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

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

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# Executive Summary


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

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

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

Since 2000:

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

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

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

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

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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 implement a set of actions focused on the health of the Nation's forests. Section 2(c).ii specifically directed the agencies to analyze the threats to mature and old-growth forests on associated Federal lands, including from wildfires and climate change. To fulfill this direction, the agencies created this report.**

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

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

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

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

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

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

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

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

# Methods

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

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

## Condition-Based Evaluations

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

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

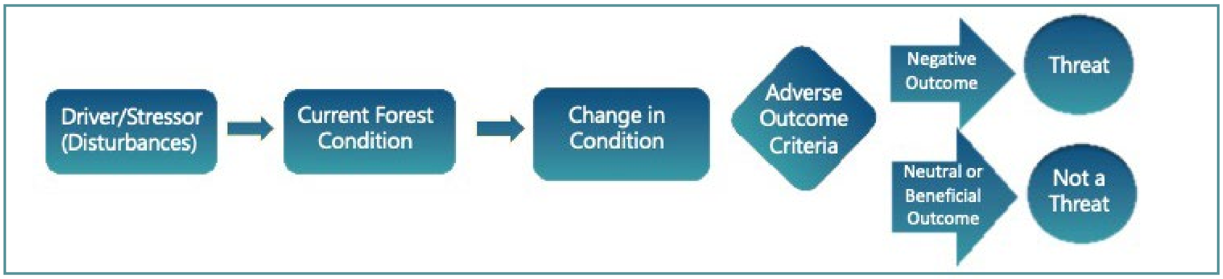


**Figure 1.**—Illustration of the framework adapted from EPA (Brown et al. 2017) and employed to identify when a disturbance such as fire—a driver or stressor—results in a threat versus an outcome that is neutral or beneficial. This framework is particularly applied in the qualitative, condition-based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

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

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

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

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

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

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

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

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

Worksheets (see methods in appendix 3) were completed by several resource specialists (for example, social scientists, ecologists, and silviculturists) in each Forest Service region to inform the condition-based evaluation. The goal of the worksheets was to systematically examine the forest conditions that determine whether various disturbances result in an adverse outcome—and thus constitute a threat—or produce a neutral or beneficial outcome. These expert elicitations, a social science method by which experts in their fields make statements that can be trusted as information, brought local information to the analysis, and made it more context specific, adding to what exists in the published literature. This framework was used to examine disturbances such as fire or hurricanes in relation to different forest types and structural stages, providing critical context for how drivers and stressors affect diverse types of mature and old-growth forests in different regions.

## Remeasured Forest Inventory and Analysis Plots

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

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

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

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

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

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

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

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

## Forest Inventory and Analysis Data Projected into the Future

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

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

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

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

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

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

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

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

# Spatial Analysis of Historical, Current, and Future Conditions

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

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

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

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

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

# Mature and Old Growth Condition Assessment

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

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

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

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