA's current and future workforce for the impacts of climate change, USDA will expand opportunities for education focused on how climate change affects the mission of the Department and its work. Core education and training should be accessible to staff at all levels in all locations.

Examples of ongoing activities to build climate literacy include:

- The Office of Property and Environmental Management's (OPEM) Sustainable Practices team convenes working groups on Facilities, Sustainable Buildings, Green Purchasing, Fleet Management, and Real Property to discuss policies, goals, best practices, challenges, and progress in achieving sustainability and climate goals.
- OPEM also hosts events and issues a quarterly newsletter, The EnviroPost, to increase employee awareness of sustainability and climate issues by highlighting agency

successes, best practices, awards, and training opportunities.

- The CCRC, a joint online platform of FS R&D and FS Office of Sustainability and Climate (OSC), hosts a series of three modules on climate change and natural resource management. The modules cover basic climate change science and modeling, climate change effects on forests and grasslands, and responses to climate change.
- FS OSC hosts webinar series on topics related to its mission; its current series is focused on topics related to environmental justice, including Tribes and climate adaptation, water, air, and recreation.
- FS R&D and OSC, the Climate Hubs, and NRCS regularly host webinars and training at various technical levels on topics related to climate that are accessible to USDA staff.

To build on these existing efforts, USDA can:

- Form a climate literacy working group. Coordinated by the Climate Hubs, this group would survey USDA agencies and offices for prior and ongoing climate education activities, identify climate literacy training needs for staff, including environmental justice issues, and suggest how to use existing frameworks to enhance climate literacy. Recognizing the Climate Hubs' intra-agency reach and experience in innovative and interactive methods to increase climate literacy, this working group will suggest how the Hubs can build climate capacity within USDA agencies, including how to reach regional and local offices.
- Expand information dissemination and training access. OEEP and the Climate Hubs will develop a sustainable strategy to disseminate climate science information from REE agencies, FS R&D, and USGCRP to relevant USDA staff. Building off the Climate Hubs' social science insights on encouraging knowledge co-production, USDA can ensure information sharing and training is relevant, useful, and equitable. USDA can ensure access to and expand the CCRC modules described above to equip staff with an understanding and common vocabulary of climate change and adaptation and mitigation responses.
- Establish a USDA climate seminar series. OEEP will continue development of a yearlong, monthly seminar series that will be at a level accessible to a diverse audience of USDA staff and develops climate literacy with progressively complex topics. The series will be science-focused, for experts and non-experts, and will provide opportunities throughout to ask questions that help dispel misconceptions related to climate. Potential subjects include GHGs in agriculture, climate impacts on crop production and animal agriculture, and options for climate adaptation and mitigation.
- Consider early climate literacy development. Hiring, training, and maintaining a climate literate workforce can start with students before they become USDA staff. Working with land-grant and other university partners, NIFA will continue to play an important role funding training and education. With investments from NIFA and assistance from the Climate Hubs, youth organizations like 4–H could be supported to deliver early climate literacy and promote positive youth development. In addition, USDA could look for opportunities to develop climate-tracks within its Internship and Recent Graduates Programs.

Performance measures developed during agency and office-level adaptation planning should include workforce climate literacy targets. Current means of evaluating climate literacy include annual Sustainability Plans, OMB Scorecards for Efficient Federal Operations and Management, and, at the Forest Service, climate-related training can support progress towards Climate Scorecard elements.




## V. USDA ACTIONS FOR CLIMATE-READY SITES AND FACILITIES

USDA will continue to improve the climate resilience of sites, fleet, and facilities and implement its Departmental Regulations and Directives for sustainable and climate adaptive operations of sites, fleet, and facilities. OPEM is responsible for coordinating with agencies, setting annual strategic goals, developing actions, and measuring progress by creating agency scorecards for improvement.

**Construct and Operate Climate-Ready Real Property**

The Department implements Department of Homeland Security structural integrity guidance to prepare for increasingly frequent and intense natural hazards, such as extreme weather and wildfires. Recent vulnerability assessments indicate many FS dams are vulnerable to large storm events for which they were not originally designed. To enhance resilience, USDA will evaluate needs to increase capacities of spillways to handle extreme storm events.

USDA is raising its standards for design, construction, operation, and maintenance of facilities and infrastructure by applying climate adaptive technologies, increasing renewable energy use and equipment efficiencies to conserve energy, and reducing its GHG footprint. New buildings are performing 30 percent more energy efficiently than the industry standard and over 45 percent of USDA-owned buildings 10,000 gross square feet and larger meet the Guiding Principles for Sustainable Federal Buildings. USDA uses third-party certification systems such as LEED or Green Globes to validate its green buildings. For construction materials, USDA prefers wood for new buildings due to its capacity for energy savings and ability to sequester carbon. Equipment performance is monitored throughout system lifecycles.

For leased buildings, USDA increasingly seeks out third-party certified green and ENERGY STAR facilities with access to public transit. However, USDA often leases facilities in remote and rural markets with limited options for green buildings. USDA will work to build climate adaptation, resilience, and sustainability awareness in these communities to achieve further facilities-related emissions reductions and climate resilience in the future. In new leases, USDA will follow the General Service Administration's green leasing guidance. By requiring sustainable and resilient buildings in all new leases, the Department would increase availability of these sustainable and resilient buildings in remote and rural markets.

To raise facility performance levels nationwide in sustainability and resilience, USDA also plans to develop a Departmental Manual to guide staff to align sustainable and resilient facility operations with the USDA Departmental Regulations on Climate Change Adaptation and Sustainable Operations.

USDA chooses locations for utility equipment and central data centers to improve operational resilience to flooding and rising sea levels. These centers feature direct digital controls, thermal aisle design, emergency power, and redundant cooling for continuity, lower operating costs, and higher capacities.

**Increase Facilities' Energy and Water Resilience**

USDA will take the following actions related to facilities energy and water management that

enhance climate adaptation and resilience or have adaptation and resilience co-benefits:

- **Increase onsite renewable energy capacity and installation of microgrids.** The energy and power supply at many USDA facilities are susceptible to the increased frequency and severity of storms. Accordingly, USDA will work to increase onsite renewable energy capacity and install microgrids to improve resilience at its facilities. This may include transitioning from propane/diesel generators to mobile solar energy systems with battery backup at remote sites and installing solar panels to enable facilities to operate off-grid. Exploring the use of energy performance contracts to install solar energy equipment, geothermal energy systems, and microgrids at remote facilities to mitigate impacts from future storms will also be considered. These climate adaptation actions will reduce the cost of electricity and eliminate the dependence on unreliable and poor-quality power at remote sites.
- **Improve the condition and resilience of government-owned infrastructure.** USDA owns miles of aging overhead and underground electrical wiring, steam pipes, natural gas pipes, and domestic water and sewer lines, which are vulnerable to severe weather events. This infrastructure requires periodic maintenance to improve and maintain reliability, functionality, and resilience. To address this issue, agencies will implement actions that have co-benefits to climate adaptation and resilience. Specifically, agencies will perform leak tests on water systems that show inconsistent consumption or lack of integrity, conduct cost-effective maintenance and repair on equipment and infrastructure, and establish and maintain good communications with local utility providers.
- **Switch fuel types, use dual fuel equipment, and reduce the carbon footprint of facilities.** Dual fuel equipment is critical for USDA's remote buildings that rely on heat from fossil fuels because interruptible natural gas supply requires secondary fuels as a backup, is subject to supply shortages, and can result in extremely high costs and damage to heating equipment. To address this issue, agencies will convert to dual fuel heating equipment, select secondary fuel types with the best GHG emission ratings, and convert heating equipment from fossil fuels to electric heat pumps that can be powered by solar panels.

**Optimize Fleet Inventory and Efficiency**

USDA is committed to maintaining an optimal fleet inventory and reducing its fleet's carbon footprint for climate adaptation and resilience. This effort includes developing standardized acquisition strategies that identify and eliminate inefficient vehicles and replace them, with safer, more efficient vehicles that use less petroleum per mile, alternative fuels, and electric and hybrid-electric vehicle technology. A focus on efficiency will encourage climate adaptation management actions and sustainable behaviors. Looking ahead, USDA plans to incorporate a standardized fleet replacement planning initiative to transition from primarily fossil fuel vehicles to a combination of biofuels, fully dedicated electric, and hybrid-electric vehicles to reduce costs, improve fleet efficiency, and meet environmental goals. USDA will also identify locations to install biofuel, alternative fueling, and electric vehicle charging infrastructure to better support non-petroleum vehicles.

## VI. USDA ACTIONS TO ENSURE A CLIMATE-READY SUPPLY OF PRODUCTS AND SERVICES

Through its Office of Contracting and Procurement (OCP), USDA supports E.O. 14008 Sec. 206 and E.O. 14005 Ensuring the Future Is Made in All of America by All of America's Workers, issued January 25, 2021. USDA is



committed to adhering to the requirements of the Made in America Laws in making clean energy, energy efficiency, and clean energy procurement decisions. Consistent with applicable law, USDA is applying and enforcing the Davis-Bacon Act and prevailing wage and benefit requirements. USDA will stay vigilant should the Secretary of Labor take steps to update prevailing wage requirements or should the Federal Acquisition Regulatory Council develop regulatory amendments to promote increased contractor attention to climate adaptation and resilience with co-benefits of reduced carbon emissions and federal sustainability. Focusing on these adaptation areas can help prevent disruption of supplies and services for mission critical activities. Furthermore, USDA procurement leadership seeks to use contracting as a lever to promote protection of communities and ecosystems where USDA has a presence. Our efforts will focus on the effects of climate change while also building long-term resilience to evolving environmental conditions.

The Department has implemented policies and practices to purchase energy efficient, sustainable, and USDA-designated biobased products in compliance with requirements in the Federal Acquisition Regulation to support climate adaptation efforts. Energy efficiency contributes to climate adaptation by reducing peak energy demand as more energy is required for air conditioning and to address uncertainty in energy generation and use resulting from extreme weather events. USDA is committed to increasing the use of sustainability criteria in its purchasing. For example, USDA continues to use blanket purchase agreements that provide efficient electronic equipment that is registered with the Electronic Product Environmental Assessment Tool (EPEAT). Purchasing EPEAT-registered equipment reduces GHG emissions, hazardous waste, and water pollutants over the life of the equipment. Procurement requirements to promote resilience apply to contracts for design, construction, operations, and maintenance. USDA selects materials made with post-consumer and pre-consumer recycled materials including carpet, gypsum board, ceiling tiles, millwork, furniture, and furnishings. In addition, the BioPreferred Program continues to support climate adaptation, working with CEQ, OMB's Office of Federal Procurement Policy, and other federal agencies, to develop guidance for establishing annual biobased-only procurement targets.

The five critical areas where procurement processes are at risk due to acute or chronic climate change impacts are:

1. **Facility upgrades.** USDA facilities need modernization to improve energy efficiency and provide resilient infrastructure. Energy efficiency, water conservation, and sustainability are all considerations for new construction and modernization. To the extent possible, USDA will expand the Solar ARS program, which is based on a contract template that was developed to be customized for performance contracts and appropriate funds projects.
2. **Forest Service infrastructure.** Forest Service infrastructure is highly susceptible to climate change and large storm events, for which it was not originally designed. For dam infrastructure, actions to address this include an inventory assessment of dam spillway capacity and a spillway rehabilitation plan.
3. **Puerto Rico infrastructure.** Puerto Rico and its infrastructure are vulnerable to the impacts of climate change particularly increased frequency and severity of storms. At ARS Mayaguez and Isabela facilities, a project to install a microgrid has been developed but remains unfunded. It can be implemented with a performance contract with sufficient capital infusion. The microgrid would eliminate the dependence of the research program on the local electrical grid.

4. **Growth of net-zero facilities.** ARS has one net-zero electricity facility and another under construction that align with current budget priorities. In 2019 an Energy Conservation Measure at the Jornada Experimental Range in Las Cruces, New Mexico, was awarded an Energy and Water Management Award by the Department of Energy's Federal Energy Management Program. A net-zero project carried out this year, at the Fort Collins Research Farm in Colorado, is complete and awaiting final connection. As energy is saved, environmental sustainability will improve due to decreasing GHG emissions and conservation of limited resources.

5. **Forest restoration.** Four Forest Restoration Initiative (4FRI) is accelerating a large-scale restoration program across 2 million acres in northern Arizona to improve forest and watershed health so forests are more resilient to climate change. 4FRI has embarked on an ambitious project to award a 20-year contract to provide forest restoration treatments on over 500,000 acres. Increased certainty of supply will help stimulate investment in restoration to reduce the impacts of climate change while supporting forest industries that strengthen local economies and conserving natural resources and aesthetic values.

## VII. NEXT STEPS

Concurrent with the release of this plan, USDA will develop guidance for agencies and offices to prepare new climate adaptation plans in line with updated Departmental Regulation 1070-001 with the aim of completing these plans by spring 2022. Agencies and offices will identify how climate change is likely to affect their ability to achieve mission, operations, and program objectives. Through adaptation planning, they will develop, prioritize, implement, and evaluate actions to integrate climate risks into strategic planning and decision-making. Agencies and offices will identify alignment with the vulnerabilities identified in this Plan and how they might contribute to the vulnerability-specific and cross-cutting adaptation actions. This process will provide the opportunity to identify knowledge gaps or programmatic needs that can be addressed through coordination with OEEP, the Climate Hubs, and intra-agency collaborations.

To measure progress towards achieving climate adaptation goals, during adaptation plan formulation, USDA agencies and offices will develop metrics relevant to their missions and adaptation strategies. The Forest Service Climate Scorecard is one model internal to USDA that can be emulated for each agency's unique needs. These agency-relevant frameworks will be used for measuring, sharing, and learning from adaptation successes and enable USDA to demonstrate how adaptation actions are making the Department and its stakeholders more resilient. Through iterative climate risk management, USDA will address emerging and future climate risks, adjust efforts and resources, and prepare American agriculture, forestry, and rural and urban communities to be resilient in a changing climate.



# APPENDIX

U.S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

| **DEPARTMENTAL REGULATION** | NUMBER:<br>DR 1070-001 |
|---|---|
| SUBJECT: U.S. Department of Agriculture Policy Statement on Climate Change Adaptation | DATE:<br>May 26, 2021 |
| OPI: Office of the Secretary | EXPIRATION DATE:<br>May 26, 2026 |

1. PURPOSE

This Departmental Regulation (DR) provides guidance on the establishment and periodic revision of the United States Department of Agriculture's (USDA) *Climate Change Adaptation Plan*. It is consistent with guidance from the Council on Environmental Quality (CEQ) for the implementation of Executive Order (E.O.) 14008, *Executive Order on Tackling the Climate Crisis at Home and Abroad*, issued on January 27, 2021.

Climate change poses a significant risk to the agriculture and forestry sectors and the communities that support and depend upon them. Through climate adaptation planning and implementation, USDA will identify how climate change is likely to affect its ability to achieve its mission, operations, and policy and program objectives. Climate change adaptation is a critical complement to mitigation; both are required to address the causes and consequences of climate change. Through climate adaptation planning, USDA will develop, prioritize, implement, and evaluate actions to minimize climate risks, and exploit new opportunities that climate change may bring. Climate adaptation planning and implementation should align with USDA efforts to ensure equity and environmental justice. By integrating climate change adaptation strategies into USDA's programs and operations, USDA better ensures that taxpayer resources are invested wisely, and that USDA services and operations remain effective under current and future climate conditions. Through climate adaptation planning, USDA is taking a leadership role in ensuring the vision of a resilient, healthy, and prosperous Nation in the face of a changing climate.

2. ACTIONS ORDERED

This policy establishes the USDA directive to integrate climate change adaptation planning, implementing actions, and performance metrics into USDA programs, policies, and operations in accordance with executive orders and additional guidance from CEQ.

a. The Chief Economist, with the full support and participation of USDA Mission Areas, agencies, and staff offices, will:

(1) Develop a *USDA Climate Change Adaptation Plan* in accordance with E.O. 14008 and CEQ guidance;

(2) Issue guidance in accordance with CEQ guidance to Mission Areas, agencies, and staff offices to complete or update their climate adaptation plans, as well as required interim deliverables; and

(3) Update the *USDA Climate Change Adaptation Plan* as appropriate and provide progress reports on the status of implementation efforts annually in accordance with CEQ guidance.

b. USDA Mission Area, agency, and staff office heads, in developing organization-specific contributions, will:

(1) Analyze how climate change may affect the ability of their organization to achieve its mission and policy, program, and operational objectives and authorities to:

(a) Identify potential impacts of climate change on their organization's areas of responsibility;

(b) Prioritize, implement, and integrate response actions into their Mission Area's, agency's, or staff office's operation, contingent on the availability of resources;

(c) Continuously assess and improve the capacity to adapt to current and future changes in the climate; and

(d) Prepare contributions to the Department's *Climate Change Adaptation Plan*.

(2) Identify, as appropriate, key performance measures to evaluate progress in climate change adaptation in the annual Departmental and Mission Area, agency, and staff office budget material, to include measures in the Summary of Budget and Performance section of the explanatory notes, submitted as part of the Congressional justification.

(a) Identify, to the extent possible, the costs associated with the accomplishment of Mission Area, agency, or staff office performance measures and provide accessible information to producers; and

(b) Identify returns to Mission Area, agency, or staff office end-users for climate adaptation actions in terms of a list of expected accomplishments.

(3) Identify, as part of the annual budget process, to the Office of Budget and Program Analysis (OBPA), areas where budget adjustments would be necessary to carry out actions identified under this DR;

(4) Identify, as appropriate, for USDA's Office of the General Counsel, areas where legal analysis is needed to carry out actions identified under this DR; and

(5) Identify the point of contact for and coordinate actions with the USDA's Global Change Task Force, as appropriate.

c. USDA Mission Areas, agencies, and staff offices will integrate information that reflects the current understanding of global climate change and its projected impacts when undertaking long-term planning exercises, setting priorities for scientific research and investigations, developing performance metrics, and making decisions affecting Mission Area, agency, or staff office resources, programs, and operations.

3. EFFECTIVE DATE AND TERMINATION

a. The provisions of this DR are effective immediately and will remain in effect until superseded or revoked.

b. This policy supersedes and replaces DR 1070-001, *U.S. Department of Agriculture (USDA) Policy Statement on Climate Change Adaptation*, dated June 15, 2015.



/s/ THOMAS J. VILSACK
SECRETARY OF AGRICULTURE

# EXHIBIT R

Live version as of 2/20/2025

**U.S. DEPARTMENT OF AGRICULTURE**
**OFFICE OF THE SECRETARY**
**WASHINGTON, DC 20250**

**SECRETARY'S MEMORANDUM 1077-004**
**June 23, 2022**

**Climate Resilience and Carbon Stewardship of America's National Forests and Grasslands**

1. PURPOSE AND BACKGROUND

a. Drought, extreme weather, flooding, and catastrophic wildfires driven by the growing climate crisis threaten the health and resilience of our communities, lands, waters, and wildlife. Climate impacts, in combination with a legacy of fire exclusion and other past management practices, are already causing severe disruption in natural systems, requiring urgent action from decision makers. Our forests on Federal lands, and the forested lands of Tribal, state, local and private landowners, provide a vast network of natural infrastructure that is increasingly important for mitigating and adapting to the effects of climate change.

b. The USDA Forest Service (USFS) manages the National Forest System, which includes 193 million acres of national forests and grasslands that provide a rich natural heritage. The USFS also provides research, technical and financial assistance for the sustainable management of 500 million acres of private, state, and Tribal forests. These forests, grasslands, and waters provide ecosystem services and benefits that we need: sequestering carbon, providing clean drinking water, stabilizing soil, buffering floods, protecting biodiversity, providing sustainable forest resources, protecting cultural resources and places of tribal importance, and enabling access to the outdoors for hundreds of millions of visitors.

c. In addition to these vital benefits, our forests are climate change mitigation powerhouses. Attaining our global climate goals cannot be achieved in the absence of investments and policies to secure healthy and climate resilient forests. America's forests—from mature and old-growth stands to working forests—already capture more than 10 percent of our nation's carbon emissions each year, and they have the potential to do more. Yet forest mortality from climate change-induced drought, pests and wildfire is a major driver of carbon emissions from some U.S. forests and could result in additional forests becoming carbon sources rather than carbon sinks.

d. On January 27, 2021, this Administration responded to the climate crisis through President Biden's Executive Order (EO) 14008, *Tackling the Climate Crisis at Home and Abroad*, which included the America the Beautiful initiative to conserve thirty percent of lands and waters by 2030. USDA followed the President's order with a comprehensive *Action Plan for Climate Adaptation and Resilience*, which provides

broad direction to overcome risks and generate solutions on our forests through wildfire risk reduction, climate-informed reforestation and restoration, applied science, and carbon stewardship. The Department and the USFS are taking additional actions consistent with EO 14008, including a rulemaking proposing to restore the *2001 Roadless Rule on the Tongass National Forest* and developing a *USFS Climate Adaptation Plan*. Most recently, on Earth Day 2022, President Biden issued EO 14072, *Strengthening the Nation's Forests, Communities, and Local Economies*, directing USDA, in partnership with other Federal agencies, to take actions to inventory old-growth and mature forests, accelerate reforestation, create and sustain jobs in the sustainable forest product sector, and develop policies to institutionalize these actions.

e. To complement the Departmentwide climate strategy and address one of the most significant risks to our forested land, the USFS issued the *Confronting the Wildfire Crisis* strategy earlier this year. Our national forests coevolved with fire, deliberately set by native Americans or resulting from lightning strikes. Periodic and, in some forest ecosystems, frequent fire caused many forests to be "patchier" and more open with widely spaced trees. More than a century of deliberate wildfire suppression strategies from Federal and state agencies and others have left many forests significantly different from their historic conditions and vulnerable to uncharacteristic and catastrophic fires. The climate crisis is exacerbating these unhealthy conditions through widespread drought, insect and disease mortality, and an increase in extreme weather events. At the same time, the number of people living in or near wildland forests has increased dramatically, creating additional challenges in protecting lives, communities, infrastructure, and natural resources from wildfire. The *Infrastructure Investment and Jobs Act* (herein "*Bipartisan Infrastructure Law*" or "BIL"), Public Law 117-58, combined with our annual appropriations, provide us with an unprecedented opportunity to invest in significant new landscape-level restoration efforts to support resilient forest ecosystems and forest-adjacent communities.

f. In addition to the risks that uncharacteristic wildfires pose to lives, property, health, and communities, wildfire-driven deforestation is a reality, with some forests unable to recover, resulting in conversion to non-forested systems. Forest values at risk are connected and often interdependent, including carbon sequestration, water, biodiversity, critical habitat, and unique ecological features such as old-growth. In particular, many old-growth and mature forests have a combination of higher carbon density and biodiversity that contributes to both carbon storage and climate resilience. While these stands may be ideal candidates for increased conservation and restoration efforts to retain large trees and maintain and restore old-growth characteristics, many are also at increasing risk of mortality through acute and chronic disturbances such as drought, wildfires, type conversion, and insect outbreaks. A primary threat to old-growth stands on national forests is no longer timber harvesting, but rather catastrophic wildfire and other disturbances resulting from the combination of climate change and past fire exclusion.

g. USDA Forest Inventory and Analysis (FIA) data indicates that there are 134 million acres of total forest area on land managed by the agency within the contiguous U.S., of

which 56 million acres are older than 100 years and approximately 11 million acres are estimated to be 200 years or older. The majority of these forests are in congressionally or administratively designated areas designed to protect and preserve their natural values. In addition, all national forests currently protect or limit management actions in old-growth stands through forest specific land management plan components or by specific Secretarial direction. This memorandum indicates leadership intent to continue protection of old-growth stands through those approaches, and to use the actions in this memorandum to inform future policy and decision-making.

h. The appropriate science-based practices that will sustain resilient forests and stabilize forest carbon are place specific. Preferential management techniques might include mechanical thinning; proactive fire use including prescribed fire and cultural burning; management approaches that consider composition, competition and structure in forest stands; promoting the growth of tree seedlings; adopting and continuing soil-friendly practices; or utilizing climate-forward reforestation techniques with the right trees in the right places and at appropriate scales.

i. As we consider actions to conserve these values, USDA will continue to recognize government to government responsibilities with Tribal Nations. We will also ensure that our work is done in accordance with USDA's *Equity Action Plan* and the landmark *Justice40* initiative. We must couple the urgent need for action on climate with the imperative to meaningfully address past inequities and advance equity and environmental justice. Equitable access to the benefits our forests provide is a matter of necessity for communities into the future.

j. As we do this work, we will vigorously pursue partnerships and opportunities for collaboration with nongovernment organizations, philanthropic organizations, academia, businesses, state and local governments and Tribes, and others to advance conservation, forest, range and watershed restoration, and reforestation and resilience projects.

k. This memorandum is intended to build on the Administration, Department and Agency's previous actions on climate change, equity and forest resilience. To that end, and consistent with EO 14008, EO 14072, the Forest Service's *Confronting the Wildfire Crisis* strategy, and other previous direction, this memorandum outlines actions that the Department and USFS will undertake so that data-informed policies, strategies, and actions are in place to provide for increased carbon stewardship and climate resilience across our national forests and grasslands. The policy of this memorandum is intended to be implemented within the context of the USFS's multiple-use mandate.

2. ACTIONS

Pursuant to this memorandum, the Secretary directs the Chief of the Forest Service, in coordination with the Under Secretary for Natural Resources and Environment, to take the following actions:

a. Spatially Identify Risks to Ecosystem Values to Inform Decision Making.

The following actions are intended to ensure that we understand where certain ecosystem values are present on the landscape, the risks to those values, and the current management direction on these respective lands:

(1) Updated Fireshed Risk Map for Ecosystem and Equity Layers.

By November 30, 2022, provide an update of the fireshed risk map included in the *Confronting the Wildfire Crisis Strategy and Implementation Plan* to:

(a) Identify wildfire risks to ecosystem values including watersheds, habitat and ecological connectivity for important wildlife and at-risk species, and carbon storage, using the best available science; and

(b) Incorporate into the fireshed risk map a spatial display of risks to underserved and socially disadvantaged communities, building on the work of other agencies throughout the Federal Government, including other agencies within USDA. Based on feedback from the national, regional and tribal roundtables, identify whether additional layers may be needed, including to identify social and economic values or other assets at risk due to increased wildfire activity, and recommend next steps to include in the Implementation Plan.

(2) Gap Analysis and Decision Support Tool.

By November 30, 2022, based on the best available information, develop a decision support tool that will:

(a) Assess climate change vulnerabilities and risks to key National Forest System resources and associated community values, including but not limited to watersheds, areas important for biodiversity and species at risk, carbon, and mature and old-growth characteristics;

(b) Identify current management direction related to those values, vulnerabilities and risks;

(c) Identify potential gaps in current management where changed or additional direction may be needed to enable more effective adaptation or mitigation actions; and

(d) Assess and prioritize reforestation opportunities.

This tool should be updated annually to incorporate significant new information. Using this tool, provide recommendations to the Secretary on how to address any identified gaps, and how to prioritize and design projects while considering multiple interrelated outcomes.

b. Develop Policy Recommendations for Climate Resilience and Carbon Stewardship on National Forest System Lands.

Based on the best available science about current and future risks including FIA data and the data and analysis derived from the action items in Section 2a and incorporating learning from the actions outlined in Section 2d by November 1, 2023, provide the Secretary with specific policy recommendations for:

(1) Carbon Stewardship.

Develop recommendations to leverage partnerships and private-sector capital in science and policy-based carbon optimization projects on National Forest System lands, including analysis of potential carbon benefits derived from National Forest System lands, utilizing a carbon accounting certification process that builds on existing work throughout the Administration, is consistent with international standards, and is informed by sound science.

(2) Wildlife Habitat and Connectivity.

In collaboration with the Farm Production and Conservation Mission Area, state and tribal wildlife agencies, and other important partners, develop recommendations for increasing and replicating successful cross-jurisdictional partnerships and programs to foster increased biodiversity, enable wildlife migration, and enhance habitat integrity and resilience.

(3) Water and Watershed Restoration and Conservation.

Develop recommendations for building on and replicating successful cross-jurisdictional partnerships and programs for water and watershed conservation, including building on recent Forests to Faucets geospatial data and other cross-boundary initiatives, and implementation of programs like the Watershed Condition Framework and Water Source Protection Program.

(4) Integration with Planning.

Develop recommendations for methods to incorporate new analyses and data and the use of new and innovative tools and technology to ensure climate resilience, and carbon stewardship considerations are integrated into forest and relevant project planning. For land management planning, this should include recommendations for how to support the explicit consideration of carbon stewardship optimization and climate adaptation in defining desired conditions, and how to evaluate whether certain National Forest System lands are appropriate for designation as "not suitable for timber production" pursuant to 16 United Status Code (U.S.C.) 1604(k), *Development of land management plans*, based on those considerations.

(5) Incentivizing Utilization of Restoration Byproducts and Wood Product Innovation.

Develop recommendations to:

(a) Support investment strategies that incentivize new utilization technologies and uses of forest restoration byproducts;

(b) Develop wood product innovations such as cross-laminated timber, wood composites to address affordable housing, nanomaterials, aviation biofuels, and urban wood utilization to enhance carbon sequestration while providing economic opportunities and increasing demand for small-diameter wood that will be generated through hazardous fuels and restoration treatments; and

(c) Identify related opportunities for jobs and economic benefits, including in underserved and socially disadvantaged communities.

(6) Outdoor Access and Recreation.

Develop recommendations for supporting climate-resilient community well-being, jobs and economic opportunity through equitable access to the outdoors and the outdoor recreation economy. Recommendations should reflect wildfire and climate-related risks to recreation infrastructure and assets and opportunities for integrating recreation outcomes into wildfire risk-reduction and restoration projects, where appropriate.

c. Further Policy Recommendation Development Guidance

(1) The recommendations in Section 2b should include guidance on how to use new data, analysis, tools, indigenous traditional ecological knowledge, and technology in multiple use decision-making to ensure that the policy recommendations called for in this section and related considerations are integrated into and informed by:

(a) Implementation of the *Confronting the Wildfire Crisis* strategy, including wildfire risk reduction and reforestation prioritization and project design;

(b) Implementation of the forthcoming USFS *Climate Adaptation Plan*;

(c) Implementation of the BIL;

(d) Implementation of priorities and opportunities in America the Beautiful, the Civilian Climate Corps, and Public Land Corps; and

(e) Other priority actions, including any recommendations for new programs or policies that would advance ecosystem integrity, climate mitigation and

resilience, and stewardship of ecosystem benefits including carbon, water, and wildlife.

(2) Recommendations must reflect the Department's and agency's Equity Action Plans, Justice40, and the *Joint Secretarial Order on Fulfilling the Trust Responsibilities to Indian Tribes in the Stewardship of Federal Lands and Waters* (Order No. 3403) and related direction.

(3) The set of recommendations as a whole should reflect and build on existing Forest Service actions and expertise in these areas and should include an assessment of what is realistically achievable under current and expected budget and staffing scenarios.

d. Carry Out Immediate Actions to Accelerate Climate Resilience and Carbon Stewardship.

While data continues to be gathered and analyzed and programmatic strategies and guidance developed, there are a series of immediate actions needed to secure ecosystem benefits, community values, and ensure equity. As the data gathering and analysis derived from the action items in Section 2a are completed, they should inform the actions outlined below – similarly, information gained through actions in this section should be incorporated into the tools identified in Section 2a. To immediately implement the direction of this memorandum, the Chief of the Forest Service, in coordination with the Under Secretary of Natural Resources and the Environment, will:

(1) BIL Implementation.

Within the confines of Congressional direction in Section 40803(g), *Priorities*, of the BIL, use the direction provided by this memorandum to inform BIL project selection, design, and implementation so that investments reflect the intended outcomes of restoring ecosystem integrity and fostering ecological resilience alongside community resilience and include consideration of multiple ecosystem values for risk reduction and restoration, including carbon, water, biodiversity and old-growth.

(2) Inventorying and Retaining Old-Growth and Mature Forest Characteristics.

(a) By April 22, 2023, implement the direction in EO 14072, in close coordination with Department of the Interior, to define, identify and complete an inventory of old-growth and mature forests on NFS lands, accounting for regional and ecological variations as appropriate; and

(b) Following completion of the inventory, recommend measures, including robust opportunities for public comment, to protect, maintain, restore, and cultivate old-growth and mature stand characteristics within the National Forest System, grounded in science-based principles of carbon stewardship optimization,

considering a range of management strategies, and recognizing complementary opportunities and tradeoffs with other ecosystem values including water, wildlife, and biodiversity and social values such as wildfire risk to communities and source-water watersheds.

(3) Scale up and Optimize Climate-Smart Reforestation.

By April 22, 2023, and in accordance with EO 14072, develop strategic guidance and an implementation plan to:

(a) Immediately increase climate-informed afforestation, agroforestry, and reforestation (planting and natural regeneration) including critical consideration given to climate-informed reforestation in areas such as fire scars that can help avoid carbon loss from forest soils; and

(b) Increase Federal cone and seed collection, and seed and seedling nursery capacity sufficient to meet anticipated demand, including collaboration with additional USDA agencies, and other Federal, state and local government, Tribal and private-sector partners.

(4) Community and Forest Product Sector Sustainability.

By April 22, 2023, and in accordance with EO 14072, develop in coordination with the Secretary of the Interior and the Secretary of Commerce, and with input from State, local, Tribal, and territorial governments, the private sector, nonprofit organizations, labor unions, and the scientific community, recommendations for community-led local and regional economic development opportunities to create and sustain jobs in outdoor recreation, and the sustainable forest product sector, including innovative materials.

(5) Proactive Fire Use.

By December 15, 2022, and in accordance with the *Confronting the Wildfire Crisis* strategy, develop strategic guidance and a plan to invest in capacity to support the safe use of prescribed fire, cultural burning, and where appropriate managed wildfire, to restore desired conditions and increase resilience in fire-adapted ecosystems.

(6) Measures and Accountability.

By December 15, 2022, develop outcome-based performance measures and systems for tracking and reporting progress on fire and climate resilience, climate adaptation, reforestation, ecosystem and watershed restoration, ecosystem services, and carbon stewardship activities, and related investments in community engagement, partnerships, collaboration, and equity.

We need our nation's forests and grasslands to serve as a critical defense in the face of climate change. Restoring, maintaining, and fostering resilient landscapes, and achieving the outcomes I have outlined above, will position our forests and grasslands to continue playing that role while providing benefits and services to the people of this country.

3. INCIDENTAL TRANSFERS

The Assistant Secretary for Administration, the Chief Financial Officer, and the Director, OBPA, are authorized to approve such transfers of funds, personnel, employment authority, space, records, property, and incidentals as may be necessary to implement the provisions of this Memorandum.

4. EFFECTIVE DATE AND TERMINATION

a. This delegation is effective immediately and will remain in effect for 1 year from the effective date or until such earlier time as the Department's published delegations of authority have been revised to incorporate the provisions of this Memorandum.

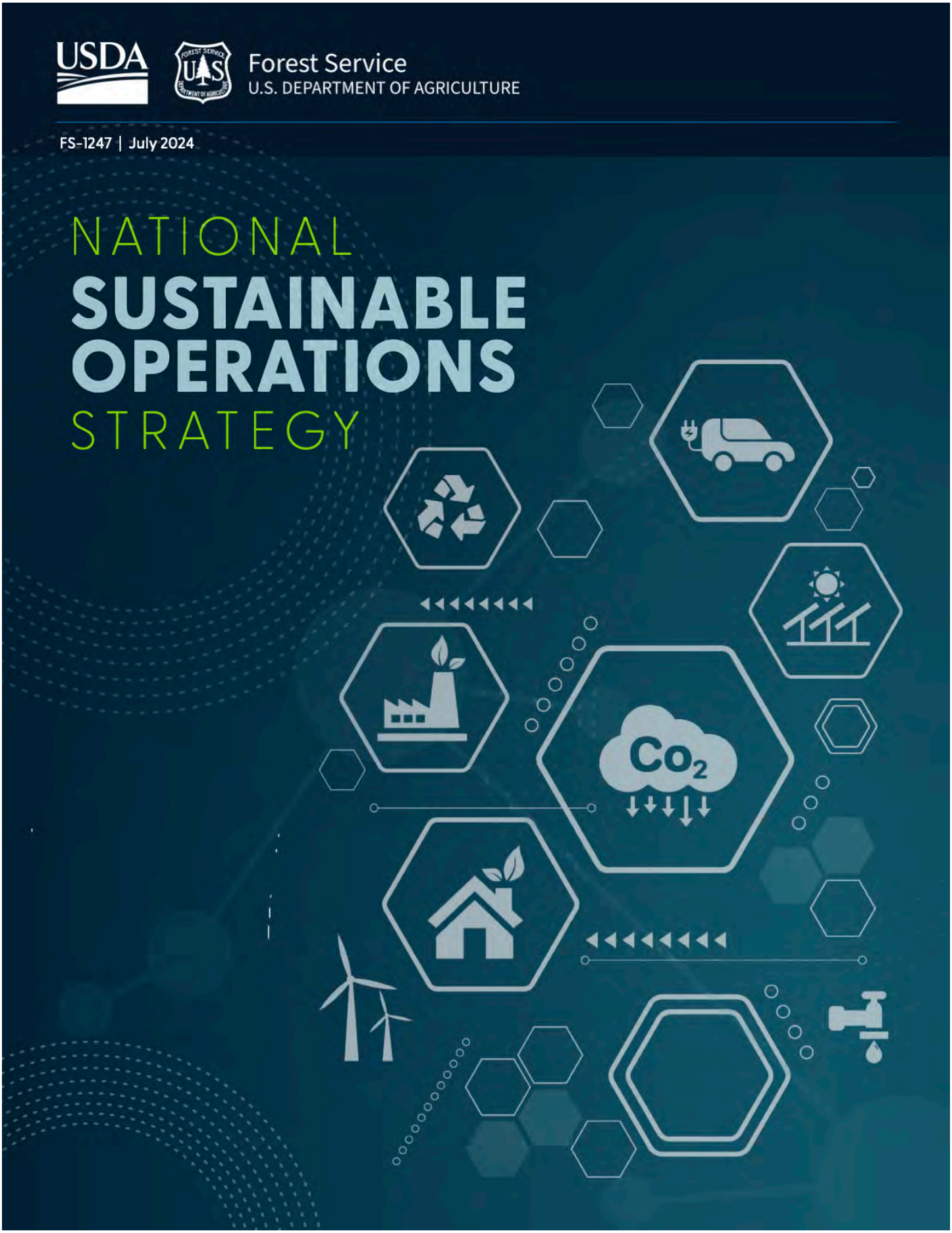
b. This Secretarial memorandum rescinds the Secretarial memorandum dated June 12, 2020 and titled *Secretarial Memorandum to the Chief of the Forest Service [to] Establish vision, priorities, and direction on: Increasing the productivity of National Forests and Grasslands, [etc.]*.

/s/ Thomas J. Vilsack
Secretary of Agriculture

# EXHIBIT S

Archived version as of 11/27/2024

The Wayback Machine - https://web.archive.org/web/20241127181111/https://www.fs.usda.gov/sites/default/f…



# VISION

THE FOREST SERVICE PRIORITIZES SUSTAINABILITY AND REDUCING OUR ENVIRONMENTAL IMPACT IN ALL ASPECTS OF OPERATIONS.

# CONTENTS


SUMMARY 4

BACKGROUND 6

THE BIG WHY 8

THE BIG WHO 10

THE BIG HOW 10

VISION 12

VALUES 12

STRATEGIC GOALS AND OBJECTIVES 13

GOAL 1. REDUCE GREENHOUSE GAS EMISSIONS 14

GOAL 2. REDUCE CONSUMPTION AND SHIFT TO SUSTAINABLE PRODUCTS AND SERVICES 18

GOAL3. EDUCATE AND ENABLE EMPLOYEES 22

REQUIREMENTS FOR SUCCESS 27

TRADEOFFS AND RISKS 28

CONNECTIONS TO OTHER AGENCY STRATEGIES AND PLANS 29

PROCESS 31

EMPLOYEE ENGAGEMENT 30

THE PATH TO IMPLEMENTATION 32

NEXT STEPS 32

CONCLUSION 32

ACKNOWLEDGMENTS 33

**APPENDIX 1** 35

**APPENDIX 2** 36

**ADDITIONAL RESOURCES** 37

# SUMMARY

Sustainability has always been at the heart of the U.S. Department of Agriculture, Forest Service mission "to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations." This sustainability focus is intricately woven into the fabric of all that the agency does, including land management strategies, operational policies, and agency commitments to employees, partners, and the public.

America's forests and grasslands are undoubtedly affected by climate change. Although Forest Service operations may contribute to the climate crisis, the agency created the National Sustainable Operations Strategy to work to reduce those contributions and shrink the agency's overall environmental footprint. How the Forest Service manages operations has environmental, social, and economic impacts that extend to the communities served by the agency. Smaller communities near national forests and grasslands are facing a future of shrinking landfill space, water shortages, and rising energy demands. The Forest Service is experiencing significant utility costs increases, which means that less funding is available for deferred maintenance, programmatic work, and other business needs.

To respond to these challenges, the Forest Service created the National Sustainable Operations Strategy. The goals of this strategy focus on reducing agency emissions, shifting consumption habits and purchases, and ensuring that Forest Service employees are supported throughout the process. This strategy demonstrates the agency's mission-focused commitment to current and future generations with the vision that "the Forest Service prioritizes sustainability and reducing our environmental impact in all aspects of operations."

Enhanced investments in capacity and infrastructure as well as updates to policies and business practices are required to be successful in this challenge. As an organization, the Forest Service is not on track to meet the goals of the Federal Sustainability Plan, but the agency has the opportunity to better reflect the requirements and policies requiring these actions in operations and management. Everyone in this agency has a role to play and can lead and contribute from their positions. This is a strategy for all employees.

Fire lookout tower. USDA Forest Service photo.



| | Goal 1: Reduce Greenhouse Gas Emissions. | Goal 2: Reduce Consumption and Shift to Sustainable Products and Services. | Goal 3: Educate and Enable Employees. |
|---|---|---|---|
| a | Reduce greenhouse gas emissions 65 percent from 2008 baseline by 2030. | Develop and implement a net-zero waste strategy. | Increase capacity for sustainable operations work. |
| b | Increase use of onsite renewable energy systems by 25 percent by 2035. | Increase use of renewables and rechargeables for fleet and operational equipment (where appropriate). | Expand internal collaboration, external partnerships, and communities of practice. |
| c | Increase purchases of carbon pollution-free electricity from the grid to 100 percent by 2035. | Increase use of locally sourced wood and biomass for power, heat, and construction (where appropriate). | Engage employees in best practices and new technology adoption through communication, education, and training. |
| d | Design, renovate, and construct buildings and sites for net-zero emissions and climate resilience. | Increase green acquisitions to 75 percent by 2035. | Recognize employees for leadership in sustainable operations actions. |
| e | Optimize building footprint and enhanced use of telework and remote work (where appropriate). | Reduce consumption of water in facilities and operations. | – |
| f | – | Evaluate new technologies and approaches for feasibility, issues, and benefits. | – |

Bridget-Teton National Forest employees remove turf and install a water-wise native pollinator garden. USDA Forest Service photo.



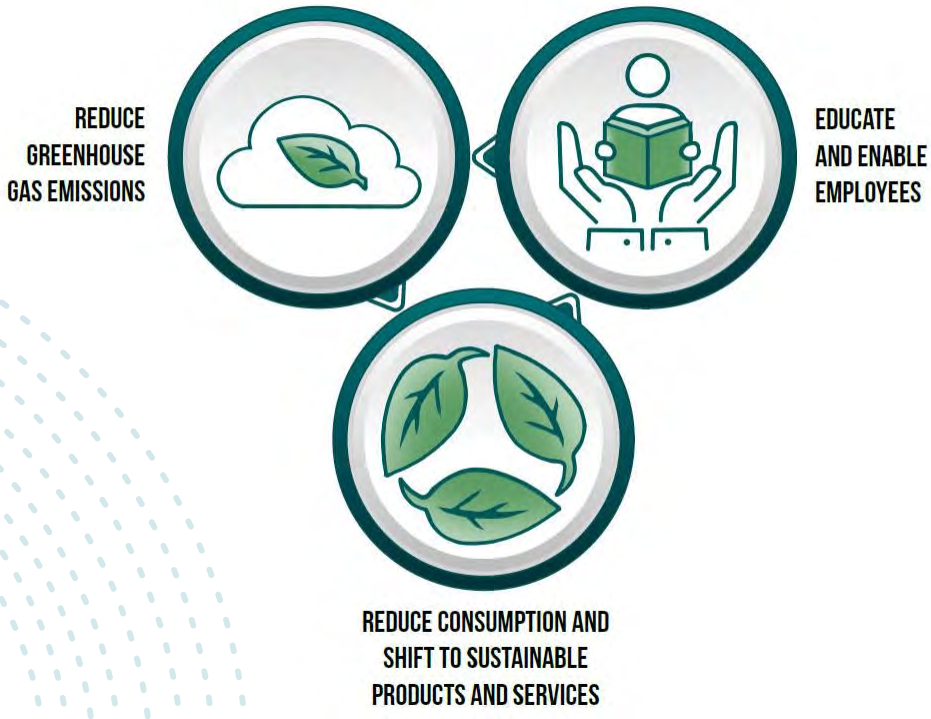
# BACKGROUND

Sustainability is at the heart of the U.S. Department of Agriculture (USDA), Forest Service mission "to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations." This sustainability focus is intricately woven into the fabric of all that the agency does, including land management strategies, operational policies, and agency commitments to employees, partners, and the public.

Sustainable operations is defined in Forest Service Manual 1313.02 as "an institutional business model that minimizes adverse impacts to the environment resulting from agency operations and individual employee actions and facilitates an expanded and integrated systems approach to operations and asset management."

Improving the sustainability of agency operations is one way the Forest Service strives to mitigate its contribution to the climate crisis and to address unintended negative environmental impacts to communities. Advancing the sustainability of the agency's operations is about more than being a good steward of public resources and a good neighbor; it is also about meeting the needs of agency employees. This work is fueled by employee passion and offers an opportunity to improve morale and the work environment. This National Sustainable Operations Strategy, while required by laws and regulations, directly supports and tiers to the Forest Service Strategic Plan and the USDA Strategic Plan. This work complements the work being done through agency land management actions to enhance climate resilience and steward carbon and other ecosystem services on the landscape.

This strategy demonstrates the agency's mission-focused commitment to current and future generations with the vision that "the Forest Service prioritizes sustainability and reducing our environmental impact in all aspects of operations." It is driven by three goals, which are interwoven and supportive of each other: reduce greenhouse gas emissions; reduce consumption and shift to sustainable products and services; and educate and enable employees. Each of these goals includes a set of key objectives. Ultimately, this strategy will be supported by a companion implementation plan.






California Conservation Corps prepares fire hoses, the number one waste stream from fire operations, for recycling. USDA Forest Service photo by Judith Downing.

"Improving the sustainability of our operations is one important way the Forest Service is striving to address climate change . . . Together, our combined actions can make a difference and help the Forest Service get to our net-zero goal by 2050."

CHIEF RANDY MOORE

St. Joe Ranger District of the Idaho Panhandle National Forest. USDA Forest Service photo by Geoff Moore.

# THE BIG WHY

Improving the sustainability of Forest Service operations is required by the agency's mission and supports agency priorities. In addition, sustainability is expected of the agency by employees and the public, is required by various laws and regulations, and is a sound fiscal strategy.



**DRIVER 1**

## ADDRESSES FOREST SERVICE PRIORITIES

The agency has committed to reducing the risk of wildfire while addressing the critical issue of climate change. By identifying and applying green technologies, developing new markets (e.g., using byproducts from restoration treatment to create products like cross-laminated timber for use in green construction and in providing power and heat to facilities), and empowering employees and partners to identify new green solutions, the Forest Service can lead by example. This work complements the agency's efforts to manage its landscapes for climate resilience, carbon stewardship, and the provision of ecosystem services to the public.

**DRIVER 2**

## EXPECTED BY EMPLOYEES AND THE PUBLIC

A 2023 Pew Center survey indicated that two-thirds of adults in the United States support prioritizing the development of renewable energy over fossil fuels. Fifty-six percent of survey respondents said that the Federal Government should be doing more to reduce the effects of global climate change. In addition, public input into the agency's planning processes indicates a strong interest in ensuring that climate change is addressed. Employee engagements and surveys have demonstrated that employees want the agency to pursue more sustainable approaches to doing business; employees feel this is the right thing to do and some have even called it a moral imperative. Employees indicated this work is directly tied to mission success and the agency's ability to address climate change.

**DRIVER 3**

## SUPPORTS FISCAL RESPONSIBILITY

Energy costs are trending upwards at a significant rate, outpacing planned budgets. From fiscal year (FY) 2021 to FY 2023, energy costs from facilities owned by the Forest Service increased by 30 percent, or nearly $8.6 million. This includes utilities such as electricity, heating fuel oil, and propane. Energy and water conservation measures, combined with reduced consumption, can help the agency meet climate and sustainability goals and reduce long-term costs. Increasing investments in on-site renewables also helps buffer against price volatility in the marketplace, while providing the agency with reliable electricity in support of mission-critical functions.

**DRIVER 4**

## REQUIRED BY LAWS AND POLICIES

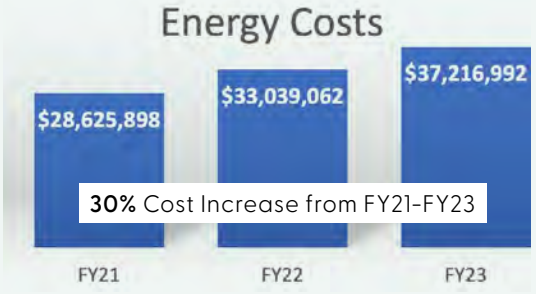
In 2021, President Biden issued Executive Order 14057: Catalyzing Clean Energy Industry and Jobs Through Federal Sustainability, which challenged the Federal Government to lead by example and move to net-zero operations by 2050. The Energy Independence and Security Act, Energy Policy Act, and the Federal Acquisition Regulation are other legal driver examples of Federal sustainability efforts. In addition, a major focus of the Inflation Reduction Act involves stimulating the green economy by provisioning States, municipalities, and industry with funds to match the Federal commitment of achieving net-zero emissions. These comprise only a subset of Federal policies requiring this work. The Forest Service's Climate Adaptation Plan specifically identifies the need to increase agency capacity in operations and infrastructure to address greenhouse gas mitigation and adaptation needs.

**We asked employees "to what extent do you think it's important the Forest Service makes its operations more sustainable?"**

Employees rated it 4.59 out of 5, or extremely important.

**Why Employees Think a Sustainable Operations Strategy Is Important:**

1. To meet public expectations
2. To lead by example
3. To be fiscally responsible




Forest Service Utility Energy Cost Per Year (MetTel)

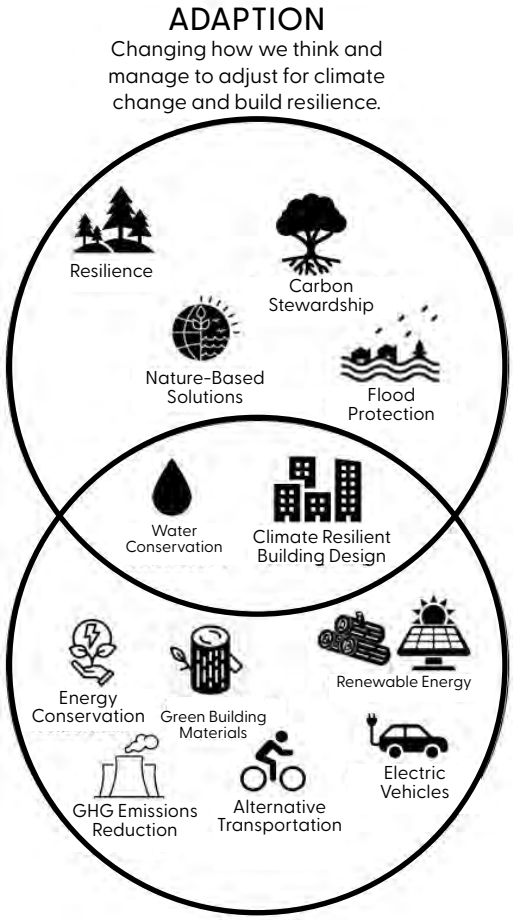


# THE BIG WHO

The Forest Service has fostered and built a broad coalition of engineers, energy managers, fleet and facilities staff, climate change coordinators, sustainable operations champions, and many others, to accomplish this ambitious set of sustainability goals and requirements. Together, in an agencywide approach, the Forest Service is focused on moving toward net-zero emissions and its pledge to become a climate-positive agency. The agency is working to enhance and build partnerships to achieve these goals. While employees from all levels of the agency will help implement this strategy, leadership will provide fundamental direction and support for its success. Washington Office Sustainable Operations staff will monitor agency progress of the strategy.

# THE BIG HOW

The National Sustainable Operations Strategy outlines broad intentions of sustainable operations. Although all of the goals and objectives are feasible and can be accomplished, capacity and investment capabilities will be the primary limiting factors in determining the pace of accomplishment. Because Forest Service employee interest is high and employees are mission-driven and passionate, their collective involvement in the strategy's efforts can further boost morale and lead to lasting improvements in the work environment. The agency's commitment to the efficient use of taxpayers' dollars is demonstrated through investments in energy and water conservation as well as waste reduction strategies, which result in long-term cost savings. A sustainable operations action implementation plan containing specific information on how the agency can deliver results on this strategy will be prepared as a companion document.




Each year the Forest Service encourages participants to use natural, recyclable, or repurposed materials to decorate the U.S. Capitol Christmas Tree. USDA Forest Service photo by Tanya E. Flores.





Bottles and cans saved for recycling on the Taylor Creek and Klondike Fires, Rogue-Siskiyou National Forest, OR, 2018. USDA Forest Service photo by Kari Greer.

# VISION

The Forest Service prioritizes sustainability and reducing our environmental impact in all aspects of operations.

This vision aims to inspire and integrate sustainable operations in every level of the Forest Service in support of the agency's mission. This strategy establishes the holistic approach that is inclusive of ongoing and future operations and places employees at the center, ensuring they are supported and have adequate resources for success.

# VALUES

The agency's core values of service, interdependence, conservation, diversity, and safety guide all aspects of Forest Service work, including sustainable operations efforts. Through employee engagement, the strategy's core team identified a set of additional values that build upon agency core values and reflect the guiding principles for the National Sustainable Operations Strategy, providing a compass for action and the foundation for implementation. The employee-informed strategy guiding values are IINSPIRE: impactful, inspirational, scalable, practical, inclusive, and responsible (see Appendix 1 for more details).

Woodsy Owl, Forest Service staff, and supporters help pick up trash in Accotink Park, VA. USDA Forest Service photo by Cecilio Ricardo.



# STRATEGIC GOALS AND OBJECTIVES

This strategy is built to inspire action and is intended to be practical and achievable. It will require direction, investment, and capacity building. Some of these objectives are existing actions that can be built upon for greater success. Others are new actions, which may involve taking risks and providing the agency with an opportunity to embrace its learning organization philosophy. As the agency continues to evolve to meet the needs of today and plan for tomorrow, considering sustainability in every decision will be essential. The goals and associated objectives are described in detail in the following sections.

# GOAL 1

# REDUCE GREENHOUSE GAS EMISSIONS



In FY 2023, 38 percent of Forest Service operational emissions came from fleet vehicles. Switching more vehicles to electric can help reduce this number. As of FY 2023, only 0.19 percent (35 vehicles) in the Forest Service fleet are electric. USDA Forest Service photo.

The Forest Service intends to reduce greenhouse gas (GHG) emissions, increase renewable and clean energy use, and improve the efficiency of agency infrastructure. This includes decarbonizing the agency's built environment, optimizing its building footprint, and focusing on net-zero emissions and climate resilience as the agency designs, renovates, and constructs new buildings.

Greenhouse gas emissions accelerate global temperature rise and the effects of climate change, leading to impacts such as increased wildfire risk, drought, and flooding. These impacts challenge the agency's ability to sustain the health and productivity of national forests and grasslands. The effects of climate change are being seen and felt across the country and not only affect ecosystem functions, biodiversity, and natural resources, but also pose a risk to human life and are financially costly. In addition, climate change disproportionately impacts underserved communities, making mitigation through reduced emissions critical to agency values of inclusivity and environmental justice.

Reducing emissions and decarbonizing agency operations is necessary for long-term sustainability as well as for slowing the rate of global warming and other associated climate change impacts facing future generations. This strategy seeks to reduce environmental impacts in all aspects of the agency's operations. This includes emissions related to electricity consumption, daily commutes, business travel, and buildings and sites. The agency's goal of limiting emissions also highlights its values of being a role model and acting responsibly, showcasing the commitment to leading the charge in reducing agency contributions to climate change.

Executive Order 14057 sets goals for the Federal Government to achieve net-zero operations by 2050. This includes a 100 percent carbon pollution-free electricity target by 2035 and a 65 percent reduction in GHG emissions from 2008 baseline values. This goal also aligns with the USDA Strategic Plan, with objectives including "Reduce Greenhouse Gas Emissions," "Promote Building Resilience to Climate Change," "Expand Renewable Energy," and utilization of "The Guiding Principles for Sustainable Federal Buildings."

Practical challenges do exist for implementation of this goal, including:

- Secure the upfront investments needed to retrofit buildings with energy and water conservation measures and to install additional renewable energy systems.
- Add capacity, either permanently or as a strike team of engineers and facilities leads, to conduct required audits and oversee necessary contracts.
- Shift agency culture away from reliance on fossil fuels.

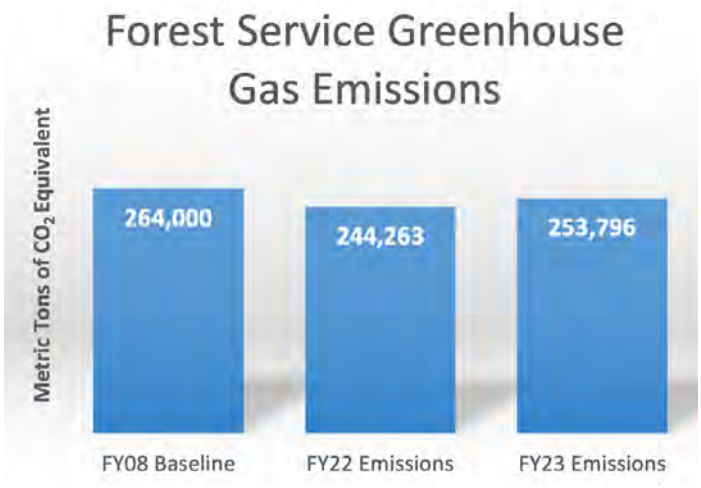
With global support to limit global warming, the decreasing costs of renewable energies, and technology advancements, it is becoming increasingly feasible and economical to limit agency emissions and decarbonize. More utility vendors are offering carbon pollution-free electricity through affordable green tariffs. Because motivation for this work is high, the agency's goal to reduce GHG emissions is becoming more and more achievable.

**OBJECTIVE 1**

## REDUCE GREENHOUSE GAS EMISSIONS 65 PERCENT FROM 2008 BASELINE BY 2030

The agency's target of a 65 percent reduction in GHG emissions aligns directly with Federal requirements. This provides a clear and measurable amount by which the agency will reduce its emissions and enables the agency to track progress and incentivize implementation to meet this goal. As of fiscal year (FY) 2023, the Forest Service has only reduced emissions by 3.9 percent from the 2008 baseline. If the agency is to meet the target 65 percent reduction by 2030, it will need to focus efforts and be proactive in actions to reduce emissions.

Decarbonizing agency operations and moving toward net-zero emissions will come with challenges, since the agency has long been reliant on fossil fuel sources to power buildings and drive fleet vehicles. However, as climate change impacts intensify, leadership support and technological advancements aid transition efforts. Accomplishing this goal will help the Nation limit global warming and mitigate catastrophic impacts from climate change. As stated in the Fifth National Climate Change Assessment, "with each additional increment of warming, the consequences of climate change increase. The faster and further the world cuts greenhouse gas emissions, the more future warming will be avoided." Investment and technical support will be necessary to begin the significant work of reducing future emissions.




Forest Service operational (e.g., facilities, infrastructure, fleet, aviation) greenhouse gas emissions as reported in the Annual Energy Data Management Report.

**OBJECTIVE 2**

## INCREASE USE OF ONSITE RENEWABLE ENERGY SYSTEMS BY 25 PERCENT BY 2035

Renewable sources of energy will be critical to meet the goal of reducing GHG emissions from agency operations. By transitioning from fossil fuel energy sources to renewable sources such as wind, solar, and bioenergy, the agency can reduce the amount of carbon being released into the atmosphere and improve air quality. By working to increase renewable energy throughout the agency, this objective also ties to the USDA Strategic Plan Goal 1.

Renewable energy sources are becoming an increasingly available and cost-effective option. Zero and low carbon energy technology costs are decreasing, and solar costs have declined in the last decade. Switching to renewable sources of energy offers energy security by ensuring a reliable source of energy will be available for future generations while allowing the agency to maintain mission-critical operations when the grid is disabled. However, equipping mission-critical facilities with solar power will require significant investment. The Forest Service currently generates about 5 percent of its total electricity from renewable energy systems. With Energy Savings Performance Contracts, more solar photovoltaics are being installed, but not at a rate that will allow us to meet this objective. Instead, some Forest Service sites continue to maintain biomass heating units while others explore wind power. All efforts help reduce the agency's reliance on fossil fuels and support this objective.



Off-grid solar photovoltaic system with battery backup at the Frenchman Work Center on the Plumas National Forest, CA. USDA Forest Service photo.

**OBJECTIVE 3**

## INCREASE PURCHASES OF CARBON POLLUTION-FREE ELECTRICITY FROM THE GRID TO 100 PERCENT BY 2035

The Forest Service will expand carbon pollution-free electricity (CFE) purchases by creating and leveraging partnerships with utilities, other Federal agencies, and the private sector. Executive Order 14057 defines CFE as electrical energy that is produced from resources that generate no carbon emissions, including marine energy, solar, wind, hydrokinetic (including tidal, wave, current, and thermal), geothermal, hydroelectric, nuclear, renewably sourced hydrogen, and electrical energy generation from fossil resources to the extent there is active capture and storage of carbon dioxide emissions meeting requirements set by the Environmental Protection Agency (EPA). With nearly 7,000 electricity accounts from more than 450 different electricity providers, the Forest Service is poised to influence the market with demand signals for additional green energy. In FY 2022, the Forest Service was able to procure approximately 45 percent of total grid-supplied electricity as carbon pollution-free. A new interagency agreement with Entergy Arkansas was signed in 2023, committing the Forest Service to procuring 100 percent CFE from their offerings. Similar negotiations are underway with other utility providers.

Powering agency buildings with CFE instead of traditional fossil fuel electricity reduces GHG emissions and related air pollution. Challenges to this transition include the growing electrical load demands at many facilities and the associated cost. Procuring CFE comes at an additional cost initially, usually as a green tariff, and therefore the agency will need to plan for higher electricity rates to meet this target. As market demand increases and renewable resource technology continues to improve, prices will likely decrease and eventually drop below the current price of fossil fuels. Another challenge may come from the need to create individual contracts or agreements with utility providers, creating an additional strain on business operations staff.

**OBJECTIVE 4**

## DESIGN, RENOVATE, AND CONSTRUCT BUILDINGS AND SITES FOR NET-ZERO EMISSIONS AND CLIMATE RESILIENCE

Sustainable site and building designs will help the Forest Service reduce the adverse effects of climate change and reduce long-term costs while providing healthy and pleasant workspaces for employees. The Forest Service Climate Adaptation Plan identifies the need for consideration of climate vulnerability to in building siting and design. The Council on Environmental Quality requires the use of the Guiding Principles for Sustainable Federal Buildings. In addition, the Forest Service has internal guidance to support enhanced sustainability of designs, including certification standards for new buildings set out in Chapter 70 of the Forest Service Handbook as well as guidelines such as the Sustainable Site Design Guide. Commitment to incorporating design, construction, maintenance, and operation of facilities in an environmentally responsible manner will minimize the environmental impacts of buildings in the agency's portfolio.

Challenges exist in transitioning to net-zero buildings and sites, such as costs, design complexity, construction experience, and material availability. Through the National Asset Management Program, the Forest Service can evaluate proposals based on climate and sustainability criteria. Energy savings performance contracts and direct investment are pathways to complete deep energy retrofits as well as energy and water conservation upgrades for existing facilities. Asset prioritization ensures that investments are targeted at buildings and sites the agency plans to continue to own and maintain. Efforts are underway to benchmark all buildings owned by the Forest Service to understand their energy performance, which will provide another data point for investment decision making. New construction and new leases are bound by sustainability requirements and clauses to move all Federal facilities toward net-zero emissions.

**OBJECTIVE 5**

## OPTIMIZE FOREST SERVICE BUILDING FOOTPRINT AND ENHANCED USE OF TELEWORK AND REMOTE WORK (WHERE APPROPRIATE)

Forest Service employees work in many buildings across the country, including offices owned by the Forest Service, leased space, co-locations with partners, and virtual or remote locations. The environmental footprint of work locations is driven by water and energy use, waste creation, and emissions from commuting. In the United States, buildings contribute to just under one-third of total emissions. According to the FY 2022 Annual Energy Data Management Report, Forest Service buildings contribute to 49 percent of operational business operations.

This objective is aligned with the goal of "a net-zero emissions building portfolio by 2045, including a 50 percent emissions reduction by 2032" in Executive Order 14057. Buildings are often maintained, heated, and cooled the same for 1 employee as they would be for 100 employees. Optimizing the agency's building footprint will not only save money but will also result in lower resource consumption and emissions. Examples include reducing the agency's overall footprint by decommissioning old buildings, letting go of expensive underutilized leases and moving employees in those areas to remote work or enhanced telework, consolidating locations or moving into different facilities, and co-locating with partners or other agencies. This objective can include practices such as hoteling, in which employees who do not go into the office every day coordinate their use of office and desk space. Expanding telework and remote options where appropriate is aligned with the USDA Strategic Plan, which states that "we will build on best practices for a hybrid work environment and continue to reevaluate the future of work at USDA."

Challenges associated with this objective include the complexity of relinquishing buildings from a political or historical standpoint, terminating existing leases before their life cycle ends, and potential management and performance concerns around telework and remote work employees. Addressing the agency's building portfolio and identifying ways to reduce footprints and consumption will be critical to meeting the goal of emissions reduction.

In 2022, the Nez Perce-Clearwater National Forest Supervisor's Office was constructed to minimize the office environmental footprint. New construction of this building utilized mass timber building technology including cross-laminated timber. The centralization of employee offices is estimated to produce an annual $1.8 million dollars in savings. USDA Forest Service photo.

A 2023 study found that remote workers can create a 54 percent lower carbon footprint. The study also found that greenhouse gas savings from telework and remote work begin to accrue with just 2 or more days per week working at home.



# GOAL 2

# REDUCE CONSUMPTION AND SHIFT TO SUSTAINABLE PRODUCTS AND SERVICES



A Job Corps camp crew receives training on solar light tower operations. USDA Forest Service photo by Kelly Jaramillo.

By shifting toward greener purchases that originate from more local and renewable sources, the agency creates less waste. Excess waste and outdated technologies lead to economic inefficiencies and contribute to greenhouse gas (GHG) emissions, the impacts of which are often unevenly distributed. The Forest Service intends to demonstrate responsibility by ensuring its strategies for technological innovation and waste reduction are thoughtfully produced. Shifting to sustainable alternatives, where possible, will also bring long-term financial benefits to the agency. Elements from this goal can be applied as the agency implements the Wildfire Crisis Strategy, the Climate Adaptation Plan, the Great American Outdoors Act, Reimagine Recreation, the Equity Action Plan, and more.

The agency will need to consider developing new policies, guidance, and criteria to be successful in reducing consumables and shifting to green purchases. These are time-consuming processes; some policy revisions may take years. This presents a challenge for the agency, which needs action and guidance now. These actions influence general procurement, space acquisition, leasing, construction, renovation projects, and more. Because the Forest Service is the largest purchaser of goods and services in USDA, this would be a significant and incredibly impactful action for the agency.

Incredible progress is being made in the green technology industry through advancements in battery capacity and investments in infrastructure. Conditions are conducive to a large-scale shift to sustainable alternatives. This achievable goal will generate a significant reduction in the agency's overall environmental footprint while making positive contributions toward the Justice40 initiative, invigorating the green economy, and supporting small businesses.




The Greening Fire Program implements sustainable operations best practices on fire incidents, such as offering reusable water bottle water filling stations. USDA Forest Service photo.

## OBJECTIVE 1

### DEVELOP AND IMPLEMENT A NET-ZERO WASTE STRATEGY

Reducing, reusing, and recovering waste streams is critical in transitioning to an agency with a net-zero waste strategy. With more than 30,000 employees and thousands of physical offices, visitor centers, and recreation sites across the country, the Forest Service generates tremendous amounts of waste. Waste transport and processes used to decompose waste release a significant amount of GHGs. As community landfills fill up across the United States, waste disposal has become an important environmental justice issue.

The Forest Service's net-zero waste strategy demonstrates a commitment to sustainability by moving toward concepts such as circularity; in the circular economy model, goods are designed to be less resource intensive, kept in circulation longer, and repurposed after their first use. This objective seeks to significantly decrease the procurement and consumption of single-use plastics, to increase the use of rechargeables, and to increase recycling and composting efforts. Combined, these efforts will help reduce the amount of the agency's waste that is sent to landfill. This effort also addresses the goals set through Executive Order 14057 Section 207: Reducing Waste and Pollution.

The agency's transition to net-zero waste requires thinking about not only what it buys and uses, but also how it disposes of existing materials. Some challenges exist in this transition. The use of salvaged and recycled materials in building renovation and construction can be time-intensive and costly but can preserve heritage values and save money in the long run. Electronics can be expensive to repair; often, it is more cost-effective to replace them, which creates e-waste, such as batteries, that generally requires special disposal strategies and additional costs. Recycling is not always available in rural or remote locations. In addition to helping build support for recycling services in rural communities, the Forest Service can reduce what goes to landfill by considering the life cycle of procured goods. Composting and recycling, especially on fire incidents, provides the agency with a controlled situation to minimize impacts on local community landfills and the environment. Agency success hinges on a balance between feasibility, cost, and efforts with the greatest impact.

## OBJECTIVE 2

### INCREASE USE OF RENEWABLES AND RECHARGEABLES FOR FLEET AND OPERATIONAL EQUIPMENT (WHERE APPROPRIATE)

The United States is in the process of investing in electric vehicles and associated infrastructure. The Inflation Reduction Act and the Bipartisan Infrastructure Law provided significant funding to advance electrification efforts. Executive Order 14057 requires the Federal Government to transition all fleet acquisitions to zero-emission vehicles by 2035.

Some challenges remain despite significant national momentum behind this objective. Supply chain delays affect the agency's ability to purchase electric vehicles and supporting equipment. Additional studies are needed to inform the performance of zero-emission vehicles for range, payload, conditions during use (e.g., cold, heat), and use type (e.g., fire, long-range field studies). The electric vehicle (EV) charging network in rural and remote



Rechargeable radios reduce e-waste from batteries; these radios can be charged using solar power or electricity. USDA Forest Service photo.

areas does not yet exist, limiting adoption. The agency is already working to address this by deploying telematics—technology that helps track vehicle performance and behaviors—to understand fleet use and determine which vehicles are best suited for transition to electric. Internal teams are also scoping best practices, policies, and guidance needed for optimal placement of electric vehicle charging stations at Forest Service sites. The agency is working with partners, utilities, industry, and other agencies to share resources and develop strategies.

In addition, the Forest Service is actively evaluating what equipment can be transitioned to rechargeable electric and conducting pilots and studies to ensure this equipment meets mission needs and safety requirements. This includes electric bicycles, chainsaws, blowers, mowers, tractors, and rechargeable batteries for radios and other equipment. Life cycle disposal concerns and proper recycling processes exist for all electric equipment. As the marketplace evolves and innovation, new technology, and research on these issues progress, there are ways to overcome the associated challenges. Ultimately, the Forest Service will establish sustainability best practices and help educate employees on the viability of zero-emission tools and equipment to conduct safe, effective work that meets this objective.

## OBJECTIVE 3

### INCREASE USE OF LOCALLY SOURCED WOOD AND BIOMASS FOR POWER, HEAT, AND CONSTRUCTION (WHERE AVAILABLE)

Utilizing locally produced wood and woody biomass contributes to economic sustainability for local communities and provides renewable products to the market. Valuable supply chains for forest restoration treatment material are provided by leveraging new wood innovation technologies, such as mass timber, biochar, and wood heat and power applications. This is an area of rapid technological development, innovation, and collaboration. Wood provides a renewable, biogenic alternative to fossil fuel and mineral-based products. In addition, biodiesel and cellulosic ethanol can provide alternatives for power for equipment that cannot be electrified. The Forest Service can demonstrate by example and showcase the use of local, innovative wood products




Images of biomass feedstocks used and briquette products; (a) forest residues, (b) sawdust residue from sawmill, (c) wood chips from forest residues used in briquette production, and (d) briquetted biomass. USDA Forest Service photos.

technologies in building and site construction and renovation projects. This objective contributes to the health and condition of the Nation's forests, supporting the Wildfire Crisis Strategy and the goals of the Inflation Reduction Act, Bipartisan Infrastructure Law, and USDA Secretarial Memo 1077-004. This objective helps the agency create jobs in rural and underserved communities while facilitating adoption of new wood biomass technologies that reduce dependence on fossil fuels.

Challenges exist around biomass energy, as current Federal definitions do not include wood biomass as a qualified source of carbon pollution-free electricity. Public policy dialogues are exploring life cycle emissions of wood biomass energy, particulate matter emissions, and the need for designating sustainable supply chains.

## OBJECTIVE 4

### INCREASE GREEN PURCHASES TO 75 PERCENT BY 2035

By obtaining more environmentally friendly and energy-efficient products and services (e.g., equipment, lighting, solar photovoltaic systems, pest control, and custodial services), the Forest Service can reduce costs, support small businesses, and reduce negative impacts on the environment and communities. Within USDA, the Forest Service is the largest purchaser of goods and services and has the highest volume of contracts. In FY 2023, the Forest Service spent over $3 billion in contracts; of those contracts, more than $1 billion, or 32 percent of total contracts, were considered green or sustainable. The Greening Fire Program is piloting new approaches, contract language, and best practices to promote green purchases for fire incidents.



The National Technology and Development Center tested seven different electric chainsaws to evaluate cutting performance, battery performance, noise, safety, cost, maintenance, user experience and other considerations. This is one example of how the agency can test and pilot new technology before deploying. Learn more in this National Technology and Development Program report. USDA Forest Service photo.

Contracting and purchasing staff engagement, empowerment, and education are critical to success. Challenges exist around general knowledge of where to procure greener products, how to properly enter data into the acquisition database, and how to write sustainability clauses into contracts. Although various statutes and the Federal Acquisition Regulation require greener purchasing, not all staff understand how to research and acquire the most environmentally friendly products or to designate those purchases in reporting. Market research education, such as how to use the USDA BioPreferred® Catalogue or the U.S. General Services

Administration (GSA) Sustainable Facilities Tool (SFTool), can increase adoption. Training is also needed on methods of incorporating sustainable evaluation factors in solicitations and sustainable clauses in contracts. The Forest Service is currently "green" or performing to standard within the USDA Sustainability Scorecard but will need to sustain and improve focus in this area to maintain that rating. The agency's standard operations, coupled with wildfire incident operations, provide a unique opportunity to utilize purchasing power and influence to help the broader Federal acquisition community become greener. Additionally, there are supply chain and logistical challenges for biomass market development for which the Forest Service can continue to support and develop solutions.

Active research, policy evaluations, and technological advances for emissions control help to address these concerns. For wood construction, sustainable supply chains and building codes are existing challenges but are being addressed with the growth of this sector. Wood biomass energy solutions that include technology to reduce particulate emissions are being piloted, which helps to advance the potential for large-scale wood-to-energy solutions. Thermal heating with wood is a time-tested solution and offers a local outlet for slash and other non-merchantable materials. Life cycle analysis, codes within standards organizations, and technology are all advancing in this area, providing a path to more confidence in green purchases.

**Federal Green Procurement Preference Programs include environmentally preferable (WaterSense®, Safer Choice®, SmartWay, EPEAT®), Energy Star®, BioPreferred®, non-ozone depleting, alternative fuels, and recovered material programs.**

## OBJECTIVE 5

### REDUCE CONSUMPTION OF WATER IN FACILITIES AND OPERATIONS

Forest Service lands provide the largest source of municipal water supply in the Nation. More than 180 million people rely on national forests for their drinking water. Water from forest lands also provides, maintains, and supports other ecological and societal services including the following: biological diversity; threatened and endangered species habitat; spawning and rearing habitat for sport and commercial fish species; and agricultural irrigation, navigation, and flood control. Because higher temperatures can result in a diminished water supply and overall stress on water infrastructure, climate change is a major threat to the water supply. As required by Executive Order 14057 and through the USDA Sustainability Strategy, this objective sets a benchmark for reduced water consumption by 2030. Increased water efficiency through the agency's facilities and operations is an important step toward conserving the Nation's finite freshwater supply and modeling the conservation ethic that drives Forest Service work.

By increasing water efficiency, reducing use habits, reusing potable water, and harvesting rainwater, the Forest Service can reduce water consumption agencywide. However, the installation and upgrades required to retrofit existing water infrastructure can involve significant upfront cost and investment. Success stories and lessons learned from units across the agency will be imperative to allocate resources strategically to meet this objective.

## OBJECTIVE 6

### EVALUATE NEW TECHNOLOGIES AND APPROACHES FOR FEASIBILITY, ISSUES, AND BENEFITS

Renewable and clean energy as well as green product solutions are fast-growing sectors across the globe. While these solutions are promising, all new technologies must be evaluated through a risk management and feasibility lens in addition to an assessment of possible tradeoffs within timeframes of varying lengths. Pilot projects are one way to identify the potential of a green solution for broader adoption.

The development of green technologies and innovations moves quickly but requires adequate vetting before agency adoption. Staff agencywide can play a role in market research and pilot testing to ensure products and approaches are assessed before large-scale deployment. The Greening Fire Program is piloting many new technologies and approaches within incidents to determine if it is a best practice that can be applied more broadly agencywide. Microgrant programs also enable testing of green products, services, and approaches at low risk. The agency can develop mechanisms to solicit field-level input and experiences (as is done in the Sustainability Stories Portal) to share knowledge, issues, and benefits of new approaches. Contracting and procurement staff should be included in the evaluation of findings so that this information can be incorporated into sustainable acquisition solutions. Research and Development and the National Technology Development Program, for example, are internal organizational partners that can help develop and test technologies.



In 2022, the Forest Service began a zero-emission vehicle pilot program in Region 9, adding Ford F-150 Lightning trucks across three national forests in Region 9: Allegheny National Forest, Huron-Manistee National Forest, and White Mountain National Forest. The program is conducting initial requirements and performance testing. Before rolling out these vehicles more broadly, it is important to understand cold weather and range performance in rugged and remote environments. The F-150s in this testing are standard issue and can travel 230 miles per charge. USDA Forest Service photo.

# GOAL 3

# EDUCATE AND ENABLE EMPLOYEES

Greening Fire and Sustainable Operations team members meet with members of the National Renewable Energy Lab to gain understanding of new technologies and approaches for improving sustainable operations. USDA Forest Service photo.



Each of the approximately 34,000 Forest Service employees has a chance to contribute to the success of this strategy, which provides a unique opportunity for employees to lead from where they are, connect across geographic and positional boundaries, and improve workplace morale and the work environment. Educating and enabling agency employees will help ensure this strategy is guided by the agency's core values. Change needs to happen at all levels, from small, individual actions to big decisions that can be implemented collectively. This also ties into the agency mission: employees are at the core of caring for the land and serving the people. Employee support is essential in implementing best practices and new technologies of sustainable operations in day-to-day activities and larger projects.

Enabling and educating employees directly connects to Executive Order 14057 (Section 401, which calls out engaging, educating, and training the Federal workforce, and Section 403, which urges building external partnerships) and the Federal Sustainability Plan's goal of developing a "climate- and sustainability-focused workforce." The Forest Service Climate Action Tracker asks questions on sustainable operations, requiring that employees be familiar with this work. Education focuses on building knowledge of what sustainable operations work is, why it is important, and what steps each employee can take. Education also provides information on new technologies and approaches.

The greatest challenge facing this goal is the funding and capacity needed for employees to be able to implement and act on this strategy. Long-term investments are necessary. Employees may be resistant to change or to adopting new sustainable technologies and methods due to concerns about cost and feasibility. Through explicit statements of support, additional funding and capacity, and good training and communication strategies, these challenges are likely surmountable.

## OBJECTIVE 1

### INCREASE SUSTAINABLE OPERATIONS CAPACITY IN THE FIELD

Developing a robust sustainable operations program requires dedicated expertise and a skilled workforce. A large portion of this work requires a background in engineering, energy management, facilities management, or a similar field. These positions are in high demand across the organization. Building field capacity for this work can enable locally driven, informed decision making and helps support broader climate and sustainability work.

Historically, there has been little to no capacity for sustainable operations work in the agency. Hiring more staff may be challenging given budget constraints. Recently, sustainable operations positions in the agency were located in each region but many of those positions have been vacant for years. This presents an opportunity to place sustainable operations specialists directly in the field and enhance capacity at the field level where it is needed. Hiring one fully dedicated position per region or station is the minimum recommendation of the strategy team for this objective, but more staff will likely be required to fully implement and maintain this strategy in the long term. Sustainable operations work is largely field-based work and generally requires knowledge of local sites and buildings. Current and future sustainable operations work can be accomplished if these challenges are overcome, and increasing capacity in this field can also reduce burdens on staff focused on other priorities. Creating new positions provides an opportunity for those interested in this work to make an impact.

## OBJECTIVE 2

### EXPAND INTERNAL COLLABORATION, EXTERNAL PARTNERSHIPS, AND COMMUNITIES OF PRACTICE

The Forest Service is a learning organization. Much of the agency's work is accomplished through valued partnerships, which provide a continuous learning and feedback loop. Sustainable operations work also benefits from the exchange of knowledge and shared benefits. Fostering stronger connections within and beyond the agency will increase capacity for sustainable operations work and the potential for other collaborative projects. Expanding internal collaboration and creating communities of practice encourages employees to exchange ideas and strategies about how to implement sustainable operations, which increases efficiency and innovation. External partnerships can help the agency accomplish goals without placing added strain on staff with existing portfolios. New and innovative public-private partnerships are needed to fully deploy this strategy. Exciting challenges await the agency in adjusting and creating new policies and processes to support this collaborative work.




The Region 5 Office partners with the Vallejo People's Garden to divert approximately 2,000 gallons of food waste per year by providing compost bins in all office kitchens and donating this material. USDA Forest Service photo.

## OBJECTIVE 3

### ENGAGE EMPLOYEES IN SUSTAINABILITY BEST PRACTICES AND NEW TECHNOLOGY ADOPTION THROUGH ONGOING COMMUNICATION, EDUCATION, AND TRAINING

There is space for every employee in the implementation of this strategy. Individual day-to-day actions can have a significant impact. By strategically sharing information, best practices, and vetted technology options, the agency can meet its sustainable operations goals. To be successful in this endeavor, the agency must equip employees with the training and information needed to make a difference and empower them to act. Communication of best practices and technology must be simple and clear to encourage widespread implementation.

Challenges may include a lack of time and staff to prepare for and provide the communication materials, activities, education, and trainings. In addition, staff are already overloaded with required training and a heavy workload. Employees in the engagement process suggested that funding and time are needed for learning and development in this area. Strategic communication about sustainable operations is imperative. The agency also needs to use existing employee forums, such as Inside the Forest Service and AgLearn, to make this information easy to access and distribute. Engaging employees regularly and providing feedback forums will help the agency ensure employee input is included while working to create a sustainability-informed workforce.



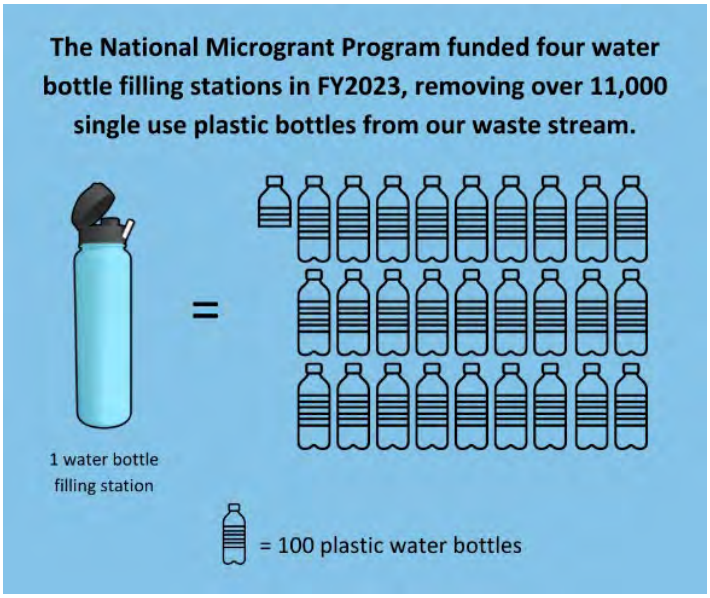
Greening Fire team ambassadors have found creative ways to recycle and reuse scrap fire hose. One example is a partnership with Hose to Habitat, a non-profit that uses scrap firehose to provide enrichment for endangered animals in captivity. USDA Forest Service photo.

## OBJECTIVE 4

### RECOGNIZE EMPLOYEES FOR LEADERSHIP IN SUSTAINABLE OPERATIONS ACTIONS

Employees already engage in many daily sustainable operations actions. Recognizing Forest Service employees for these contributions reinforces the value and importance of sustainability actions and encourages those recognized to continue doing good work. Recognition can also motivate others to follow the lead of those recognized. In economics, nudge theory suggests people can be nudged to change behavior and one powerful tool is comparison. Employees want to know if they are performing the same, better, or worse than their colleagues. They can nudge each other toward increased implementation and action of sustainable operations by recognizing proactive employees.

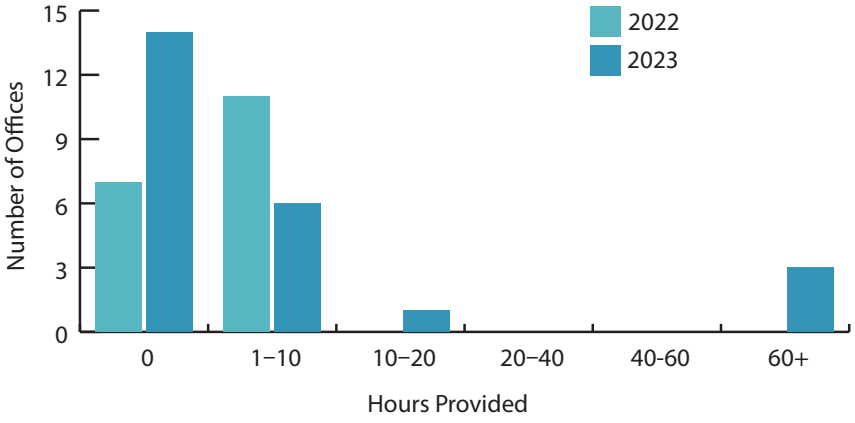
Employees and supervisors at every level must be familiar with sustainable operations in order to recognize meaningful work in this field. With the wide range of actions that can be considered sustainable operations, not every action may be outwardly recognizable as such. The agency has a unique opportunity to develop ways to recognize employees, such as through feature stories, callouts in Inside the Forest Service, or perhaps a new national awards category. These issues can be resolved during implementation. Recognition is critical to encourage sustainable operations efforts in others and promote awareness of different types of sustainable operations actions, from small changes in individual behavior to larger projects and sustainability initiatives.



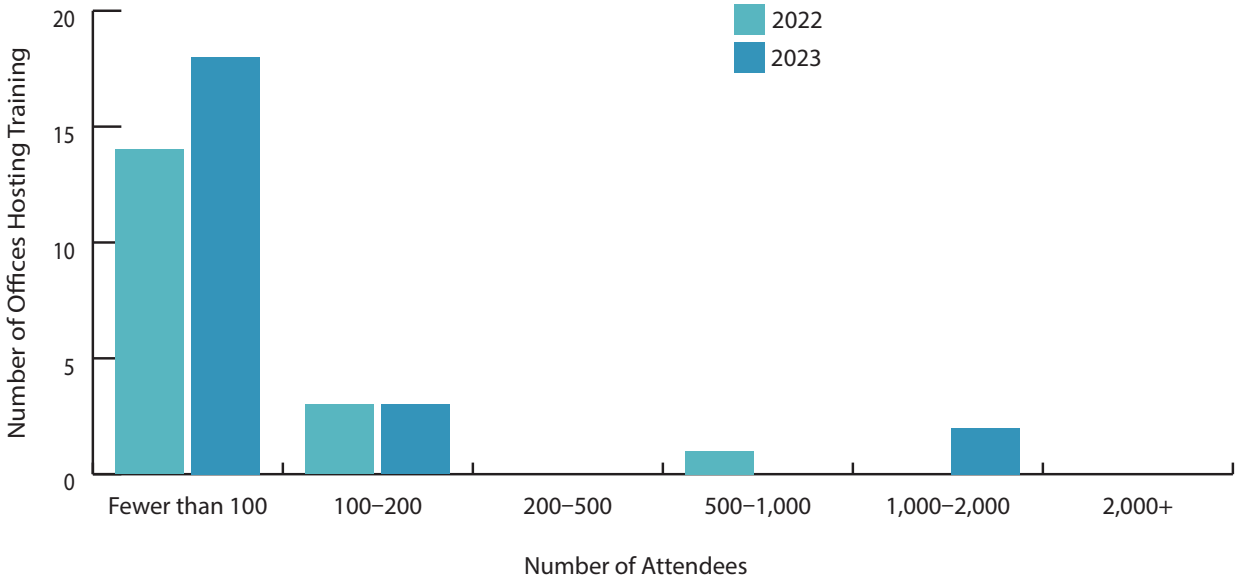
## SUSTAINABLE OPERATIONS TRAINING

**FISCAL YEAR 2022 FOREST SERVICE CLIMATE ACTION TRACKER DATA ON SUSTAINABLE OPERATIONS TRAINING.**

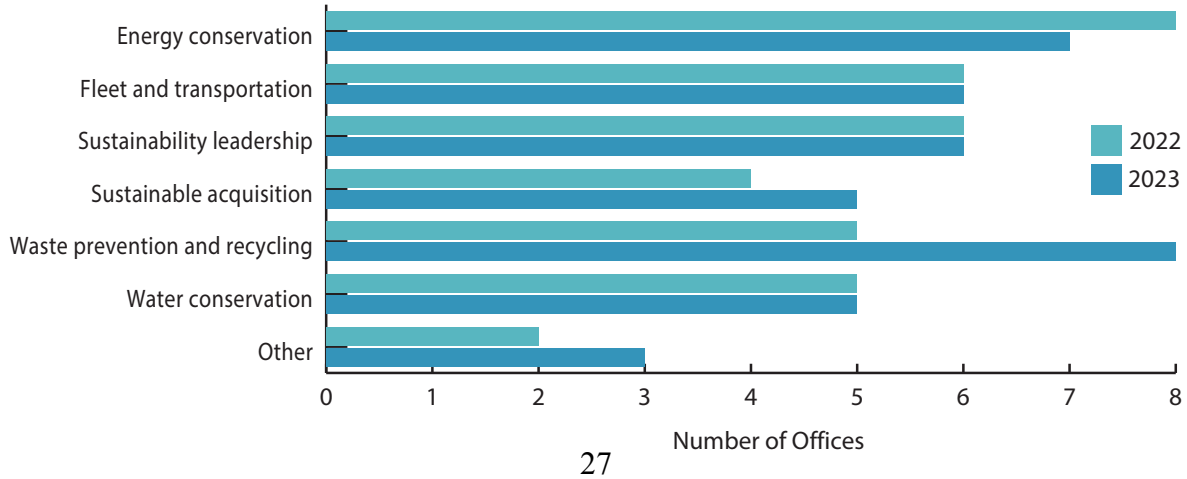
**Total hours of sustainable operations training provided by national, regional, and station offices.**




**Number people who attended trainings focused on sustainable operations by national, regional, and station offices.**




**Number of national and regional offices and stations that addressed each footprint area in their sustainability-focused trainings.**



# Everyday Sustainable Operations

A vigorous sustainable operations program is one way the Forest Service is reducing our contributions to the climate crisis and investing in a healthy financial future. Green teams and sustainability-minded employees across the Forest Service have been engaged in sustainable operations initiatives for decades; now we are building a broad strategy to build this work. Here are some of **the things we do** and **how you can help**.



# REQUIREMENTS FOR SUCCESS

Through the engagement and sensing process, employees identified essential components of a successful strategy. The goals and objectives of this strategy need to be practical, tangible, and realistic. Actions must be rooted in data and the collective expertise of the organization and fueled by passionate employees. Employees expressed that key commitments include:

1. leadership at all levels articulating that sustainability work is a priority and how it compliments other priorities,
2. additional workforce capacity and dedicated positions, and
3. budget for implementation.




Remote solar power used at an incident command post. USDA Forest Service photo.



Remote solar power can be used for remote operations. USDA Forest Service photo.

# TRADEOFFS AND RISKS

The agency's ambitious strategy, while achievable, is not without tradeoffs and risks. Investment decisions will be based on science and data. Research needs will be identified to measure the feasibility and environmental impact of new technologies. When applicable, the agency can use life cycle assessments to understand products and technological impacts from production to disposal, and compare this with alternative solutions.

The Forest Service also needs to assess whether new, more sustainable technologies can fulfill agency needs while acknowledging potential safety risks associated with use of the new technology. The associated tradeoffs and risks may change over time as the technology improves. The implementation plan will be updated accordingly.

Additionally, the agency needs to understand the tradeoffs of sustainability work as it relates to employees. Surveys showed that, while excited about this work, many employees feel overwhelmed and concerned that without additional capacity, workloads will greatly increase. Employees also expressed concern that potential political changes may affect long-term investments in this work, which has tempered optimism with caution.

Sustainability initiatives often have many solutions. It is imperative that the agency understands the breadth and scope of options to allow for local flexibility in implementation.

## **Electric Vehicles** Assessing Risks and Tradeoffs

Electric Vehicles (EVs) can help the agency reduce carbon emissions from gas and diesel but there are known environmental impacts of battery production and disposal. The agency is assessing the feasibility of different EV uses, including mileage ranges and the need for power and performance in different climates and conditions (e.g., cold weather, remote rugged terrain). In addition, the agency can identify plans for disposal of EVs and battery recycling plans.

# CONNECTIONS TO OTHER AGENCY STRATEGIES AND PLANS

This strategy supports numerous ongoing efforts across the agency directly and indirectly. These strategic connections reinforce the importance of this work. For each of these important agency strategies and plans, discrete connections and opportunities have been identified to help support this work through the Sustainable Operations Strategy.

## USDA STRATEGIC PLAN

Directly addresses cross-cutting theme of "addressing climate change via climate smart agriculture, forestry, and renewable energy."

Provides pathways for the agency to deliver on Goals 1.3 (water), 1.4 (reduce greenhouse gas emissions), 3.1 (renewable energy), 3.2 (new markets), and 5.3 and 5.4 (green rural and Tribal economies).

## FOREST SERVICE STRATEGIC PLAN

Supports goals of empowering employees, partnering with the public, and sustainably managing for healthy and resilient landscapes.

Provides new sustainable pathways to accomplish these goals.

## CLIMATE ADAPTATION PLAN

Demonstrates commitment to reducing environmental impacts and greenhouse gas emissions, which mitigates agency contributions to climate change.

Provides opportunities to reduce risk and address climate vulnerabilities with new onsite renewable energy solutions.

## WILDFIRE CRISIS STRATEGY

Addresses the mitigation of agency contributions to climate change that may exacerbate the wildfire crisis.

Reduces spending on energy, fuel, and waste disposal, as the agency increases the pace and scale of landscape treatments.

Supports the development of supply chains for biomass and wood products from restoration as well as risk reduction landscapes for construction, heating, and electricity.

## EQUITY ACTION PLAN

Provides green business prospects for local suppliers and small businesses, including those that meet the small, disadvantaged business requirements.

Reduces impacts to low-income, minority, and socially vulnerable communities by reducing pollutants and waste in community landfills.

Provides opportunity to engage youth, low-income, minority, and socially vulnerable communities to improve sustainability through employment and partnership opportunities, which benefits all people.




Examples of some of the agency strategies and plans supported by the National Sustainable Operations Strategy. USDA Forest Service image.

## REIMAGINE RECREATION

Models citizenship and conservation stewardship to and with the public.

Creates aesthetically pleasing alternatives to traditional infrastructure.

Reduces noise, light, and pollution impacts for the land and people served.

Provides green product solutions and best practices to reduce waste generated and disposed of at sites.

## TRIBAL ACTION PLAN

Considers long-term and broad-scale impacts of operational choices.

Embraces a diverse set of values and knowledge around sustainability, many of which have long been present in Native and Indigenous cultures.

Creates new opportunities for collaboration, partnerships, and small businesses.

Offers the opportunity for youth participation and internships.

## RISK MANAGEMENT

Supports the understanding of core functional needs within the organization, as well as sustainability culture and doctrine.

Reduces hazards associated with pollutants and waste byproducts.

Supports risk reduction for operational assets due to various vulnerabilities (e.g., onsite renewables reduce risk of power outage to mission-critical facilities).

| | REDUCE GREENHOUSE GAS EMISSIONS | | | | | REDUCE CONSUMPTION AND SHIFT TO SUSTAINABLE PRODUCTS AND SERVICES | | | | | | EDUCATE AND ENABLE EMPLOYEES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STRATEGIC CONNECTIONS** | 1a | 1b | 1c | 1d | 1e | 2a | 2b | 2c | 2d | 2e | 2f | 3a | 3b | 3c | 3d |
| FOREST SERVICE STRATEGIC PLAN | Forthcoming | | | | | | | | | | | | | | |
| USDA STRATEGIC PLAN | ● | ● | ● | ● | | | | ● | ● | ● | ● | | ● | | |
| CLIMATE ADAPTATION PLAN | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | |
| WILDFIRE CRISIS STRATEGY | ● | ● | ● | | | ● | | ● | | | | | | ● | |
| EQUITY ACTION PLAN | ● | | | | | ● | | | ● | | | | ● | ● | |
| REIMAGINE RECREATION | | | | ● | | ● | | | | ● | | | ● | ● | |
| TRIBAL ACTION PLAN | | | | ● | | | | | ● | | | | ● | ● | |

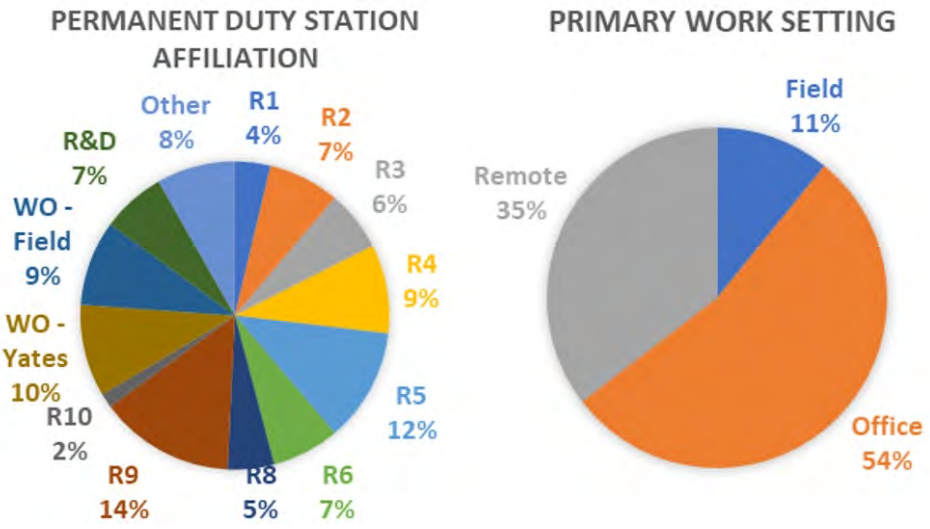
# PROCESS

## EMPLOYEE ENGAGEMENT

Employee engagement and feedback were critical to the formation of this strategy and will be essential to its successful implementation. A core team, consisting of approximately 20 staff from across deputy areas, position types, and geographies, was assembled to guide the process. This team met weekly for nearly 6 months to scope and support the development of the strategy, including conducting a horizon scanning analysis, strengths, weaknesses, opportunities and threats (SWOT) analysis, and an analysis addressing barriers, challenges, and opportunities.

The core team deployed two primary engagement mechanisms to solicit broader employee feedback: webinars and a survey. Three 1-hour virtual employee engagement webinar sessions were offered to any employee who wanted to participate. Each engagement consisted of a briefing on sustainable operations and the strategy, live polling, and time for discussion. An online survey was also created to provide a forum for more robust and detailed feedback. The engagements asked employees about the proposed vision, values, goals, and objectives of the strategy, which gauged interest and gave participants space to voice concerns or suggestions. To reach the maximum number of employees, these engagements were advertised through Inside the Forest Service and various email listservs. In addition to these engagements, core team members also brought forward feedback and concerns elevated in their personal and professional networks.

The following summary includes feedback from the survey and engagement sessions.




Participation distribution from employee engagements.

### ATTENDEES

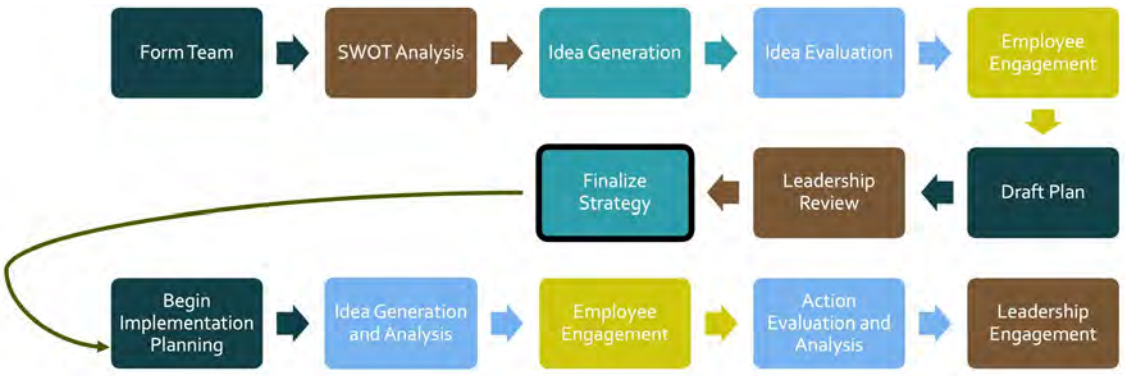
In total, 385 employees from across the agency participated, representing every region (at all levels), research stations, and many Washington Office deputy staff areas (State, Private and Tribal Forestry; Research and Development; Chief Financial Officer; Business Operations, etc.). Employees working remotely as well as those in the field and the office were all represented.

### PERCEPTIONS AND FEEDBACK

Most participants believed making Forest Service operations more sustainable is important. Most employees had at least heard of sustainable operations or felt knowledgeable about it, although a small percentage did indicate that this information was completely new to them. Most participants considered all three proposed goals "very" or "extremely" important to include in the strategy. When asked how they felt about the strategy overall, employees overwhelmingly felt "hopeful" or otherwise optimistic about the effort, though some indicated feeling "cautious" or "overwhelmed."

Employees also identified challenges to implementing sustainable operations, such as a lack of funding, a lack of leadership intent and guidance especially at the regional office or forest level, a lack of clear roles for implementation, and concern around electric vehicle adoption and life cycles. In addition, employees flagged that the term "net zero" did not resonate well with them; while it is something to strive toward, it is likely unachievable.

When asked about what was missing, many employees provided feedback on specific actions they would like to see in the implementation plan. This input will be incorporated as the implementation plan is developed.



## THE PATH TO IMPLEMENTATION

This document outlines the vision, values, goals, and objectives of the Sustainable Operations Strategy. An implementation plan, which is under development in spring 2024, will be paired with this strategy and will outline the specific action items needs to accomplish agency goals and objectives. Although action items have not been explicitly outlined in this document, through engagement sessions and survey feedback the core team and Forest Service employees have proposed numerous action items ideas that could help the agency achieve the goals and objectives of this strategy. The implementation team will evaluate these and other similar types of actions against the values, goals and objectives of the strategy to determine if they should be included in the priority action plan for implementation. These will include performance measures, timeframes for implementation, and anticipated outcomes.

## NEXT STEPS

A companion implementation plan will designate specific actions and anticipated outcomes for varying timeframes. This strategy will use a data-driven approach for investment in implementation and will prioritize the actions that have the largest return on investment, highest likelihood of success, and greatest impact in reducing the agency's contributions to climate change.

Recyclables diverted from the landfill on Jack Fire, OR. USDA Forest Service photo by Phil Torchio.



# CONCLUSION

The Sustainable Operations Strategy supports the Forest Service mission, helps the agency meet Federal requirements as well as public and employee expectations, and sets up the agency for long-term cost savings and greenhouse gas emissions reductions. While this strategy is ambitious, it is also doable. The strategy is good business and helps the Forest Service continue to be a careful steward of public resources.

# ACKNOWLEDGMENTS

Thank you to the cross-deputy core team that spent countless hours brainstorming, sensing, thinking critically and creatively, groundtruthing, researching, writing and more! Thank you to Office of Sustainability and Climate leadership, Chris Swanston and Dixie Porter, for supporting this work. Thank you to the deputy chief areas and supervisors that nominated and supported core team members. And finally, thank you to all of the employees who have contributed to the development of this strategy as well as sustainability efforts and initiatives!

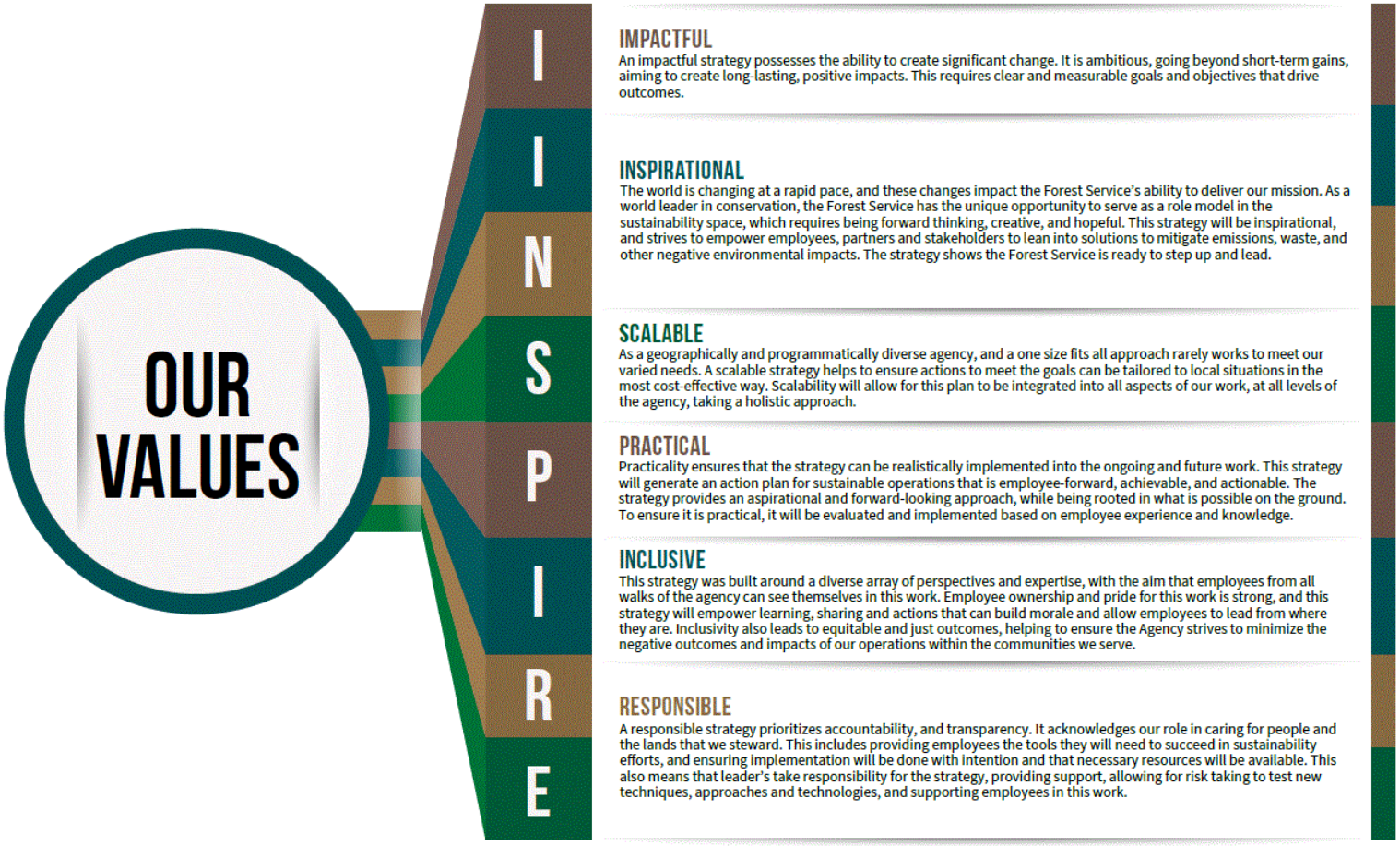
The National Sustainable Operations Strategy core team included: Jennifer Hayes (lead), Maya Bhadury, Jessica Haas, Melissa Taggart, Isabel Dawson, Kristin Armstrong, Chris Farley, Katelyn Ulmer, Jeff Loomis, Darren Lemon, Sarah LaPlante, Sharon Gamble, Carol Moritz, Vicki Eitemiller, Renee Jewell, Kelly Jaramillo, Chuck Ruhsenberger, Lauren Wilmert, Derek Darter, and Emilie Lang.




Firefighters refill reusable jugs at a mobile water treatment system rig. USDA Forest Service photo by Kelly Jaramillo.

**APPENDIX 1:**

# SUSTAINABLE OPERATIONS STRATEGY GUIDING VALUES (IN ADDITION TO AGENCY CORE VALUES)



**APPENDIX 2:**

## EXECUTIVE ORDER 14057 TARGETS CROSSWALK

| *EO14057 Requirements x Forest Service Sustainable Operations Strategy* | Reduce Greenhouse Gas Emissions | | | | | Reduce Consumption and Shift to Sustainable Products and Services | | | | | | Educate and Enable Employees | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 1c | 1d | 1e | 2a | 2b | 2c | 2d | 2e | 2f | 3a | 3b | 3c | 3d |
| 65% reduction of overall GHG[1] emissions by 2030 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | | ★ | ★ | ★ | ★ | ★ |
| 100% ZEV[2] acquisitions by 2035 | | | | ★ | | | ★ | | ★ | | ★ | ★ | | ★ | |
| 100% CFE[3] by 2030 | | | ★ | | | | | | | | ★ | ★ | | ★ | |
| Net-zero procurement by 2050 | | | | | | ★ | ★ | | ★ | | ★ | ★ | | ★ | |
| 50% building emissions reduction by 2032 | ★ | ★ | ★ | ★ | ★ | ★ | | ★ | ★ | ★ | ★ | | | | |

[1] Greenhouse gas, [2] Zero emissions vehicles, [3] Carbon pollution-free electricity

| EO14057 Requirements | Forest Service FY 2022–2023 Performance | Remaining Difference |
|---|---|---|
| **65% reduction of overall GHG emissions by 2030** *(from 2008 baseline)* | **3.8%**<br>*2008 agency baseline: 263,749 MT $CO_2e$[1]*<br>*FY 2023 emissions: 253,796 MT $CO_2e$* | **61.2%** *or 171,437 MT $CO_2e$* |
| **100% ZEV acquisitions by 2035** | **.25%**<br>*FY 2023: 2 of the 806 fleet vehicles purchased were ZEV (total ZEV in fleet = 35)* | **99.75%** |
| **100% CFE by 2030** | **44%** | **56%** |
| **Net-zero procurement by 2050 (Buy Clean)** | **39.6%** | **60.4%** |
| **50% building emissions reduction by 2032** | *Measure pending*<br>*In FY 2023, buildings accounted for more than half of agency operational emissions.* | n/a |

[1] Metric tons of carbon dioxide equivalent

**ADDITIONAL RESOURCES:**

- Executive Order 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability
- USDA Strategic Plan Fiscal Years 2022-2026
- Guiding Principles for Sustainable Federal Buildings and Associated Instructions
- The Paris Climate Agreement at the United Nations Climate Change Conference
- The Fifth National Climate Assessment
- Implementing Instructions for Executive Order 13834, Efficient Federal Operations
- Waste as an environmental justice issue:
  - WE ACT for Environmental Justice
  - Green America
  - National Waste and Recycling Association
  - Environmental and Energy Study Institute
- Waste and its Contribution to Climate Change
- Circular Economy Principles: Eliminate Waste and Pollution
- U.S. Environmental Protection Agency: What is a Circular Economy?
- Ellen MacArthur Foundation: What is a Circular Economy?
- U.S. Environmental Protection Agency: Climate Change Impacts on Freshwater Resources
- U.S. Energy Information Administration: Biomass and the Environment
- USDA Forest Service Research and Development: Bioenergy and Biomass
- USDA Regional Biomass Research Centers: Agricultural Research Service
- Fifth National Climate Assessment, Chapter 11: Agriculture, Food Systems, and Rural Communities
- Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability
- USDA Forest Service Sustainable Operations
- News Article: USDA Forest Service Testing Ford F-150 Lightning Electric Pickups
- Office of the Federal Chief Sustainability Officer: 100% Zero-Emission Vehicle Acquisitions by 2035
- The Butterfly Diagram: Visualizing the Circular Economy



Visitors fishing at Spruce Knob Lake, Monongahela National Forest, Randolph County, WV. USDA Forest Service photo by Kelly Bridges.

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at How to File a Program Discrimination Complaint and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

Live version as of 2/20/2025

An official website of the United States government Here's how you know

**Forest Service**
U.S. DEPARTMENT OF AGRICULTURE

MENU

Home ▸ system ▸ Page not found

The requested page could not be found.

**Visit Us** | **Managing the Land** | **Learn** | **Science and Technology** | **Working with Us** | **About the Agency** | **Inside the FS**

askUSDA
Contact Us
Sitemap
Policies & Links
Our Performance
Careers
Fraud, Waste, and Abuse Hotline
Inspector General
Plain Writing
Open
FOIA
Accessibility Statement
Privacy Policy
Non-Discrimination Statement
USDA Anti-Harassment Policy
Forest Service Anti-Harassment Policy
Information Quality
USA.gov
Whitehouse.gov
eGov
No FEAR Act Data
Whistleblower Protection Coordinator

**Forest Service**
U.S. DEPARTMENT OF AGRICULTURE

# EXHIBIT T

Live version as of 2/20/2025

United States Department of Agriculture

**MEMORANDUM TO THE FIELD FOR THE NATURAL RESOURCES CONSERVATION SERVICE (NRCS) CONCERNING PARTNERSHIPS FOR CLIMATE-SMART COMMODITIES**

(1) Purpose.

This document is meant to aid in the administration of Partnerships for Climate-Smart Commodities by summarizing and further defining responsibilities within USDA and external to USDA with respect to the effort. The primary guiding documents for Partnerships for Climate-Smart Commodities are the Notice of Funding Opportunity combined with the individual grant agreements executed at the national level with each grant recipient.

(2) References.

The authority for the Partnerships for Climate-Smart Commodities funding opportunity (USDA-NRCS-COMM-22-NOFO0001139) is the Commodity Credit Corporation Charter Act (15 U.S.C. 714 et seq). This funding opportunity leverages the authorities under Section 5 of the Commodity Credit Corporation Charter Act at 15 U.S.C. 714c with particular emphasis on the following subsection: "(e) increase the domestic consumption of agricultural commodities (other than tobacco) by expanding or aiding in the expansion of domestic markets or by developing or aiding in the development of new and additional markets, marketing facilities, and uses for such commodities." Partnerships for Climate-Smart Commodities Grants are administered under 2 CFR Part 200 et seq – Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards.

(3) Definitions for Partnerships for Climate-Smart Commodities Funding Opportunity.

A **Climate-Smart Commodity** is an agricultural commodity that is produced using agricultural (farming, ranching, or forestry) practices that reduce greenhouse gas emissions or sequester carbon.

**Climate-Smart production practices** include agricultural and forestry practices or combinations of practices, and/or practice enhancements that provide Greenhouse Gas (GHG) benefits and/or carbon sequestration. Practices may include, but are not limited, to the following: cover crops, low-till or no-till, nutrient management, enhanced efficiency fertilizers, manure management, feed management to reduce enteric emissions, buffers, wetland, and grassland management, tree planting on working lands, agroforestry and afforestation on working lands, afforestation/reforestation and sustainable forest management, planting for high carbon sequestration rate, maintaining and improving forest soil quality, increase on-site carbon storage through forest stand Management, alternate

wetting and drying on rice fields, climate-smart pasture practices, such as prescribed grazing or legume interseeding, and soil amendments, like biochar.

(4) Forms.

USDA forms referenced in this notice are:

a. AD-1026 (Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) Certification);
b. CCC-902 (Farm Operating Plan for Payment Eligibility 2009 and Subsequent Program Years);
c. AD-2047 (Customer Data Worksheet to facilitate the collection of customer data for Business Partner Record); and
d. CPA-052 (NRCS Environmental Evaluation CPA-52 Worksheet).

(5) Reports.

See section on Reporting and Duplicate Payments.

(6) Background.

Up to approximately $3.1 billion will be made available for the Partnerships for Climate-Smart Commodities projects through this funding opportunity, which will build markets and invest in America's climate-smart farmers, ranchers, and forest owners to strengthen U.S. rural and agricultural communities. Through the Partnerships for Climate-Smart Commodities, USDA will support the production and marketing of climate-smart commodities through a set of pilot projects that provide voluntary incentives through partners to producers and landowners, including early adopters, to:

a. implement climate-smart production practices, activities, and systems on working lands,
b. measure/quantify, monitor and verify the carbon and GHG benefits associated with those practices, and
c. develop markets and promote the resulting climate-smart commodities.

All projects must be tied to the development of markets and promotion of climate-smart commodities. Markets for climate-smart commodities may include companies or processors sourcing climate-smart commodities to meet internal targets or other supply chain goals, biofuel and renewable energy markets, companies seeking to sell branded consumer products, or other opportunities that could provide a premium or additional revenue for participating producers and landowners. Sufficient incentives to encourage producer participation, as well as generation of verifiable greenhouse gas reductions and carbon sequestration are critical to project success.

(7) Policy.

This directive further describes the responsibilities related to Partnerships for Climate-Smart Commodities.

(8) Responsibilities.

See Topic-Specific Sections

(9) Topic-Specific Sections.

a. General Administration

i. Overview

This section provides information on the general administration information for Partnerships for Climate-Smart Commodities.

ii. Roles and Responsibilities

1. NHQ Climate-Smart Commodities Team

In general, Partnerships for Climate-Smart Commodities will be administered by a National Headquarters team with leadership from the Under Secretary for Farm Production and Conservation and the Chief of NRCS with strong support and collaboration from the FSA Administrator and leaders across the Department.

The Director of Climate-Smart Commodities, currently the Acting Senior Advisor for Climate-Smart Commodities, will lead the team with a staff that includes an Acting Deputy Director, Acting Division Directors and Acting National Program Officers (NPOs). The NPOs are responsible for negotiating agreements, administrative tasks associated with the agreements, and general oversight of a suite of projects under the opportunity. The NPOs will be the primary contact with the grant recipients.

2. State and County Offices (NRCS/FSA)

Each State Executive Director and State Conservationist will identify a separate State Climate-Smart Commodities POC. The NRCS and FSA State Climate-Smart Commodities POCs will be the primary contacts with the NPOs and also the primary contacts for any field office staff that need to be engaged for Partnerships for Climate-Smart Commodities related activities in their respective agencies. Field office staff should direct any questions on Partnerships for Climate-Smart Commodities to their respective Agency's State Climate-Smart Commodities POC, who will then engage the appropriate NPO as needed.

3. Grant Recipient

Each grant recipient will be responsible for implementation of the Partnerships for Climate-Smart Commodities project, including all technical assistance with project producers.

4. Contractors

Various contractors may be leveraged by USDA at the Headquarters or State level or by grant recipients under their grant agreements. The primary contract discussed in this

guidance is a headquarters contractor that will assist with cultural and environmental survey activities.

5. Producers

Producers are beneficiaries of Partnerships for Climate-Smart Commodities as the USDA Partnerships for Climate-Smart Commodities grants are applying climate-smart practices and building climate-smart markets to benefit producers.

iii. Actions

1. NHQ Climate-Smart Commodities Team

NHQ Climate-Smart Commodities Team will follow the provisions of this directive and associated guidance.

2. State and County Offices (NRCS/FSA)

State and County Offices will follow the provisions of this directive and associated guidance.

Each State Executive Director and State Conservationist will identify a separate State Climate-Smart Commodities POC. The name of the State POC should be submitted by the State Executive Director or State Conservationist to **climate-smart-commodities@usda.gov** by Thursday, **April 27, 2023**.

iv. Funding Codes

1. NRCS

With regard to Partnerships for Climate-Smart Commodities, NRCS will use Conservation Technical Assistance funds for HELC/WC technical assistance and NHQ will provide fund codes for activities related to Environmental and Cultural Resources.

2. FSA

FSA will use the Activity Reporting System codes: Program "Farm Records" and Activity "NRCS Support" for the activities related to creating Farm/Tract/Field for new customers and providing copies of maps and subsidiary prints to producers who request them for their participation in Partnerships for Climate-Smart Commodities.

FSA will use the Activity Reporting System codes: Program "Eligibility" and Activity "NRCS Support" for the activities related to completing eligibility forms including the CCC-902, AD-2047 and AD-1026.

3. Other Information

Additional Partnerships for Climate-Smart Commodities funding may be made available in the future. States will be notified accordingly.

b. Producer Eligibility and Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) Compliance

i. Overview

In order to be eligible for an incentive payment as a part of the Partnerships for Climate-Smart Commodities, a producer must:

1. Establish Farm Records with the Farm Service Agency (have farm, tract, and fields numbers in place);
2. Complete an AD-2047 (Customer Data Worksheet to facilitate the collection of customer data for Business Partner Record);
3. Certify HELC and WC compliance via Form AD-1026, Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) Certification; and
4. Certify that they are not a foreign person or entity.

Farm, tract, and field numbers are required for the producer, and ultimately the Partnerships for Climate-Smart Commodities grant recipient, to report climate-smart practice implementation to USDA, as well as to certify and maintain HELC/WC compliance. This will require that some producers that do not already have these records, like perennial crop growers, feedlots or forest land owners, establish these records with USDA.

Producers are not bound by the payment limitations and the adjusted gross income (AGI) limitations that are in place for other USDA programs.

In order to demonstrate HELC/WC compliance for Partnerships for Climate-Smart Commodities incentive payments, producers will need to request a copy of their subsidiary print from their **USDA Service Center**. The producer will then provide this documentation to the Partnerships for Climate-Smart Commodities grant recipient as proof of compliance. A current year subsidiary print will be required for each crop year that the producer receives a payment, and HELC/WC eligibility information is provided under the AD-1026 and Conservation Compliance sections of subsidiary (determined by year, which can change at any time during the year or in a subsequent year). As is the case already, field office staff will not provide documentation to anyone besides the producer unless they have provided a written authorization, according to normal policy. Producers will need to demonstrate to the grant recipient that they have control of the land for the term of their beneficiary contract.

ii. Roles and Responsibilities

1. NHQ Climate-Smart Commodities Team

The National Program Officers (NPOs) will clarify the process for determining eligibility, HEL/WC compliance and the grant requirements with the Partnerships for Climate-Smart Commodities grant recipient. The NPOs will provide a training module for the grant recipient to ensure expectations are clear and grant recipients understand the producer documentation.

The NPOs will facilitate back-end checks on producers to determine if they have later been determined out of compliance.

The NPOs will troubleshoot any issues that the grant recipients are having with HELC/WC compliance eligibility, including eligibility determination backlogs.

2. State and County Offices (NRCS/FSA)

FSA county office staff will create farm records including farm, tract, and field numbers as requested by a producer. They will forward the AD-1026 with requests for technical determinations to NRCS, as needed. The county office staff will also provide a map and subsidiary prints to a producer as requested.

FSA county office staff will collect new producer information using business file and complete the CCC-902 and AD-2047, as requested by a producer.

There are no additional tasks expected of county office staff. However, county office staff may see an increase in related HELC/WC workload triggered by an increase in technical determinations.

NRCS State Conservationists and FSA State Executive Directors will monitor any backlogs of eligibility determinations or Farm Record establishment, and address issues accordingly. For HELC/WC compliance under Partnerships for Climate-Smart Commodities, the NRCS and FSA roles are the same as it would be for any other customer. The State Climate-Smart Commodities POCs may be notified by the NPO that a particular project has encountered a backlog in determinations, who will work with their state leadership to help address any resource needs.

3. Contractors

A Partnerships headquarters contractor may assist with the back-end checks on producers to determine if they have not maintained compliance.

4. Grant Recipients

Grant recipients are responsible for determining producer eligibility within the funding opportunity requirements. Partners will inform producers of eligibility requirements and direct them to local USDA offices for requested information as necessary, including but not limited to, farm and tract establishment, HELC/WC determinations, and environmental evaluations (described further in section D). Privacy of producers is a priority through this process.

At minimum, the grant recipients will collect and review subsidiary reports from participating producers. They will ensure that the producer is listed as “certified” for AD-1026 and “compliant” in all sections of the conservation compliance portion of subsidiary before an incentive payment is made. They will also check that the Subsidiary Print for "Foreign Person" indicates "Not Applicable". Farm, tract, field numbers and producer name will be provided to the National Program Officer as a part of routine grant reporting.

5. Producers

The producer will work with FSA to establish farm records and complete an AD-1026, if they have not already. Producers will request records from their **USDA Service Center** as needed to voluntarily participate in a Partnerships for Climate-Smart Commodities project.

The producer will complete the CCC-902 and AD-2047 at the FSA County Office, if they have not already. Producers will request records from their **USDA Service Center** as needed to participate in a Partnerships for Climate-Smart Commodities project.

c. Reporting and Duplicate Payments

i. Overview

USDA's robust data and learning strategy for Partnerships for Climate-Smart Commodities will include requirements for grantees to submit the following information as part of their quarterly reporting:

1. Progress reports and updates on farm, tract, and field data including, but not limited to, producers enrolled, acres, crops, and livestock covered, climate-smart practices implemented and related incentives;
2. Updates on project summary data including geographic data, partner activities, and marketing activities as well as financial and budget information;
3. Measurement/Quantification, Monitoring, Reporting and Verification (MMRV) methods, modeled and measured GHG benefits, and environmental co-benefits including, as applicable water, air, and habitat related benefits.
4. Other periodic updates on supplemental data, including information related to the MMRV plan and direct field measurement results will also be required.

Additional reporting and data sharing requirements may apply at time of award. Certain reporting elements will be required to be georeferenced. Financial reporting will also be required consistent with 2 CFR 200. Spot checks may be required upon review of reporting documents or other USDA analyses. Data will be submitted through a secure portal where producer privacy will be protected according to applicable laws.

Data will be available internally to be compared with NRCS data.

ii. Roles and Responsibilities

1. NHQ Partnerships Team

NPOs will monitor quarterly and ad hoc data reporting from grant recipients. NPOs will also use automated dashboards to check for potential overlap on each practice-field combination on a quarterly basis after the partners provide reporting. If a potential duplicate is identified, the NPO will notify the State Climate-Smart Commodities POCs for further review.

If the State Climate-Smart Commodities POC confirms a duplicate payment **and** the obligation dates indicate that the Climate-Smart Commodities contract was **after** the date of the NRCS or FSA direct producer contract, then the NPO will notify the grant recipient that the producer beneficiary contract funds must be recovered.

2. State and County Offices (NRCS/FSA)

The State Climate-Smart Commodities POCs will receive a list of suspected duplicate payments from the NPO, research and provide findings to the NPO.

If the State Climate-Smart Commodities POC confirms a duplicate payment and the obligation dates indicate that the Climate-Smart Commodities contract was **before** the date of an NRCS or FSA direct producer contract, then the State Climate-Smart Commodities POC will notify the appropriate county office staff that the contract funds must be recovered.

Provide potential duplicate payments to NPO if found through county office staff normal reviews.

**Note:** If funding was for an enhancement beyond what was done originally through FSA/NRCS, repayment is not needed.

3. Contractors

Headquarters contractors will be leveraged to develop dashboards and other data analysis resources.

4. Grant Recipients

Grant recipients will provide required reporting and attest that producers and land owners will not be involved in multiple USDA programs that fund the same practice on the same land. Federal funds under this funding opportunity may not be used to pay for implementation of the same practice on the same land, but funding may be used to enhance a practice or to further incentivize the climate-smart commodity generated, especially with respect to early adopters.

5. Producers

Producers must ensure and certify that they are not receiving a payment for the same practice on the same land at the same time.

d. Environmental and Cultural Resources Review

i. Overview

A Finding of No Significant Impact (FONSI) was signed by USDA NRCS on August 26, 2022, for Partnerships for Climate-Smart Commodities. A copy of the Programmatic Environmental Assessment for Partnerships for Climate-Smart Commodities is available at **www.usda.gov/climate-smart-commodities** . The overall impacts of the funding

opportunity, including those to cultural resources, were considered in the Programmatic EA. Additional project or site specific cultural and environmental analysis may be identified to tier to this Programmatic EA and comply with other relevant laws.

The grant recipient is responsible for all technical assistance, including planning practices consistent with NRCS practice standards, interim practice standards and/or alternative practice standards and providing information for any site specific environmental review.

ii. Roles and Responsibilities

1. NHQ Partnerships Team

Following grant agreement execution, NPOs will send a copy of the Project Environmental and Cultural Resources Letter to the grant recipient and the NRCS State POC. On a project by project basis, this letter will be signed by the Acting Director for Climate-Smart Commodities on behalf of the NRCS Chief and delineate whether any additional site specific environmental or cultural resources review will be required by practice for the project. NPOs will coordinate with State POCs and also headquarters contractors and recipients to ensure sufficient information is provided for site specific review as needed.

2. State and County Offices (NRCS)

As requested, the NRCS State Climate-Smart Commodities POCs will ensure required CPA-52s are completed and signed in a timely manner. NRCS State Climate-Smart Commodities POCs will review Environmental Evaluation information developed by the Partner (and checked by the Contractor) to ensure that adverse impacts have been minimized, and also will work with appropriate State Office staff and the Contractor to complete any required consultations. NRCS State POCs will ensure the site-specific CPA-52s are completed and signed by the appropriate Responsible Federal Official (RFO) in the State Office.

3. Contractors

Headquarters contractors will review information on the CPA-52s submitted by the recipients and prepare consultation materials as needed. Contractors may reach out to the grant recipients, in coordination with the NPO, for additional information prior to signature or any associated consultations.

4. Grant Recipients

Grant recipients must complete the CPA-52 through Section O for each field where site-specific review is required. The recipient must then send the CPA-52 in a zipped, password protected file to **climatesmart@clarkgroupllc.com** (or a designated website provided by the NPO) for completion and signature by USDA. Recipients must not execute a beneficiary contract for a field where a CPA-52 is required until they receive a CPA-52 for that field that is signed by a USDA representative.

5. Producers

Producers will provide information to the grant recipient as requested when signing up for a particular project.

6. Site Specific Environmental and Cultural Resources Review Step Chart

If a project requires site specific review, then the following step chart should be followed.

<table>
<tr><td>Step</td><td>Climate-Smart Commodities Environmental & Cultural Resources Compliance Review Process</td></tr>
<tr><td>1</td><td>Recipient completes any required site-specific Environmental Evaluation (EE) CPA-52 completed through Section O for each applicable producer beneficiary contract and submits in a zipped, password protected file to climatesmart@clarkgroupllc.com (or a designated website provided by the NPO). Go to Step 2.</td></tr>
<tr><td>2</td><td>Contractor reviews CPA-52 information. Go to Step 3.</td></tr>
<tr><td>3</td><td><table><tr><td>If Consultation is…</td><td>THEN…</td></tr><tr><td>Required</td><td>Go to step 4.</td></tr><tr><td>Not required</td><td>Go to step 7.</td></tr></table></td></tr>
<tr><td>4</td><td>Contractor drafts consultation package. Go to Step 5.</td></tr>
<tr><td>5</td><td>Contractor provides the NRCS State Climate-Smart Commodities POC with the consultation materials (with cc: to NPO), and state staff performs necessary consultation. Go to Step 6.</td></tr>
<tr><td>6</td><td><table><tr><td>If consultation concurrence is…</td><td>THEN…</td></tr><tr><td>Received</td><td>Go to step 7.</td></tr><tr><td>Not received</td><td>Tract is ineligible for Project</td></tr></table></td></tr>
<tr><td>7</td><td>Contractor updates CPA-52 to reflect consultation outcome (if any). Go to Step 8.</td></tr>
<tr><td>8</td><td>Contractor sends CPA-52 with attachments to the NRCS State Climate-Smart Commodities POC (with cc: to NPO). Go to Step 9.</td></tr>
<tr><td>9</td><td>NRCS State Climate-Smart Commodities POC uses state-defined review process to review. Go to Step 10.</td></tr>
</table>

<table>
<tr><td>10</td><td><table>
<tr><td>If additional information is…</td><td>THEN…</td></tr>
<tr><td>Needed</td><td>Go to step 11A.</td></tr>
<tr><td>Not needed</td><td>Go to step 11B.</td></tr>
</table></td></tr>
<tr><td>11A</td><td>NRCS State Climate-Smart Commodities POC requests additional information from contractor (and cc: NPO). Go to Step 4 or Step 12 as indicated.</td></tr>
<tr><td>11B</td><td>NRCS State Climate-Smart Commodities POC will ensure that the CPA-52 is signed by an appropriate NRCS representative in their state. The NRCS State POC then completes the form at Partnership for Climate Smart CPA-52 Submission Portal (office.com), attaches the signed CPA-52 and submits the form. The signed CPA-52 will be the official record. Go to Step 13.</td></tr>
<tr><td>12</td><td>Contractor develops other requested information. Go to Step 8.</td></tr>
<tr><td>13</td><td>NPO maintains record of completed CPA-52’s using SharePoint database. Go to Step 14.</td></tr>
<tr><td>14</td><td>Partner receives signed, site-specific CPA-52 from automated system.</td></tr>
</table>

**Note:** Consultation refers to a consultation for Section 7 of the Endangered Species Act, Section 106 of the National Historic Preservation Act or other special environmental concerns.

Terry J. Cosby
Chief
Natural Resources Conservation Service

# EXHIBIT U

Live version as of 2/20/2025

United States Department of Agriculture

**MEMORANDUM TO THE FIELD FOR THE FARM SERVICE AGENCY (FSA) CONCERNING PARTNERSHIPS FOR CLIMATE-SMART COMMODITIES**

(1) Purpose.

This document is meant to aid in the administration of Partnerships for Climate-Smart Commodities by summarizing and further defining responsibilities within USDA and external to USDA with respect to the effort. The primary guiding documents for Partnerships for Climate-Smart Commodities are the Notice of Funding Opportunity combined with the individual grant agreements executed at the national level with each grant recipient.

(2) References.

The authority for the Partnerships for Climate-Smart Commodities funding opportunity (USDA-NRCS-COMM-22-NOFO0001139) is the Commodity Credit Corporation Charter Act (15 U.S.C. 714 et seq). This funding opportunity leverages the authorities under Section 5 of the Commodity Credit Corporation Charter Act at 15 U.S.C. 714c with particular emphasis on the following subsection: "(e) increase the domestic consumption of agricultural commodities (other than tobacco) by expanding or aiding in the expansion of domestic markets or by developing or aiding in the development of new and additional markets, marketing facilities, and uses for such commodities." Partnerships for Climate-Smart Commodities Grants are administered under 2 CFR Part 200 et seq – Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards.

(3) Definitions for Partnerships for Climate-Smart Commodities Funding Opportunity.

A **Climate-Smart Commodity** is an agricultural commodity that is produced using agricultural (farming, ranching, or forestry) practices that reduce greenhouse gas emissions or sequester carbon.

**Climate-Smart production practices** include agricultural and forestry practices or combinations of practices, and/or practice enhancements that provide Greenhouse Gas (GHG) benefits and/or carbon sequestration. Practices may include, **but are not limited**, to the following: cover crops, low-till or no-till, nutrient management, enhanced efficiency fertilizers, manure management, feed management to reduce enteric emissions, buffers, wetland, and grassland management, tree planting on working lands, agroforestry and afforestation on working lands, afforestation/reforestation and sustainable forest management, planting for high carbon sequestration rate, maintaining and improving forest soil quality, increase on-site carbon storage through forest stand management, alternate

wetting and drying on rice fields, climate-smart pasture practices, such as prescribed grazing or legume inter-seeding, and soil amendments, like biochar.

(4) Forms.

USDA forms referenced in this notice are:

a. AD-1026 (Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) Certification);
b. CCC-902 (Farm Operating Plan for Payment Eligibility 2009 and Subsequent Program Years);
c. AD-2047 (Customer Data Worksheet to facilitate the collection of customer data for Business Partner Record); and
d. CPA-052 (NRCS Environmental Evaluation CPA-52 Worksheet).

(5) Reports.

See section on Reporting and Duplicate Payments.

(6) Background.

Up to approximately $3.1 billion will be made available for the Partnerships for Climate-Smart Commodities projects through this funding opportunity, which will build markets and invest in America's climate-smart farmers, ranchers, and forest owners to strengthen U.S. rural and agricultural communities. Through the Partnerships for Climate-Smart Commodities, USDA will support the production and marketing of climate-smart commodities through a set of pilot projects that provide voluntary incentives through partners to producers and landowners, including early adopters, to:

a. implement climate-smart production practices, activities, and systems on working lands,
b. measure/quantify, monitor and verify the carbon and GHG benefits associated with those practices, and
c. develop markets and promote the resulting climate-smart commodities.

All projects must be tied to the development of markets and promotion of climate-smart commodities. Markets for climate-smart commodities may include companies or processors sourcing climate-smart commodities to meet internal targets or other supply chain goals, biofuel and renewable energy markets, companies seeking to sell branded consumer products, or other opportunities that could provide a premium or additional revenue for participating producers and landowners. Sufficient incentives to encourage producer participation, as well as generation of verifiable greenhouse gas reductions and carbon sequestration are critical to project success.

(7) Policy.

This directive further describes the responsibilities related to Partnerships for Climate-Smart Commodities.

(8) Responsibilities.

See Topic-Specific Sections

(9) Topic-Specific Sections.

a. General Administration

i. Overview

This section provides information on the general administration information for Partnerships for Climate-Smart Commodities.

ii. Roles and Responsibilities

1. NHQ Climate-Smart Commodities Team

In general, Partnerships for Climate-Smart Commodities will be administered by a National Headquarters team with leadership from the Under Secretary for Farm Production and Conservation and the Chief of NRCS with strong support and collaboration from the FSA Administrator and leaders across the Department.

The Director of Climate-Smart Commodities, currently the Acting Senior Advisor for Climate-Smart Commodities, will lead the team with a staff that includes an Acting Deputy Director, Acting Division Directors and Acting National Program Officers (NPOs). The NPOs are responsible for negotiating agreements, administrative tasks associated with the agreements, and general oversight of a suite of projects under the opportunity. The NPOs will be the primary contact with the grant recipients.

2. State and County Offices (NRCS/FSA)

Each State Executive Director and State Conservationist will identify a separate State Climate-Smart Commodities POC. The NRCS and FSA State Climate-Smart Commodities POCs will be the primary contacts with the NPOs and also the primary contacts for any field office staff that need to be engaged for Partnerships for Climate-Smart Commodities related activities in their respective agencies. Field office staff should direct any questions on Partnerships for Climate-Smart Commodities to their respective Agency's State Climate-Smart Commodities POC, who will then engage the appropriate NPO as needed.

3. Grant Recipient

Each grant recipient will be responsible for implementation of the Partnerships for Climate-Smart Commodities project, including all technical assistance with project producers.

4. Contractors

Various contractors may be leveraged by USDA at the Headquarters or State level or by grant recipients under their grant agreements. The primary contract discussed in this

guidance is a headquarters contractor that will assist with cultural and environmental survey activities.

5. Producers

Producers are beneficiaries of Partnerships for Climate-Smart Commodities as the USDA Partnerships for Climate-Smart Commodities grants are applying climate-smart practices and building climate-smart markets to benefit producers.

iii. Actions

1. NHQ Climate-Smart Commodities Team

NHQ Climate-Smart Commodities Team will follow the provisions of this directive and associated guidance.

2. State and County Offices (NRCS/FSA)

State and County Offices will follow the provisions of this directive and associated guidance.

Each State Executive Director and State Conservationist will identify a separate State Climate-Smart Commodities POC. The name of the State POC should be submitted by the State Executive Director or State Conservationist to **climate-smart-commodities@usda.gov** by Thursday, **April 27, 2023**.

iv. Funding Codes

1. NRCS

With regard to Partnerships for Climate-Smart Commodities, NRCS will use Conservation Technical Assistance funds for HELC/WC technical assistance and NHQ will provide fund codes for activities related to Environmental and Cultural Resources.

2. FSA

FSA will use the Activity Reporting System codes: Program "Farm Records" and Activity "NRCS Support" for the activities related to creating Farm/Tract/Field for new customers and providing copies of maps and subsidiary prints to producers who request them for their participation in Partnerships for Climate-Smart Commodities.

FSA will use the Activity Reporting System codes: Program "Eligibility" and Activity "NRCS Support" for the activities related to completing eligibility forms including the CCC-902, AD-2047 and AD-1026.

3. Other Information

Additional Partnerships for Climate-Smart Commodities funding may be made available in the future. States will be notified accordingly.

b. Producer Eligibility and Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) Compliance

i. Overview

In order to be eligible for an incentive payment as a part of the Partnerships for Climate-Smart Commodities, a producer must:

1. Establish Farm Records with the Farm Service Agency (have farm, tract, and fields numbers in place);
2. Complete an AD-2047 (Customer Data Worksheet to facilitate the collection of customer data for Business Partner Record);
3. Certify HELC and WC compliance via Form AD-1026, Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) Certification; and
4. Certify that they are not a foreign person or entity.

Farm, tract, and field numbers are required for the producer, and ultimately the Partnerships for Climate-Smart Commodities grant recipient, to report climate-smart practice implementation to USDA, as well as to certify and maintain HELC/WC compliance. This will require that some producers that do not already have these records, like perennial crop growers, feedlots or forest land owners, establish these records with USDA.

Producers are not bound by the payment limitations and the adjusted gross income (AGI) limitations that are in place for other USDA programs.

In order to demonstrate HELC/WC compliance for Partnerships for Climate-Smart Commodities incentive payments, producers will need to request a copy of their subsidiary print from their **USDA Service Center**. The producer will then provide this documentation to the Partnerships for Climate-Smart Commodities grant recipient as proof of compliance. A current year subsidiary print will be required for each crop year that the producer receives a payment, and HELC/WC eligibility information is provided under the AD-1026 and Conservation Compliance sections of subsidiary (determined by year, which can change at any time during the year or in a subsequent year). As is the case already, field office staff will not provide documentation to anyone besides the producer unless they have provided a written authorization, according to normal policy. Producers will need to demonstrate to the grant recipient that they have control of the land for the term of their beneficiary contract.

ii. Roles and Responsibilities

1. NHQ Climate-Smart Commodities Team

The National Program Officers (NPOs) will clarify the process for determining eligibility, HEL/WC compliance and the grant requirements with the Partnerships for Climate-Smart Commodities grant recipient. The NPOs will provide a training module for the grant recipient to ensure expectations are clear and grant recipients understand the producer documentation.

The NPOs will facilitate back-end checks on producers to determine if they have later been determined out of compliance.

The NPOs will troubleshoot any issues that the grant recipients are having with HELC/WC compliance eligibility, including eligibility determination backlogs.

2. State and County Offices (NRCS/FSA)

FSA county office staff will create farm records including farm, tract, and field numbers as requested by a producer. They will forward the AD-1026 with requests for technical determinations to NRCS, as needed. The county office staff will also provide a map and subsidiary prints to a producer as requested.

FSA county office staff will collect new producer information using business file and complete the CCC-902 and AD-2047, as requested by a producer.

There are no additional tasks expected of county office staff. However, county office staff may see an increase in related HELC/WC workload triggered by an increase in technical determinations.

NRCS State Conservationists and FSA State Executive Directors will monitor any backlogs of eligibility determinations or Farm Record establishment, and address issues accordingly. For HELC/WC compliance under Partnerships for Climate-Smart Commodities, the NRCS and FSA roles are the same as it would be for any other customer. The State Climate-Smart Commodities POCs may be notified by the NPO that a particular project has encountered a backlog in determinations, who will work with their state leadership to help address any resource needs.

3. Contractors

A Partnerships headquarters contractor may assist with the back-end checks on producers to determine if they have not maintained compliance.

4. Grant Recipients

Grant recipients are responsible for determining producer eligibility within the funding opportunity requirements. Partners will inform producers of eligibility requirements and direct them to local USDA offices for requested information as necessary, including but not limited to, farm and tract establishment, HELC/WC determinations, and environmental evaluations (described further in section D). Privacy of producers is a priority through this process.

At minimum, the grant recipients will collect and review subsidiary reports from participating producers. They will ensure that the producer is listed as “certified” for AD-1026 and “compliant” in all sections of the conservation compliance portion of subsidiary before an incentive payment is made. They will also check that the Subsidiary Print for "Foreign Person" indicates "Not Applicable". Farm, tract, field numbers and producer name will be provided to the National Program Officer as a part of routine grant reporting.

5. Producers

The producer will work with FSA to establish farm records and complete an AD-1026, if they have not already. Producers will request records from their **USDA Service Center** as needed to voluntarily participate in a Partnerships for Climate-Smart Commodities project.

The producer will complete the CCC-902 and AD-2047 at the FSA County Office, if they have not already. Producers will request records from their **USDA Service Center** as needed to participate in a Partnerships for Climate-Smart Commodities project.

c. Reporting and Duplicate Payments

i. Overview

USDA's robust data and learning strategy for Partnerships for Climate-Smart Commodities will include requirements for grantees to submit the following information as part of their quarterly reporting:

1. Progress reports and updates on farm, tract, and field data including, but not limited to, producers enrolled, acres, crops, and livestock covered, climate-smart practices implemented and related incentives;
2. Updates on project summary data including geographic data, partner activities, and marketing activities as well as financial and budget information;
3. Measurement/Quantification, Monitoring, Reporting and Verification (MMRV) methods, modeled and measured GHG benefits, and environmental co-benefits including, as applicable water, air, and habitat related benefits.
4. Other periodic updates on supplemental data, including information related to the MMRV plan and direct field measurement results will also be required.

Additional reporting and data sharing requirements may apply at time of award. Certain reporting elements will be required to be georeferenced. Financial reporting will also be required consistent with 2 CFR 200. Spot checks may be required upon review of reporting documents or other USDA analyses. Data will be submitted through a secure portal where producer privacy will be protected according to applicable laws.

Data will be available internally to be compared with NRCS data.

ii. Roles and Responsibilities

1. NHQ Partnerships Team

NPOs will monitor quarterly and ad hoc data reporting from grant recipients. NPOs will also use automated dashboards to check for potential overlap on each practice-field combination on a quarterly basis after the partners provide reporting. If a potential duplicate is identified, the NPO will notify the State Climate-Smart Commodities POCs for further review.

If the State Climate-Smart Commodities POC confirms a duplicate payment **and** the obligation dates indicate that the Climate-Smart Commodities contract was **after** the date of the NRCS or FSA direct producer contract, then the NPO will notify the grant recipient that the producer beneficiary contract funds must be recovered.

2. State and County Offices (NRCS/FSA)

The State Climate-Smart Commodities POCs will receive a list of suspected duplicate payments from the NPO, research and provide findings to the NPO.

If the State Climate-Smart Commodities POC confirms a duplicate payment and the obligation dates indicate that the Climate-Smart Commodities contract was **before** the date of an NRCS or FSA direct producer contract, then the State Climate-Smart Commodities POC will notify the appropriate county office staff that the contract funds must be recovered.

Provide potential duplicate payments to NPO if found through county office staff normal reviews.

**Note:** If funding was for an enhancement beyond what was done originally through FSA/NRCS, repayment is not needed.

3. Contractors

Headquarters contractors will be leveraged to develop dashboards and other data analysis resources.

4. Grant Recipients

Grant recipients will provide required reporting and attest that producers and land owners will not be involved in multiple USDA programs that fund the same practice on the same land. Federal funds under this funding opportunity may not be used to pay for implementation of the same practice on the same land, but funding may be used to enhance a practice or to further incentivize the climate-smart commodity generated, especially with respect to early adopters.

5. Producers

Producers must ensure and certify that they are not receiving a payment for the same practice on the same land at the same time.

d. Environmental and Cultural Resources Review

i. Overview

A Finding of No Significant Impact (FONSI) was signed by USDA NRCS on August 26, 2022, for Partnerships for Climate-Smart Commodities. A copy of the Programmatic Environmental Assessment for Partnerships for Climate-Smart Commodities is available at **www.usda.gov/climate-smart-commodities** . The overall impacts of the funding

opportunity, including those to cultural resources, were considered in the Programmatic EA. Additional project or site specific cultural and environmental analysis may be identified to tier to this Programmatic EA and comply with other relevant laws.

The grant recipient is responsible for all technical assistance, including planning practices consistent with NRCS practice standards, interim practice standards and/or alternative practice standards and providing information for any site specific environmental review.

ii. Roles and Responsibilities

1. NHQ Partnerships Team

Following grant agreement execution, NPOs will send a copy of the Project Environmental and Cultural Resources Letter to the grant recipient and the NRCS State POC. On a project by project basis, this letter will be signed by the Acting Director for Climate-Smart Commodities on behalf of the NRCS Chief and delineate whether any additional site specific environmental or cultural resources review will be required by practice for the project. NPOs will coordinate with State POCs and also headquarters contractors and recipients to ensure sufficient information is provided for site specific review as needed.

2. State and County Offices (NRCS)

As requested, the NRCS State Climate-Smart Commodities POCs will ensure required CPA-52s are completed and signed in a timely manner. NRCS State Climate-Smart Commodities POCs will review Environmental Evaluation information developed by the Partner (and checked by the Contractor) to ensure that adverse impacts have been minimized, and also will work with appropriate State Office staff and the Contractor to complete any required consultations. NRCS State POCs will ensure the site-specific CPA-52s are completed and signed by the appropriate Responsible Federal Official (RFO) in the State Office.

3. Contractors

Headquarters contractors will review information on the CPA-52s submitted by the recipients and prepare consultation materials as needed. Contractors may reach out to the grant recipients, in coordination with the NPO, for additional information prior to signature or any associated consultations.

4. Grant Recipients

Grant recipients must complete the CPA-52 through Section O for each field where site-specific review is required. The recipient must then send the CPA-52 in a zipped, password protected file to **climatesmart@clarkgroupllc.com** (or a designated website provided by the NPO) for completion and signature by USDA. Recipients must not execute a beneficiary contract for a field where a CPA-52 is required until they receive a CPA-52 for that field that is signed by a USDA representative.

5. Producers

Producers will provide information to the grant recipient as requested when signing up for a particular project.

6. Site Specific Environmental and Cultural Resources Review Step Chart

If a project requires site specific review, then the following step chart should be followed.

<table>
<tr><td>Step</td><td>Climate-Smart Commodities Environmental & Cultural Resources Compliance Review Process</td></tr>
<tr><td>1</td><td>Recipient completes any required site-specific Environmental Evaluation (EE) CPA-52 completed through Section O for each applicable producer beneficiary contract and submits in a zipped, password protected file to climatesmart@clarkgroupllc.com (or a designated website provided by the NPO). Go to Step 2.</td></tr>
<tr><td>2</td><td>Contractor reviews CPA-52 information. Go to Step 3.</td></tr>
<tr><td>3</td><td><table><tr><td>If Consultation is…</td><td>THEN…</td></tr><tr><td>Required</td><td>Go to step 4.</td></tr><tr><td>Not required</td><td>Go to step 7.</td></tr></table></td></tr>
<tr><td>4</td><td>Contractor drafts consultation package. Go to Step 5.</td></tr>
<tr><td>5</td><td>Contractor provides the NRCS State Climate-Smart Commodities POC with the consultation materials (with cc: to NPO), and state staff performs necessary consultation. Go to Step 6.</td></tr>
<tr><td>6</td><td><table><tr><td>If consultation concurrence is…</td><td>THEN…</td></tr><tr><td>Received</td><td>Go to step 7.</td></tr><tr><td>Not received</td><td>Tract is ineligible for Project</td></tr></table></td></tr>
<tr><td>7</td><td>Contractor updates CPA-52 to reflect consultation outcome (if any). Go to Step 8.</td></tr>
<tr><td>8</td><td>Contractor sends CPA-52 with attachments to the NRCS State Climate-Smart Commodities POC (with cc: to NPO). Go to Step 9.</td></tr>
<tr><td>9</td><td>NRCS State Climate-Smart Commodities POC uses state-defined review process to review. Go to Step 10.</td></tr>
</table>

<table>
<tr><td>10</td><td><table>
<tr><td>If additional information is…</td><td>THEN…</td></tr>
<tr><td>Needed</td><td>Go to step 11A.</td></tr>
<tr><td>Not needed</td><td>Go to step 11B.</td></tr>
</table></td></tr>
<tr><td>11A</td><td>NRCS State Climate-Smart Commodities POC requests additional information from contractor (and cc: NPO). Go to Step 4 or Step 12 as indicated.</td></tr>
<tr><td>11B</td><td>NRCS State Climate-Smart Commodities POC will ensure that the CPA-52 is signed by an appropriate NRCS representative in their state. The NRCS State POC then completes the form at Partnership for Climate Smart CPA-52 Submission Portal (office.com), attaches the signed CPA-52 and submits the form. The signed CPA-52 will be the official record. Go to Step 13.</td></tr>
<tr><td>12</td><td>Contractor develops other requested information. Go to Step 8.</td></tr>
<tr><td>13</td><td>NPO maintains record of completed CPA-52’s using SharePoint database. Go to Step 14.</td></tr>
<tr><td>14</td><td>Partner receives signed, site-specific CPA-52 from automated system.</td></tr>
</table>

**Note:** Consultation refers to a consultation for Section 7 of the Endangered Species Act, Section 106 of the National Historic Preservation Act or other special environmental concerns.

Zach Ducheneaux
Administrator
Farm Service Agency

# EXHIBIT V

Archived version as of 01/12/2025

The Wayback Machine - https://web.archive.org/web/20250112215121/https://www.rd.usda.gov/no…
An official website of the United States government Here's how you know

USDA Rural Development
U.S. DEPARTMENT OF AGRICULTURE

# Empowering Rural America New ERA Program

Application Window:
**CLOSED**

Program Application Period:
**Application Opened on July 31, 2023**
**Application Closed on September 15, 2023**

**Fact Sheet (/web/20250112215121/https://www.rd.usda.gov/media/file/download/rd-fs-rus-newera-final508.pdf)**

**Federal Register Notice (https://web.archive.org/web/20250112215121/https://www.govinfo.gov/content/pkg/FR-2023-05-16/pdf/2023-10392.pdf)**

## Overview

### Inflation Reduction Act

- Inflation Reduction Act by USDA (https://web.archive.org/web/20250112215121/https://www.usda.gov/ira)
- Inflation Reduction Act for Rural Development (/web/20250112215121/https://www.rd.usda.gov/inflation-reduction-act)

- Rural Energy for America by Rural Development (/web/20250112215121/https://www.rd.usda.gov/node/28570)
- IRA Climate and Clean Energy Solution Investment Factsheets by state for NRCS & Rural Development (https://web.archive.org/web/20250112215121/https://www.nrcs.usda.gov/about/priorities/inflation-reduction-act/inflation-reduction-act-investments-by-state)

## Review the Inflation Reduction Act Frequently Asked Questions (/web/20250112215121/https://www.rd.usda.gov/inflation-reduction-act/ira-faqs)

RUS is extending the closing date for New ERA LOI submissions to **September 15, 2023**. LOIs shall be submitted through Grants.gov. Further information on how to submit an LOI at Grants.gov will be provided in a forthcoming Federal Register notice, as well as via an application guide.

## Frequently Asked Questions

- Frequently Asked Questions: Accounting Treatment for Forgiven Loans (/web/20250112215121/https://www.rd.usda.gov/media/file/download/faq-accounting-treatment-extinguished-or-forgiven-loans.pdf)

## Federal Register Notice - 7/27/2023

Announcement (https://web.archive.org/web/20250112215121/https://www.govinfo.gov/

content/pkg/FR-2023-07-27/pdf/2023-15897.pdf)of the opening of the online application window for the New ERA Program.

### Latest version of the GHG ART Template – 8/25/2023

The latest version of the Greenhouse Gas (GHG) Achievable Reduction Tool (ART) is available. Please use the latest version of this template (v4.2c Template7-08252023). Template 7 includes enhanced "Error" flags in Tables 2 and 3. Template 7 does not change any of the calculations from Template 6. Please check back periodically for any other updates to the ART tool.

## What does this program do?

The Empowering Rural America (New ERA) program helps rural Americans transition to clean, affordable, and reliable energy. By reducing air and water pollution, New ERA funding improves health outcomes and lower energy costs for people in rural communities. New ERA program funding is available to member-owned rural electric cooperatives, which have been the backbone of America's rural power delivery for nearly a century.

This $9.7 billion program is part of the Inflation Reduction Act (https://web.archive.org/web/20250112215121/https://www.rd.usda.gov/inflation-reduction-act) and represents the largest investment in rural electrification since President Franklin Delano Roosevelt signed the Rural Electrification Act into law in 1936.

## Who can apply for this program?

The New ERA program is available only to rural electric cooperatives, including:

- Existing or former USDA Rural Utilities Service (RUS) borrowers
- Borrowers of the former Rural Electrification Administration
- Rural electric cooperatives that serve predominantly rural areas
- Wholly or jointly owned subsidiaries of rural electric cooperatives

**Note**: For the purposes of the New ERA program, the term "predominantly rural" means a service territory where at least 50 percent of its consumers are rural.

To create opportunities for rural electric cooperatives of all sizes – and to ensure cooperatives compete only against their peers – New ERA applicants are separated into three categories:

- Category 1: Total utility plant value equal to or more than $500 million
- Category 2: Total utility plant value more than $200 million and less than $500 million
- Category 3: Total utility plant value equal to or less than $200 million

## Are there any additional eligibility requirements?

Yes. You must demonstrate that your proposed project is eligible, financially and technically feasible, affordable, and reliable. If selected, you will be required to provide reasonably adequate security for financed investments. All projects must be completed and verified by September 30, 2031.

## How can funds be used?

Funds can be used to make energy efficiency improvements to eligible generation and transmission systems, to purchase, build, or deploy renewable energy, zero-emission systems, carbon capture storage systems, or to purchase renewable energy.

The New ERA program is designed to be flexible. The program

prioritizes greenhouse gas reductions rather than requiring the use of specific technologies. For example, you can seek funding for renewable and zero-emission systems that eliminate aging, obsolete, or expensive infrastructure. You can also change your purchased-power mixes to support cleaner portfolios, manage stranded assets, and boost your transition to clean energy.

Applications will be scored and ranked on the greatest reduction in cost-per-unit measure of greenhouse gases. Projects must be reliable, resilient (able to recover quickly following an unexpected disruption), and affordable. The cost of unit of reduction will be considered. We encourage applicants to think ambitiously! Maximize your technical options to bring about the greatest reduction in greenhouse gas emissions to create jobs and economic opportunity, and improve the quality of life in your rural communities.

## What types of funding are available?

You can apply for the following types of financial assistance:

- **Loan only**: The interest rate (https://web.archive.org/web/20250112215121/https://www.rd.usda.gov/page/rural-utilities-loan-interest-rates) for loans will be set either at the U.S. Treasury rate or at a fixed rate as low as 2 percent. Treasury interest rates are set at the time funds are drawn. These rates are set periodically. A zero percent interest rate is available to refinance stranded assets or for projects that serve predominantly distressed, disadvantaged, or energy communities (as defined in the funding notice).

- **Grant only:** Applicants can apply for a grant only that equals no more than 25 percent of the total project cost. Applicants would have to demonstrate the ability to meet the remaining 75 percent of the project cost.

**Loan and Grant Combinations**: Applicants can request loan and grant combination financing for proposed projects.

- **Loan Refinancing or Loan Modification**: In addition to loan and

grant combinations, applicants may propose to refinance debt related to a stranded asset if the applicant utilizes the refinancing savings to fund an eligible project. No single borrower or awardee can receive more than 10 percent of the available funding, which is $970 million of the $9.7 billion available in this program.

## How do we get started?

To be considered for funding, you must first submit a Letter of Interest (LOI). The LOI window is open from July 31 through September 15, 2023. You are welcome to partner with other eligible cooperatives and submit your proposal or proposals in a single LOI.

- RUS will begin evaluating and scoring LOIs after the September 15, 2023 deadline.
- Invitations to submit an Application will be sent to top-ranking LOIs.
- A successful application must meet all program requirements. Scoring and ranking will be re-evaluated prior to funding.

Additional information about the New ERA program is available in the Notice of Funding Opportunity (NOFO) published in the Federal Register and on the USDA Rural Development Inflation Reduction Act (/web/20250112215121/https://www.rd.usda.gov/inflation-reduction-act). Click the plus sign to the right of “Funding Opportunities,” and see the first bullet point: “Section 22004.”

## Who can answer questions?

- Reference the list of Frequently Asked Questions (FAQs) (/web/20250112215121/https://www.rd.usda.gov/inflation-reduction-act/ira-faqs)
- You can email New ERA program questions to: RD.RUS.IRA.Questions@usda.gov (https://web.archive.org/web/20250112215121/mailto:SM.RD.RUS.IRA.Questions@usda.gov)

## What governs this program?

Section 22004 of the Inflation Reduction Act (7 USC 8103 (j)) (https://web.archive.org/web/20250112215121/https://www.rd.usda.gov/sites/default/files/USDA_IRA_RDExtract.pdf) governs the New ERA program.

## To Apply

### Latest version of the GHG ART Template – 8/25/2023

The latest version of the Greenhouse Gas (GHG) Achievable Reduction Tool (ART) is available. Please use the latest version of this template (v4.2c Template7-08252023). Template 7 includes enhanced "Error" flags in Tables 2 and 3. Template 7 does not change any of the calculations from Template 6. Please check back periodically for any other updates to the ART tool.

The Agency will open a Grants.gov opportunity by notice in the Federal Register, the RUS website at Empowering Rural America (New ERA) Program (/web/20250112215121/https://www.rd.usda.gov/node/28986), and Grants.gov on or before July 31, 2023.

To be considered for funding, you must first submit a Letter of Interest (LOI). The LOI window is open from July 31 through September 15, 2023. You are welcome to partner with other eligible cooperatives and submit your proposal or proposals in a single LOI.

- RUS will begin evaluating and scoring LOIs after the September 15, 2023 deadline.
- Invitations to submit an Application will be sent to top-ranking LOIs.

- A successful application must meet all program requirements. Scoring and ranking will be re-evaluated prior to funding.

Additional information about the New ERA program is available in the Notice of Funding Opportunity (NOFO) published in the Federal Register (https://web.archive.org/web/20250112215121/https://www.govinfo.gov/content/pkg/FR-2023-05-16/pdf/2023-10392.pdf), and on the USDA Rural Development Information Reduction Act (/web/20250112215121/https://www.rd.usda.gov/inflation-reduction-act)webpage. Select Funding Opportunities," and see the first bullet point: "Section 22004."

PPAs Under New ERA (/web/20250112215121/https://www.rd.usda.gov/media/file/download/usda-rd-ppas-under-new-era.pdf)

**ART** RUS IRA GHG Calculator (/web/20250112215121/https://www.rd.usda.gov/media/file/download/rus-ira-ghg-calculator-v42c-template7-08252023.xlsx)

**Achievable Reduction Tool (ART)**The purpose of the ART workbook is to provide a simple GHG calculator that will estimate emission reductions generally in a standard manner that allows for a direct comparison of Letters of Interest (LOIs) on an equal or "apples-to-apples" basis. Eligible Entities will be requested to attach the completed calculator spreadsheet to the SF 424 in Grants.gov. We are providing it here along with generic examples for informational purposes.

## Generic Test Cases

- Generic G&T1 Renewables and Non ZE Phase Down (/web/20250112215121/https://www.rd.usda.gov/media/file/download/usda-rd-rus-ghg-generic-gt1-renewables-and-non-ze-phase-down-05232023)
- Generic G&T2 - Renewables Additions (/web/20250112215121/https://www.rd.usda.gov/media/file/download/usda-rd-rus-ghg-generic-gt2-renewables-additions-05232023)
- Generic Distribution Coop - Renewables Additions (/

web/20250112215121/https://www.rd.usda.gov/media/file/download/usda-rd-rus-ghg-generic-distrib-coop-renewables-addns-05232023)

- Subsidiary Project Developer With No System Data (/web/20250112215121/https://www.rd.usda.gov/media/file/download/usda-rd-rus-ghg-subsid-proj-developer-w-no-system-data-05232023)

## Additional Resources

- USDA Rural Development PACE and New ERA Joint Application Model (/web/20250112215121/https://www.rd.usda.gov/media/file/download/rd-rus-pace-new-era-joint-application-process-models-06272023.pdf)
- Stranded Investment Calculator Sample (/web/20250112215121/https://www.rd.usda.gov/media/file/download/sample-stranded-investment-calculator-06272023.xlsx)
- Letter of Interest (/web/20250112215121/https://www.rd.usda.gov/media/file/download/final-sample-letter-interest-new-era-07242023.pdf)Sample (/web/20250112215121/https://www.rd.usda.gov/media/file/download/final-sample-letter-interest-new-era-07242023.pdf)
- IRA Section 22004 New ERA Letter of Interest Guide (/web/20250112215121/https://www.rd.usda.gov/media/file/download/rus-ira-newera-program-guide-loi-stage82323.pdf)

## Other Requirements

## Contact

You can email New ERA program questions to: SM.RD.RUS.IRA.Questions@usda.gov (https://web.archive.org/web/20250112215121/mailto:sm.rd.rus.ira.questions@usda.gov)

## Events

# Upcoming Webinars

**NOTE:** Webinars will be recorded for interested parties who are not able to attend. Once they are available, the recordings will be posted here.

# Past Webinars

**Rural Clean Energy Federal Funding Fair (EPA's Greenhouse Gas Reduction Fund, DOE's ERA, US TREAS on Direct Pay, and USDA's REAP and RUS Electric Programs)**

- When: May 28, 2024 l Webinar Recording (EPA, DOE, US TREAS, USDA RD) (https://web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=iqwMotn-L4s)

**Rural Clean Energy Federal Funding Fair (USDA's REAP and RUS Electric Programs, DOE's GDO, and TREAS on Direct Pay)**

- When: April 9, 2024 l Webinar Recording (US TREAS on Direct Pay) and Webinar Recording (DOE's Grid Deployment Office & USDA's REAP and RUS Electric Programs)

**Rural Clean Energy Federal Funding Fair (REAP, RUS, ERA, Direct Pay)**

- **When:** March 14 l Webinar Recording (REAP and ERA) (https://web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=MYai7bwveyc) and Webinar Recording (RUS Electric Program and Direct Pay) (https://

web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=EqHUM3jj4Dg)

## New ERA Office Hours

- **When:** Aug 15 | Webinar Recording (https://web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=LovpnFwo4MA)

## Investing in America: REAP IRA Technical Assistance Update

- **Description:** This announcement will be most valuable for those who engage in, or seek to engage in, technical assistance for applicants to the REAP program funded by the Inflation Reduction Act.
- **When:** July 13 | Webinar Recording (https://web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=ffYFHnMJ5V0)

## New ERA Program and Greenhouse Gas Calculator Overview

- **When**: June 8 (https://web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=xDIJWOONVjg) | Webinar

## Office Hours for USDA PACE and New ERA Programs

- **When:** June 22 Webinar (https://web.archive.org/web/20250112215121/https://youtu.be/wLPgPRgS2qI) | July 6 (https://web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=T0tngh6nML0)

## Overview of funding available through IRA

- **Description:** RUS will provide background on the NOFOs for PACE and New ERA that were published in the Federal Register on May 16, 2023. RUS will also provide a brief overview of how these programs compare to other federal clean energy programs

in rural America.

- **When:** May 22 Webinar (https://web.archive.org/web/20250112215121/https://youtu.be/yzh8BexQZWg) | May 24 Webinar (https://web.archive.org/web/20250112215121/https://youtu.be/SYMZHcTy7Vk) | May 31 Webinar | June 1 Webinar (https://web.archive.org/web/20250112215121/https://www.youtube.com/watch?v=L8cAHDrZeck)

## RUS update on IRA funding

- **Description:** The Rural Utilities Service (RUS) will provide general background information on the Notice of Funding Opportunity (NOFO) for both its Powering Affordable Clean Energy (PACE) program under Section 22001 and New Empowering Rural America (New ERA) program under Section 22004 of the IRA.
- **When:** May 17 Webinar (https://web.archive.org/web/20250112215121/https://youtu.be/TGu9wJ_B4dU)

Live version as of 2/20/2025

An official website of the United States government Here's how you know

**Official websites use .gov**
A **.gov** website belongs to an official government organization in the United States.

**Secure .gov websites use HTTPS**
A **lock** (🔒) or **https://** means you've safely connected to the .gov website. Share sensitive information only on official, secure websites.

USDA Rural Development
U.S. DEPARTMENT OF AGRICULTURE

Oops! File Not Found

# Perhaps you were looking for one of these areas?

## Programs & Services (/programs-services)

All Programs (/programs-services/all-programs)

Loan Turn Times (/page/sfh-guaranteed-lender)

Lender Training (/page/usda-linc-training-resource-library)

## Newsroom (/newsroom)

News Releases (/newsroom/news-releases)

Stakeholder Announcements (/newsroom/stakeholder-announcements)

Funding Opportunities (/newsroom/federal-funding-opportunities)

## Resources (/resources)

Publications (/resources/publications)

Regulations and Guidance (/resources/regulations)

Handbooks (/resources/directives/handbooks)

**Still need help? Try our general contact information (/browse-state) or email rdwebmaster@usda.gov (mailto:rdwebmaster@usda.gov) for technical assistance.**

# EXHIBIT W

Archived version as of 01/17/2025

The Wayback Machine - https://web.archive.org/web/20250117222002/https://www.fs.usda.gov/...

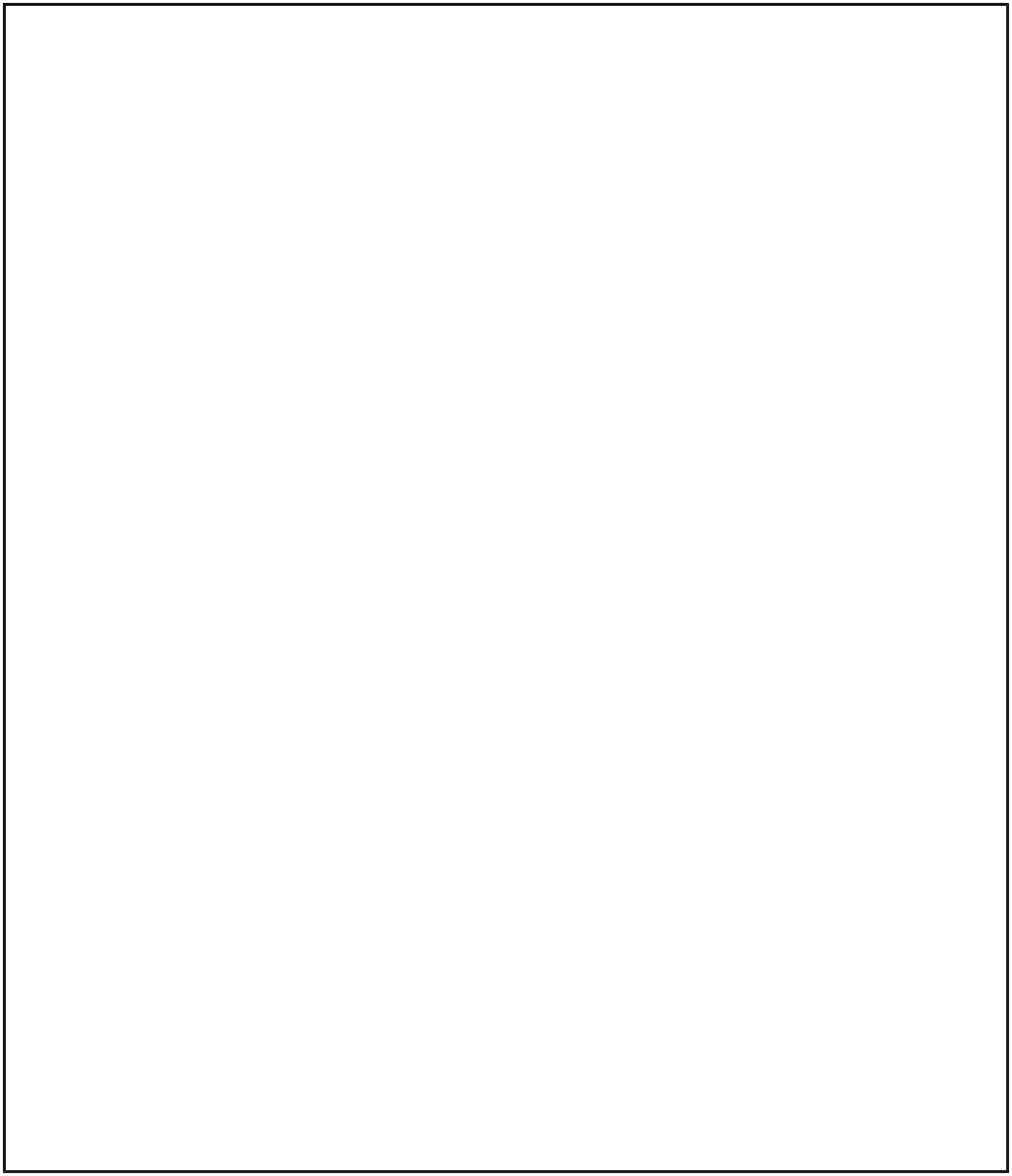
An official website of the United States government Here's how you know



# Climate Tools and Data

Adapting to climate change requires the use of the latest climate data, information, and tools. The Forest Service has developed a variety of products to support climate-informed decision-making.

Source: https://usfs.maps.arcgis.com/apps/MinimalGallery/index.html?appid=74a3d16ebea445e1b8c81423081e8fd1



## Sustainability and Climate

- Adaptation
- Carbon
- **Climate Tools and Data**
- Policy and Initiatives
- Sustainable Operations
- Vulnerability Assessments
- Climate Action Tracker

## Related Content

- Climate Change Resource Center
- USDA Climate Hubs
- Adaptation Partners
- Northern Institute of Applied Climate Science

## Managing the Land

- Fire Management
- Forests and Grasslands
- International Cooperation
- Invasive Species



**Forest Service**
U.S. DEPARTMENT OF AGRICULTURE

Live version as of 2/20/2025

You are not authorized to access this page.

## Managing the Land

- Fire Management
- Forests and Grasslands
- International Cooperation
- Invasive Species
- Land Management Planning
- Lands and Realty Management
- Natural Resources
- Private Land
- Recreation Management
- Urban Forests



**Forest Service**
U.S. DEPARTMENT OF AGRICULTURE

# EXHIBIT X

Archived version as of 01/17/2025

The Wayback Machine - https://web.archive.org/web/20250117222108/https://www.fs.usda.gov/...
An official website of the United States government Here's how you know



# Climate Action Tracker

The Climate Action Tracker is the primary reporting and tracking tool for the Forest Service on climate change actions. The information from the tracker is used to inform agency operations and investments toward becoming a 100 percent climate positive agency. Progress in the tracker is measured across four dimensions: Serving People, Organizational Capacity, Natural Resources Stewardship, and Operations and Infrastructure. Each dimension has a broader goal supported by several specific strategic objectives.




## 2023 Progress Report

Fiscal Year 2023 marks the second year of reporting on agency progress using the Climate Action Tracker. The 2023 Full Report (PDF, 9.3 MB) and 2023 Executive Summary (PDF, 940 KB) highlights agency progress across the four tracker dimensions and 13 strategic objectives. The Climate Action Tracker also includes a summary of Regional Climate Action Plans that were developed by each Forest Service region in 2023.

## Sustainability and Climate

Adaptation

- Carbon
- Climate Tools and Data
- Policy and Initiatives
- Sustainable Operations
- Vulnerability Assessments
- **Climate Action Tracker**

## Managing the Land

- Fire Management
- Forests and Grasslands
- International Cooperation
- Invasive Species
- Land Management Planning
- Lands and Realty Management
- Natural Resources
- Private Land
- Recreation Management
- **Sustainability and Climate**
- Urban Forests

Policies & Links

Our Performance

Careers

Fraud, Waste, and Abuse Hotline

Inspector General

Plain Writing

Open

FOIA

Accessibility Statement

Privacy Policy

Non-Discrimination Statement

USDA Anti-Harassment Policy

Forest Service Anti-Harassment Policy

Information Quality

USA.gov

Whitehouse.gov

eGov

No FEAR Act Data

Whistleblower Protection Coordinator

**Forest Service**
U.S. DEPARTMENT OF AGRICULTURE

Live version as of 2/20/2025

An official website of the United States government Here's how you know

Forest Service
U.S. DEPARTMENT OF AGRICULTURE

MENU

Home ▸ system ▸ Access denied

You are not authorized to access this page.

## Managing the Land

- Fire Management
- Forests and Grasslands
- International Cooperation
- Invasive Species
- Land Management Planning
- Lands and Realty Management
- Natural Resources
- Private Land
- Recreation Management
- Urban Forests

Accessibility Statement
Privacy Policy
Non-Discrimination Statement
USDA Anti-Harassment Policy
Forest Service Anti-Harassment Policy
Information Quality
USA.gov
Whitehouse.gov
eGov
No FEAR Act Data
Whistleblower Protection Coordinator

**Forest Service**
U.S. DEPARTMENT OF AGRICULTURE

# EXHIBIT Y

Archived version as of 01/17/2025

The Wayback Machine - https://web.archive.org/web/20250117230420/https://www.nrcs.usda.gov/conser...

An official website of the United States government Here's how you know





# Adaptation



Adaptation actions can be taken in response to local climate change impacts and projections to reduce risks and vulnerabilities, build resilience and help to maintain productivity.

Climate change poses environmental, social, and agricultural challenges that require adaptation measures to help adjust to new or changing climatic patterns. Adaptation actions can be taken in response to local climate change impacts and projections to reduce risks and vulnerabilities, build resilience and help to maintain productivity. Adaptation actions in agriculture may include changing or adjusting various management practices and inputs, including nutrient inputs, tillage practices, crop species, crop rotations, harvest strategies, livestock management, irrigation, and uses of natural resources.

NRCS along with other USDA agencies provides resources, tools, programs and services to assist agricultural producers in understanding and adapting to the impacts of climate change they face. NRCS can support producers who want to voluntarily implement climate-smart management solutions to help adapt their operations and build resilience, while maintaining productivity and conserving and restoring the natural resources on their lands. NRCS also helps producers pursue voluntary Climate-Smart Mitigation Activities (/web/20250117230420/https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/climate/climate-smart-mitigation-activities) that address the causes of climate change by reducing greenhouse gas emissions and increasing carbon sequestration on their operations. Many of these mitigation activities may provide adaptation benefits as well.



The NRCS Climate Change Adaptation Plan highlights seven areas identified as key agency vulnerabilities and prioritized actions to address them.

**DOWNLOAD THE PLAN** →

## USDA and NRCS Climate Change Adaptation Plans

Climate change has the potential to disrupt USDA's efforts to meet its mission and goals. The vulnerability of USDA operations and programs to climate change is highly dependent on the magnitude and pattern of climate changes and their local impacts.

In October 2021 (https://web.archive.org/web/20250117230420/https://www.usda.gov/media/press-releases/2021/10/07/usda-announces-plan-integrate-climate-adaptation-its-missions-and), USDA released its Department-wide Action Plan for Climate Adaptation and Resilience (https://web.archive.org/web/20250117230420/https://www.sustainability.gov/pdfs/usda-2021-cap.pdf) that describes how USDA will integrate climate adaptation into its mission, programs, and operations. The plan, an update to the 2014 Adaptation Plan (https://web.archive.org/web/20250117230420/https://www.usda.gov/sites/default/files/documents/USDA_Climate_Change_Adaptation_Plan_FULL.pdf), identifies key vulnerabilities to the effects of climate change in USDA's mission and establishes a framework for addressing these impacts across the Department.

In 2022, NRCS finalized the NRCS Climate Change Adaptation Plan (https://web.archive.org/web/20250117230420/https://www.usda.gov/sites/default/files/documents/1_FPAC_NRCS_ClimateAdaptationPlan_2022.pdf), an agency-specific plan that identifies and prioritizes climate vulnerabilities and actions to integrate climate change into its programs, operations and decision-making. The plan provides a framework organized around seven main action areas:

- **Action Area 1:** Increase climate literacy and staffing capacity to deliver assistance that is reflective of climate change
- **Action Area 2:** Enhance science, research, and data for understanding, measuring, and tracking climate-related impacts and outcomes
- **Action Area 3:** Integrate climate information into current business procedures, assessments, and opportunities
- **Action Area 4:** Ensure current and future conservation investments are reflective of climate change needs
- **Action Area 5:** Assess and address disproportionate climate change impacts on vulnerable communities
- **Action Area 6:** Strengthen partnerships and collaboration to address climate change
- **Action Area 7:** Address risks to agency infrastructure

Live version as of 2/20/2025

An official website of the United States government Here's how you know

Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE (HTTPS://USDA.GOV)

MENU



# 403 - Access Denied

Home Conservation Basics (/conservation-basics) Natural Resource Concerns (/conservation-basics/...

## This page is not available.

### AskUSDA

One central entry point for you to access information and help from USDA

Ask.USDA.gov (https://ask.usda.gov/s/)

1-833-ONE-USDA (tel:8336638732)

askusda@usda.gov (mailto:askusd

a@usda.gov)

ASK A QUESTION (HTTPS://ASK.USDA.GOV/S/)



# Natural Resources Conservation Service

U.S. DEPARTMENT OF AGRICULTURE (HTTPS://USDA.GOV)

---

## Policies and Statements

FOIA (/foia)

Information Quality (/information-quality)

Our Performance (/performace)

Privacy Policy (/privacy)

Accessibility Statement (https://www.usda.gov/accessibility-statement)

Non-Discrimination Statement (/non-discrimination)

## Related Sites

USDA.gov (https://usda.gov)

AskUSDA (https://ask.usda.gov/s/)

Office of the Inspector General (https://www.usda.gov/oig)

USA.gov (https://usa.gov)

WhiteHouse.gov (https://whitehouse.gov)

## Resources

OneFPAC - Employee Links (/employees)

eDirectives (/edirectives)

Glossary (https://www.usda.gov/glossary)

No Fear Act Data (/no-fear-act)

Open Government (https://www.usda.gov/open)

Plain Writing (https://www.usda.gov/plain-writing)

Report Fraud on USDA Contract (https://usdaoig.oversight.gov/resources/contractor-fraud)

Sitemap (/sitemap.xml)

## Subscribe to our Newsletter

Stay updated on the latest news and stories from NRCS and other USDA topics.

(mailto:askusda@usda.gov)

(https://facebook.com/usdanrcs)

(https://twitter.com/USDA_NRCS)

(https://www.flickr.com/photos/usdagov/collections/72157624326158670/)

(https://www.youtube.com/theusdanrcs)

(https://www.linkedin.com/company/natural-resources-conservation-service/)