Forest Service
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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

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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.

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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.

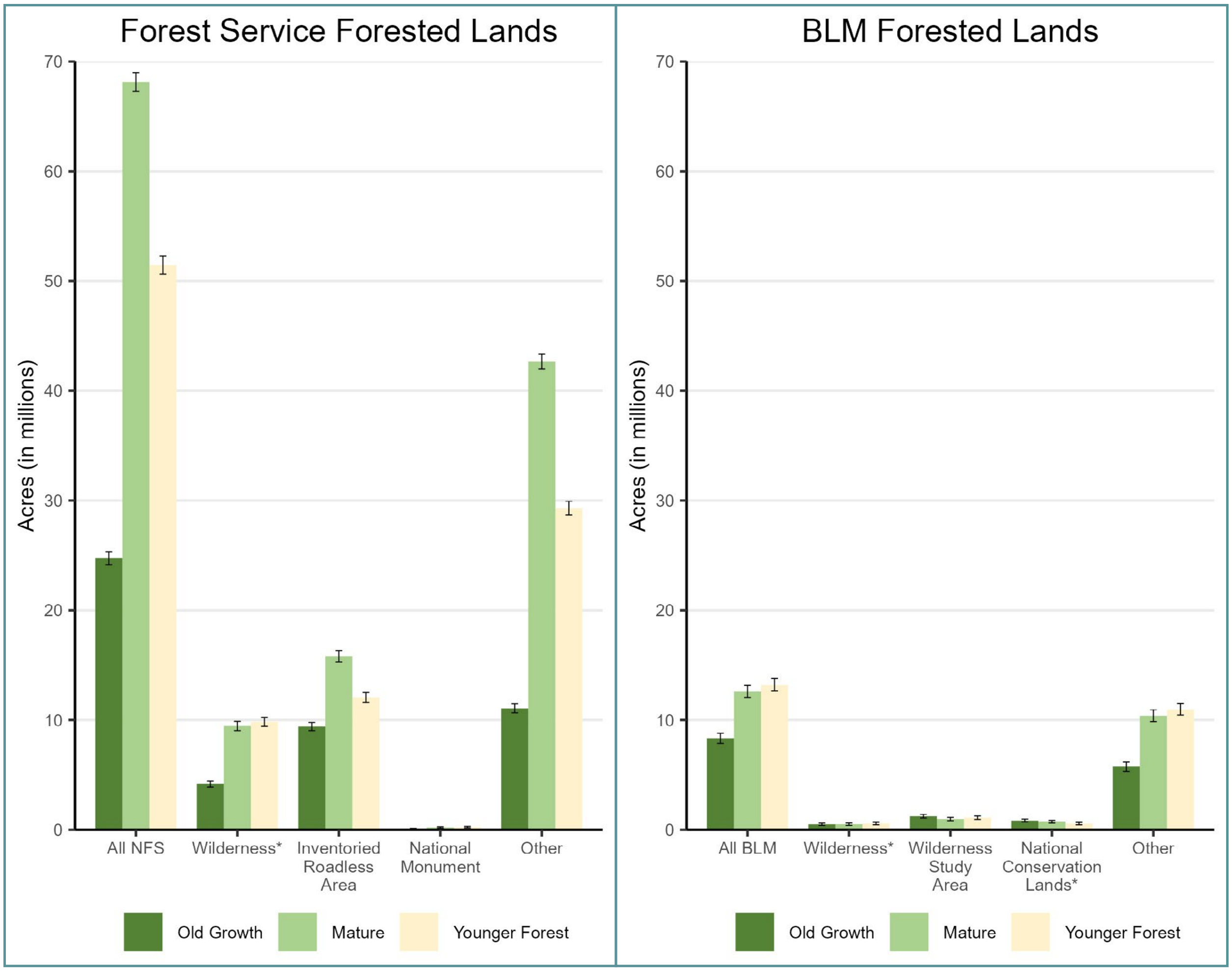
Table 1.—National total area (acres) of younger, mature, and old-growth forest land[a] on Forest Service and BLM lands, shown by congressionally designated land-use allocations. "Other" category includes all remaining land-use allocations.

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 10 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.

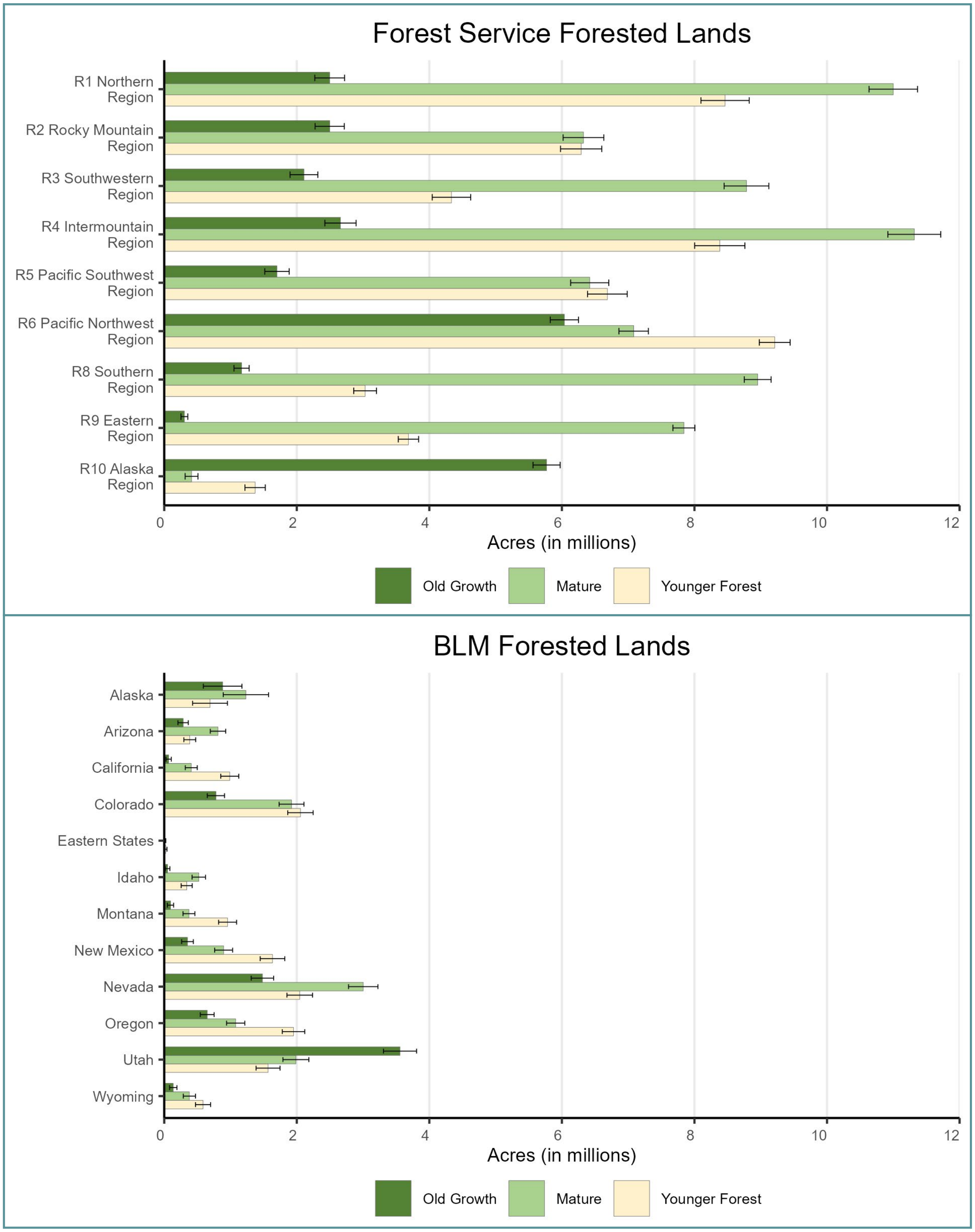
Table 2.—Area (acres) of mature and old-growth forest land[a] by FIA forest type group, shown in alphabetical order. Combined total acres are shown for Forest Service and BLM forested lands.

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.)

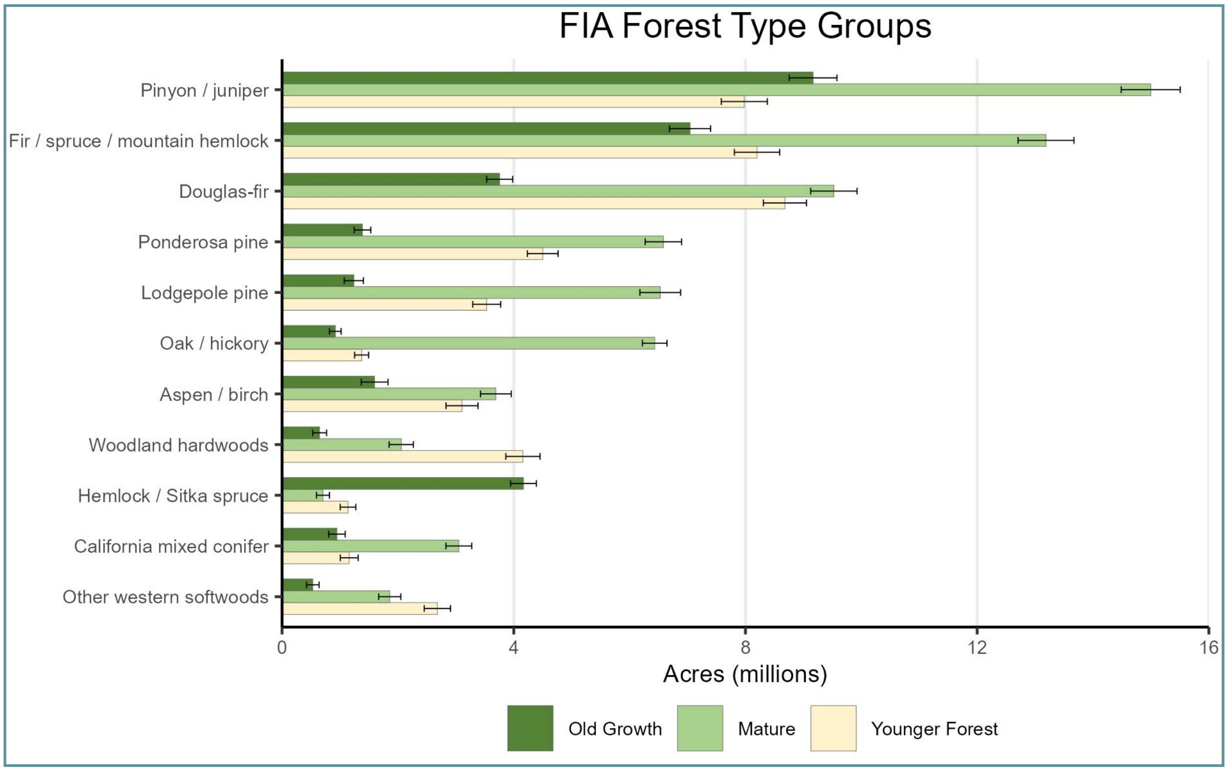


Figure 3.—Combined Forest Service and BLM area (in acres) of old-growth, mature, and younger forest by FIA forest type group. Only forest type groups with an area estimate of at least five million acres are shown.

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.

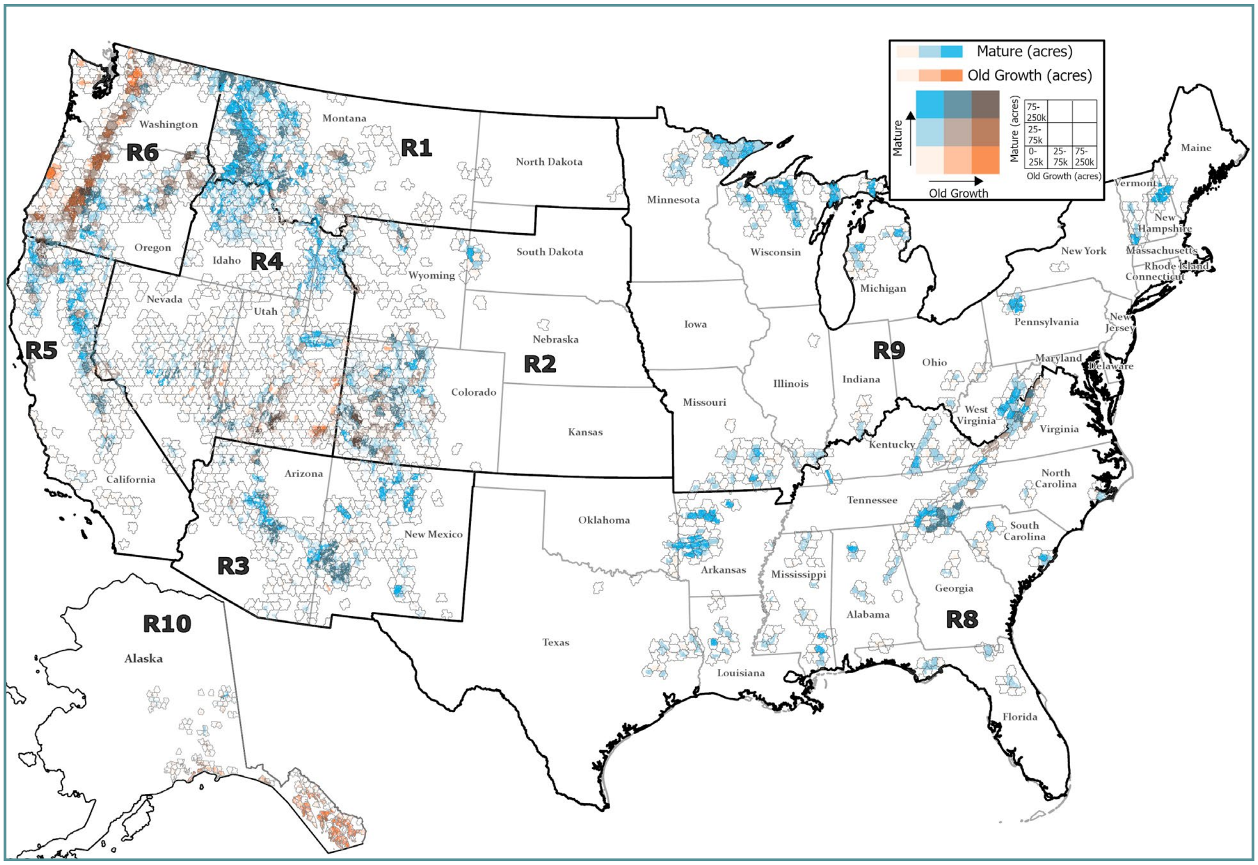


Figure 4.—Bivariate map of mature and old-growth acres by fireshed for Forest Service and BLM forested land area, coterminous and coastal Alaska. Only Forest Service and BLM land ownerships are shaded within a fireshed (see appendix 3 for acres of old-growth and mature forest land by fireshed in tabular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

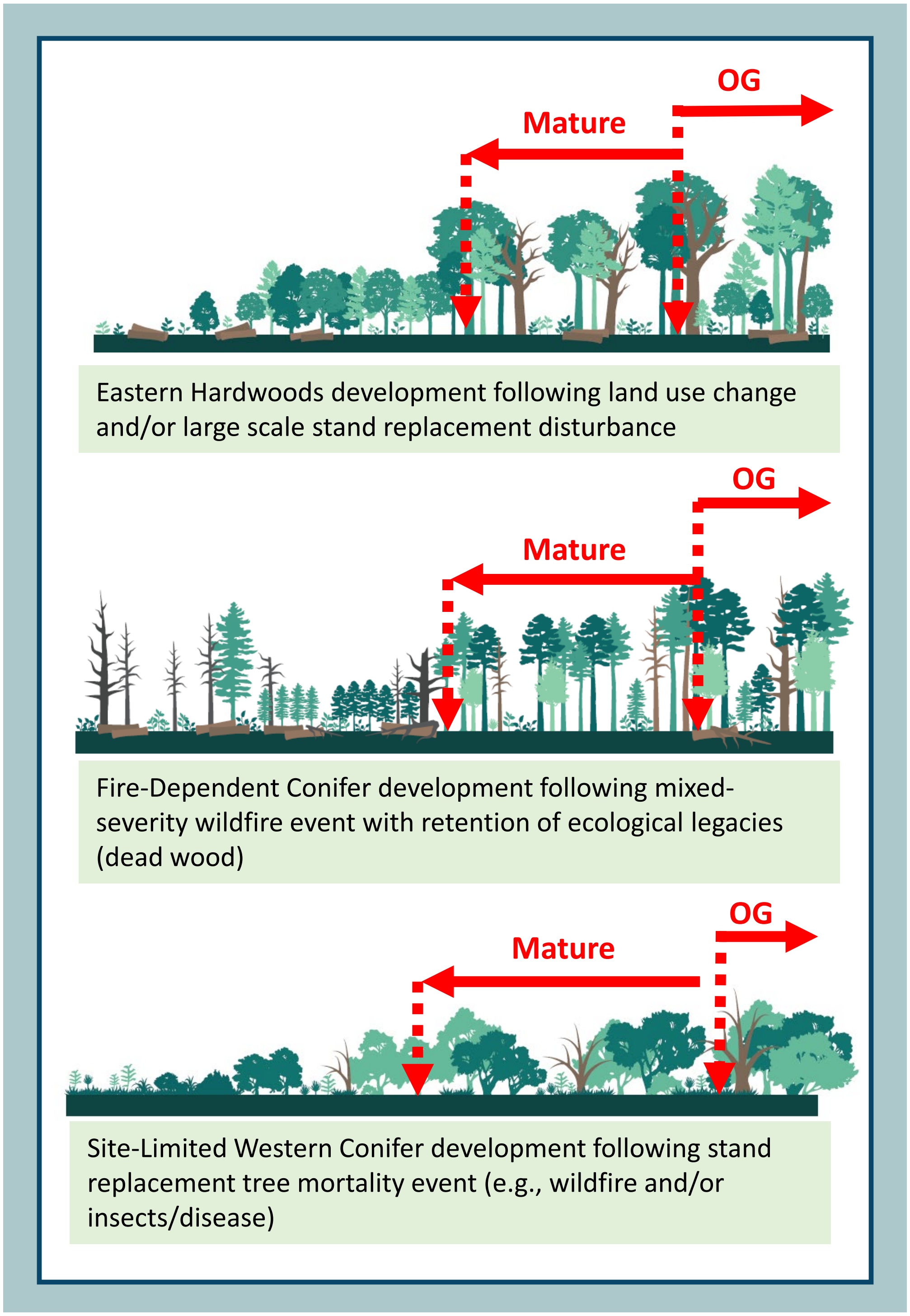


Figure 5.—Four-stage forest development model for several ecosystem archetype examples. Adapted from Woodall et al (2023).

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.

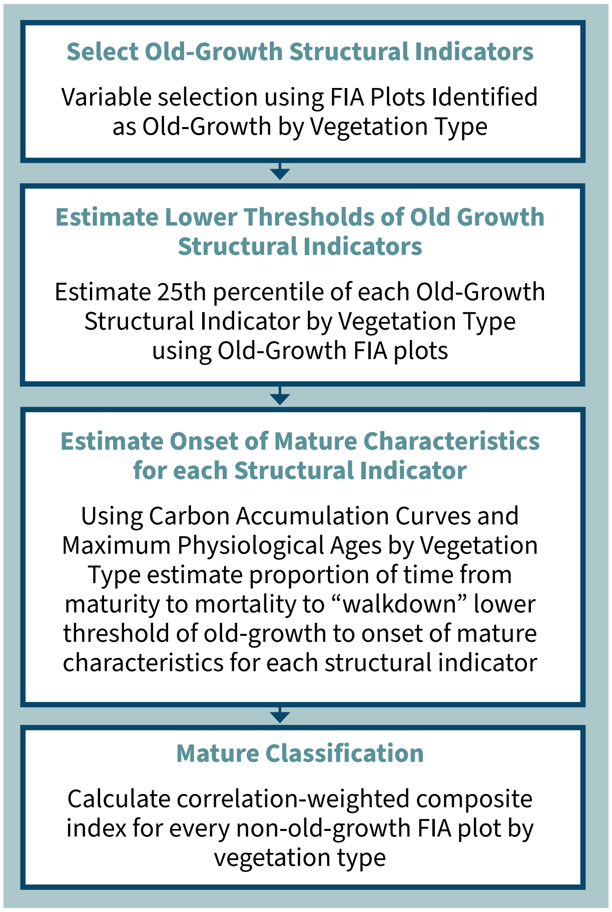


Figure 6.—Fundamental components of the FIGSS approach (Woodall et al. 2023) include selecting old-growth structural indicators that are used to identify the lower thresholds of old-growth attributes, then using a walkdown factor to identify the onset of mature forest conditions. The definitions are 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. 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: Class_0 = 2–9.8 inches DBH Class_1 = 9.9–19.7 inches DBH Class_2 = 19.8–39.4 inches DBH Class_3 = 39.5+ inches DBH Calculate index values from TPA classes, then calculate DDI from index values. 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. 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.

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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; 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; 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 forest[b]	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.