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Conservation of Dry Forest Old Growth in Eastern Oregon

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Abstract

Conservation of old-growth forests has become an increasingly important objective of Forest Service managers over the last three decades. The US Forest Service recently made changes to policies that prohibit cutting of live trees >53 cm (the “21-inch rule”). We review the disturbance ecology of dry and mesic old-growth forests of Oregon and contrast conservation policies for these two forest types. We describe the development of age-based alternatives to the 21-inch rule on the Klamath Reservation and in the Malheur National Forest in eastern Oregon. We conclude by outlining an adaptive management strategy to conserve dry forest old growth that seeks to restore the ecological processes that perpetuate old tree populations over time. We argue that what is good for dry forest ecosystems is good for dry forest old growth, especially in the face of changing climate and disturbance regimes.

Study Implications: Age-based limits are a viable alternative to the size-based limits that the U.S. Forest Service has been using to conserve old growth in dry, fire-prone forests of eastern Oregon. Another alternative is a process-based approach that emphasizes restoring processes, including frequent fire that make old-growth trees resistant to a warmer and more fiery future. Multiscale inventories that track the abundance and distribution of trees of different species, sizes, and ages can inform tree conservation priorities and assess progress towards desired outcomes. Robust monitoring programs can facilitate collaborative data-driven adaptation at the local level and improve dry forest old-growth conservation outcomes.

Keywords: 21-inch rule, adaptive management, climate change, eastern Oregon, Fremont-Winema National Forest, Klamath Reservation, Klamath Tribes, Malheur National Forest, old growth

Old-growth forests managed by the United States Forest Service (USFS) in Oregon are nationally and globally significant resources that provide irreplaceable habitat, store vast amounts of carbon, and form the structural foundation for forest communities that will be resilient to climate change (Smithwick et al. 2002, Vosick et al. 2007, Marcot et al. 2018). These trees and the forests where they are found are cultural icons of immense value to tribal members, outdoorspeople, and the general public (Blicharska and Mikusiński 2014). Their management serves as a model for conservation nationally (Waring and Franklin 1979, Lee 2009). Conservation of old growth became a critical management objective of the USFS and synecdoche for forest management beginning in the late 1980s and early 1990s because of declines in old-growth dependent species (Thomas et al. 2006, Spies and Duncan 2012).

Conservation of old growth, particularly in the dry interior regions of Oregon, is of acute importance because old trees are in steep decline globally and across the American West (Lutz et al. 2009, van Mantgem et al. 2009, Lindenmayer et al. 2012, Mcintyre et al. 2015, Reilly and Spies 2016). Conservation strategies for old growth in Oregon differ markedly between Douglas-fir/western hemlock forests found in the most mesic sites west of the Cascade Mountains and the dry, fire-prone forests that are common in the interior of the state and scattered throughout the Willamette Valley, Klamath Mountains, and other dry sites west of the Cascades. A critical appraisal of strategies to conserve dry forest old-growth trees is timely because the USFS recently revised policy that prohibits cutting of live trees ≥53 cm diameter at breast height (DBH) (the "21-inch rule") in national forests of eastern Oregon (Figure 1).

In this article, we contrast the disturbance ecology of mesic and dry old growth, discuss implications of these differences for management, and describe how policy to conserve these two types of old growth have diverged over the past three decades in Oregon. We describe how age-based alternatives to prohibitions on cutting trees ≥53 cm have evolved over the past 10 years. With this history as background, we outline an adaptive dry forest old-growth conservation strategy that focuses on restoring the key processes

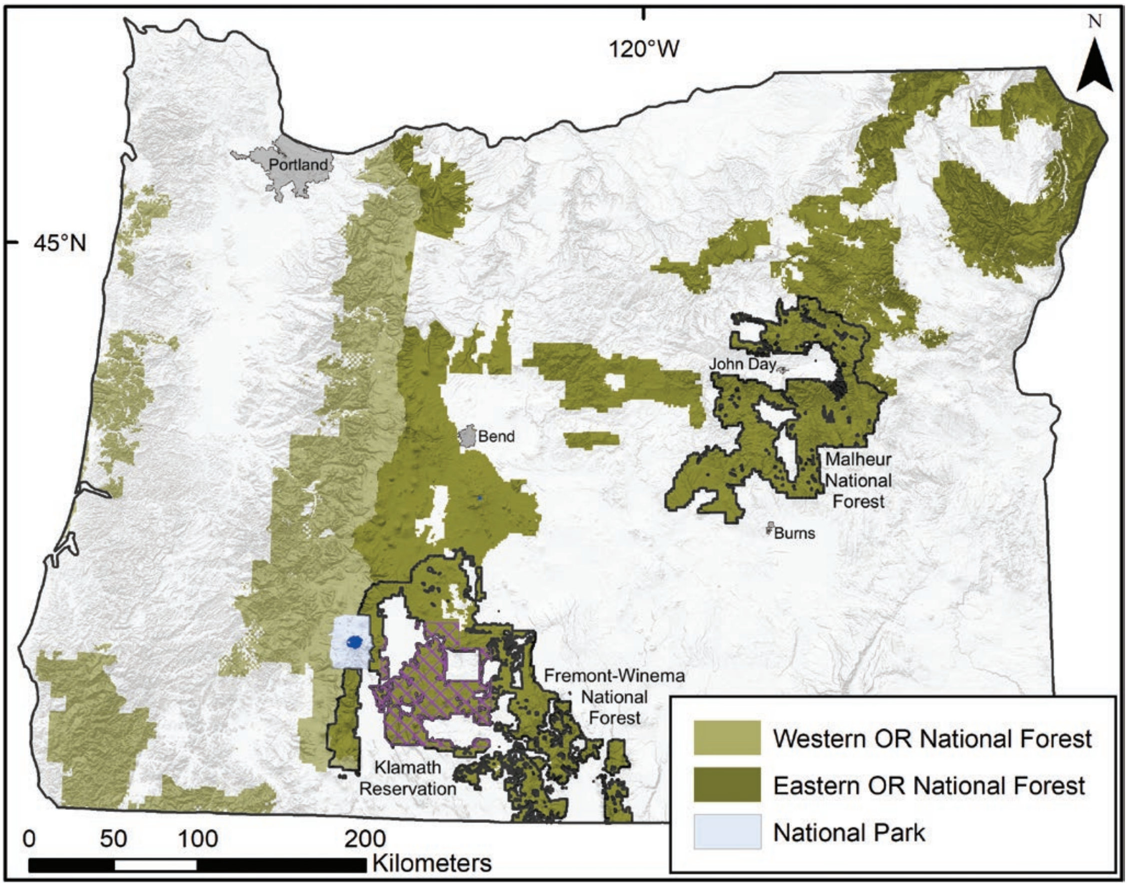

Figure 1. Map of eastern Oregon national forests where the USFS recently made changes to old-growth conservation policies. The Fremont-Winema and Malheur National Forests are highlighted in bold. The Klamath Reservation within the Fremont-Winema National Forest is highlighted in crosshatch. Dry forests are ubiquitous east of the crest of the Cascades, although moister forests are found at high elevations and cooler aspects. Mesic forests are common west of the Cascades, although dry, fire-prone forests are common in southwest Oregon and interdigitated with mesic forests throughout the west slope of the Cascades.

that perpetuate old-growth trees over time in the face of climate change.

Disturbance Ecology of Mesic and Dry Old Growth

The iconic tree species of mesic forests found in the most productive landscape settings west of the crest of the Cascade Mountains in Oregon is coastal Douglas-fir (*Pseudotsuga menziesii* var. menziesii). Coastal Douglas-fir is shade-intolerant relative to other trees found in mesic forests, moderately drought tolerant, and fire resistant (Franklin and Dyrness 1988). Forests of older Douglas-fir and shade-tolerant species including western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) and western redcedar (*Thuja plicata* Donn ex D. Don) may go hundreds of years without wildfire in the most productive forests of the Coast Range and the central and northern portions of the western Cascades (Agee 1996). These structurally complex, closed-canopy forests provide critical habitat for species like the northern spotted owl (*Strix occidentalis caurina*) that depend on dense, multilayered forests for hiding, thermal cover, nesting structures, and foraging opportunities (Franklin et al. 1981, Noon and Blakesley 2006).

Ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) is ubiquitous in dry forests east of the crest of the Cascades. Ponderosa is shade-intolerant, drought tolerant, and resistant to fire. It occurs most commonly in mixed stands along with shade-intolerant western larch (*Larix occidentalis* Nutt.), shade-tolerant grand fir and white fir (*Abies grandis* [Dougl.] Lindl. and *Abies concolor* [Gord. and Glend.] Lindl.), and relatively shade-tolerant Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco var. glauca [Beissn.] Franco) (Simpson 2007). Historical mean fire return intervals for these dry mixed conifer forests ranged from 8 to 31 years (Johnston et al. 2017, Merschel et al. 2018, Heyerdahl et al. 2019). Although infrequent fire in the most productive west side Douglas-fir forests historically often killed most of the overstory and reset succession across forest patches 100–1,000 ha, frequent surface fire in dry eastern Oregon stands historically killed seedlings, scattered individual overstory trees, or patches of trees <1 ha (Agee 1996, Youngblood et al. 2004).

Differences in the natural disturbance processes that characterize the most productive mesic old-growth Douglas-fir forests and dry mixed-conifer forests have important implications for management strategies to conserve old growth (Franklin and Johnson 2012). Historically, stand-replacing fire in mesic Douglas-fir forests synchronized successional dynamics at relatively coarse spatial scales (100–1,000 ha). Long fire disturbance intervals suggest that most of these forests are not currently outside the historical range of variability in fire frequency (Halofsky et al. 2018).

Dry ponderosa pine and mixed conifer stands, in contrast, are usually well outside the historical range of variability in fire frequency (Hessburg et al. 2019). Frequent fire was critical to the development and persistence of old-growth ponderosa pine and western larch because it removed competition for limited water (Franklin et al. 2002). Conservation of these trees after more than a century without fire requires active management to remove younger trees that compete with old growth for resources and create ladder fuels that carry fire into the canopy of old-growth trees (Bradford and Bell 2017, Stephens et al. 2020) (Figure 2).

Figure 2. Examples of mesic Douglas-fir dominated forests in western Oregon (left) and mixed conifer forest in eastern Oregon (right). Both forests feature large 300+-year-old shade-intolerant conifers and an understory of shade-tolerant tree species (note 400+-year-old Douglas-fir and ponderosa pine in the upper left of each photo). The abundance of shade-tolerant species in mesic west side old growth likely does not represent a significant departure from historical conditions. The abundance of shade-tolerant species in mixed conifer stands in eastern Oregon that historically burned frequently represents a significant departure from historical conditions and requires restoration to be resilient to future climate and disturbance regimes.

Conservation Strategies for Mesic and Dry Old Growth Diverge

The USFS has struggled to craft policy that accommodates key ecological processes and human demands on resources throughout the agency's 115-year history (Clary 1986). Since passage of the National Forest Management Act in 1976, the Forest Service has attempted to meet the challenge of tailoring different management strategies for different forest communities while meeting multiple use objectives by preparing and periodically revising land management plans for individual national forests (Hirt 1996). Forest planning underwent a revolutionary change in the early 1990s after federal courts halted timber harvest within the range of the northern spotted owl because land management plans were inadequate to ensure the viability of old-growth-dependent species (Hungerford 1994). The USFS reacted to this crisis by adopting an ecosystem-management approach that requires use of the best available science to achieve conservation objectives at broader spatial and temporal scales than existing land management plans for individual national forests (Thomas et al. 2006).

The ecosystem-management approach was first operationalized in 1994 with the adoption of the Northwest Forest Plan (NWFP), which amended land management plans of national forests in western Oregon, western Washington, and northern California. The NWFP acknowledges the temporal and spatial scale of historical fire in the most productive mesic Douglas-fir forests by creating large well-connected reserves managed for structurally complex older forest habitat. Logging within mesic NWFP reserves is prohibited except for thinning treatments in stands less than 80 years old that are designed to diversify structure and accelerate development of late-successional characteristics. The NWFP's coarse-scale approach assumes that providing a distribution and abundance of habitat within the natural range of variability at a landscape scale will conserve biota of concern (Thomas et al. 2006).

The USFS's approach for dry, fire-prone forests of eastern Oregon and Washington initially mirrored west-side planning efforts that culminated in the NWFP but ultimately followed a very different policy trajectory. Land-management plans for eastern Oregon national forests adopted in 1989 and 1990 called for the rapid harvest of remaining old-growth trees. In 1993, President Clinton directed the Forest Service to "develop a scientifically sound and ecosystem-based strategy for management of eastside forests" to avoid legal injunctions against east side timber harvest (Quigley et al. 1996). The planning effort that resulted—the Interior Columbia Basin Ecosystem Management Project (ICBEMP)—emphasized extensive thinning of dry forests to enhance resistance of old trees to disturbance (Quigley et al. 1996, Langston 2000).

In 1995, the Forest Service adopted a number of amendments to east-side land-management plans that provided interim protection to aquatic and terrestrial resources pending completion of ICBEMP. Among these interim amendments was a "wildlife standard" that prohibited cutting of live trees >53 cm DBH. This standard, referred to as the "21-inch rule," was intended to be in place for 12–18 months until ICBEMP would provide new direction for conserving old-growth forest structure (USDA 1995). The 21-inch rule fundamentally changed the nature of east-side timber harvest, halting the removal of large trees that had been the staple of eastern Oregon timber sales for decades.

ICBEMP was delayed by administrative appeals until 2001, when the Bush administration set aside ICBEMP in favor of a new planning effort that would emphasize timber production. Neither the Bush plan nor land management plans under subsequent administrations were ever completed, and today, most east-side national forests are operating under land management plans that are more than 25 years old (Duncan and Thompson 2006, Skillen 2015). Without a replacement policy, the 21-inch rule remained management direction through 2020, more than two decades past its intended expiration. Unlike the NWFP, which achieves old-growth conservation goals via coarse-scale reserves, the 21-inch rule serves as an ad hoc fine-scale conservation strategy that attempts to achieve old-growth conservation objectives at the scale of individual trees.

Although the 21-inch rule is intended to conserve old-growth trees, there was an imperfect relationship between age and size of trees growing in dry environments (Van Pelt 2008). The 21-inch rule failed to protect small old trees present on many sites and required retention of large but young trees (Merschel et al. 2019, Riling et al. 2019). This failure is important because old trees are not simply enlarged versions of younger trees. Old trees play critical and unique ecological roles in dry forests that differ from those provided by young trees, even young trees of large size (Franklin et al. 2018). The crowns of old trees typically incorporate large branch systems and other decadent features that provide unique habitats for wildlife (Franklin and Waring 1980). The persistence of old trees is associated with extensive root systems and mutualistic underground networks that contribute to drought resistance and movement of deep soil water to near-surface soils (Lehto and Zwiazek 2011). The large percentage of heartwood in old-growth stems results in wood that is more resistant to decay, which, among other things, results in snag- and log-decay patterns that provide unique specialized habitats for vertebrates, invertebrates, and other biota (Castello et al. 1995).

Scientists and managers are increasingly concerned that a one-size-fits-all restriction on cutting does not serve old-growth conservation objectives. Many shade-tolerant trees that have infilled into dry eastern Oregon stands since the onset of fire suppression are >53 cm and the 21-inch rule limits managers' abilities to reduce competition and fuel ladders around old shade-intolerant trees (Stine et al. 2014, Johnston 2017, Spies et al. 2018). In essence, old-growth trees are at risk today from a decades-old temporary policy decision designed to protect old growth that became permanent in the absence of new policy. To address this situation, the Forest Service launched a National Environmental Policy Act (NEPA) process in 2020 intended to adapt the 21-inch rule to reflect the latest science and promote forest resilience to future climate and disturbance regimes.

Age-based Alternatives to the 21-inch Rule

The paradox of dry old-growth conservation is that protecting old trees usually requires removing other trees, some of which may be relatively large (i.e., >53 cm) and are evocative of complex mesic old-growth forests. This type of active management is controversial because many members of the public value unlogged forests (Kimmins 2003, Ribe 2006, Pesklevits et al. 2011). Even when active management is supported by diverse stakeholders, some environmental groups demand strict and unambiguous guidelines to be assured that ecological rather than timber-production goals are being served by timber harvest. The persistence of the 21-inch rule long after its intended expiration reflects, in part, the desire on the part of many conservation groups for discrete, measurable, and easily enforceable tree-protection standards (see, for instance, Oregon Wild's position on the 21-inch rule at https://oregonwild.org/about/blog/forever-21).

Age-based limits on cutting of trees provide a solution to conserve old trees and remove younger trees that threaten the survival of old trees. Although identifying old trees is inherently more uncertain than measuring diameter, managers have long recognized distinctive morphological characteristics of ponderosa pine that diagnose age (Hornibrook 1939, Pearson 1946). More recently, Van Pelt (2008) developed relatively accurate, easy-to-use methods for estimating the age of ponderosa pine and other major dry interior Pacific Northwest species based on their physical appearance. Van Pelt's methods and derivatives of these methods (e.g., Franklin et al. 2013, Johnston et al. 2018) have been used on the Fremont-Winema and Malheur National Forests to conserve old trees in conjunction with or in lieu of diameter limits (Table 1). Age-based alternatives to the general prohibition on logging trees ≥53 cm are implemented via amendments to Land and Resource Management Plans during NEPA analysis of restoration actions within individual planning areas ranging in size from 3,000 to 24,000 ha.

The Klamath Tribes played a key role in the development of age-based alternatives to the 21-inch rule on the 931,000 ha Fremont-Winema National Forest. Following loss of federal recognition of the Klamath Tribes in 1954, over 169,650 ha of tribal forestland was transferred to the USFS (Figure 1). After restoration of federal recognition in 1986 and years of litigation that affirmed the sovereign rights of the Klamath Tribes, the Forest Service agreed to work cooperatively with the Tribes in management of Klamath Reservation lands (Nie 2008, Diver 2016). In 2008, the Klamath Tribes approved a management plan for the reservation that based desired future forest conditions in part on historical structure and composition (Johnson et al. 2008, Hatcher et al. 2017). Restoration of historical conditions involves perpetuating old growth through time, and the Tribes' plan emphasized both retention of all live and dead old-growth trees (defined as >150 years of age) and the harvest of younger, large trees, especially where they are in competition with old-growth trees or shading understory plants that provided forage for big game.

The shift from size- to age-based retention standards in the Klamath Reservation management plan was motivated by the Tribes' recognition that some old (up to 500 years of age) ponderosa pine trees were <53 cm DBH and that many large white fir <150 years of age—including trees >53 cm—threatened older trees. The Klamath Tribes' Natural Resources Department field-tested the Van Pelt (2008) guide for aging trees and adapted it to local conditions. NEPA decisions for land management projects within the Klamath Reservation contain commitments

Table 1. Visual cues that help identify age of trees (adopted from Van Pelt 2008, Franklin et al. 2013, Johnston et al. 2018).

	Crown		Bark		Branches	
	>150	<150	>150	<150	>150	<150
Ponderosa pine	Flat complex crown with large branches		Brown or black; narrow shallow fissures	Orange-red color; distinctive wide bark plates	Large dead branches; no dead branch stubs on lower third of the tree	
Western larch			Bark fissures > 6 cm	Bark fissures < 6 cm	Large and gnarly epicormic branches present; no branch whorls or knots on lower trunk	Branch whorls or knots present on lower trunk
Douglas-fir			Bark fissures > 7 cm	Bark fissures < 7 cm	Dead branches > 1.7 m off the ground	Dead branches < 1.7 m off the ground
Grand fir	Multiple iterations that include large dead spike tops		Bark fissures > 2.5 cm	Bark fissures < 2.5 cm	Live branches > 6m off ground	Numerous broom-like fine branches < 2 mm diameter near the ground

to retain trees that appear to be at least 150 years of age. Projects implementing those commitments have been underway for more than five years. A joint monitoring effort between the USFS and the Klamath Tribes Natural Resources Department is assessing the operational effectiveness of using visual characteristics to identify and retain trees >150 years of age. Future projects on the Fremont-Winema will also implement age-based limits on cutting and incorporate lessons learned from the current efforts (Franklin et al. 2013, Hatcher et al. 2017, USDA 2017, 2018).

The use of age-based cutting guidelines on the 700,000 ha Malheur National Forest is driven by the growing role for collaborative stakeholder groups in management of eastern Oregon national forests (Butler et al. 2015, Abrams 2019). The Blue Mountains Forest Partners (BMFP) based in John Day and the Harney County Restoration Collaborative (HCRC) based in Burns convene representatives from the timber industry, conservation groups, and community members to develop strategies for dry-forest restoration (Figure 3). Both groups developed "zones of agreement" documents, which represent agreement among diverse stakeholders about appropriate forest-restoration treatments (see for examples https://www.bluemountainsforestpartners.org/work/zones-of-agreement/). A critical basis for agreement among conservation and industry representatives for active management is the conservation of old trees (Brown 2012). Zones-of-agreement documents adopt the approach developed by Franklin et al. (2013) and Franklin and Johnson (2012) to conserve all trees estimated to be >150 years old given physical characteristics based on those authors' experience developing age-based cutting guidelines for the Klamath Reservation (Johnson et al. 2008). The Malheur National Forest adopted the BMFP's age-based conservation approach for a number of different forest-restoration projects.

The collaborative management framework on the Malheur National Forest relies on monitoring treatments, which inform periodic revisions of BMFP zones-of-agreement documents and results in modifications of future projects to better achieve ecological objectives (Lindsay and Johnston 2020). Monitoring also fosters a joint learning environment between diverse stakeholders that helps build and maintain social license for increasing the pace and scale of restoration treatments (Urgenson et al. 2017). Collaborative monitoring led by BMFP and HCRC on the Malheur is both qualitative and quantitative. Qualitative monitoring takes the form of 6–10 field trips per year to completed projects to discuss whether treatments have achieved objectives and whether treatments or objectives require modification. Qualitative monitoring has been ongoing since 2010 and involves repeat visits over many years.

Figure 3. Members of the BMFP, USFS managers, and university scientists meet in the field to discuss forest restoration challenges and opportunities on the Malheur National Forest.

Quantitative monitoring has been ongoing since 2014 and involves field data collection within a network of 550 long-term monitoring plots systematically located across eight different NEPA planning areas. Data are collected within treated stands and in untreated controls and include measurement of changes in overstory tree structure, surface fuel loading, and understory vegetation. Quantitative monitoring results play an increasingly prominent role in revisions to zones of agreement as longitudinal data accumulate and are capable of quantifying change over time that results from treatment. Three different restoration projects planned and implemented over the last 10 years illustrate how information is synthesized by the BMFP and USFS to better achieve old-growth conservation objectives.

In 2008–2010, the BMFP worked with the USFS to plan the Damon Wildland Urban Interface Project, implementation of which began in 2010. Consistent with the 21-inch rule, all trees ≥53 cm within Damon treatment units were protected from cutting. Stakeholders recognized that treatment units contained many shade-tolerant grand fir and Douglas-fir that were ≥53 cm DBH that "didn't belong there" because they were established after fire was excluded from the landscape and were competing with 300+ year old shade-intolerant ponderosa pine and western larch. The group could not reach consensus on mechanically removing these trees and ultimately decided to rely on prescribed fire to remove younger shade-tolerant trees, which are generally considered less fire resistant than pine and larch. Monitoring following postharvest prescribed fire demonstrated that shade-intolerant and shade-tolerant trees ≥53 cm were equally resistant to low-intensity prescribed fire and that fire failed to remove large but young trees (Figure 4, Photo A).

Collaboration led by the BMFP on design of subsequent restoration projects incorporated lessons learned from Damon. The Elk 16 project, initiated in 2016, permitted logging of shade-tolerant trees that were ≥53 cm but determined to be <150 years old based on morphological characteristics. Shade-tolerant trees ≥53 cm were removed only in stands outside of areas managed for habitat connectivity and from stands being treated to restore quaking aspen (*Populus tremuloides*). Elk 16 prescriptions emphasized creation of a complex post-treatment spatial pattern (Churchill et al. 2013). Many Elk 16 stands where trees ≥53 cm were cut emphasized retaining clumps of trees where no cutting occurred and creating small gaps where all trees were removed (Figure 4, Photo B). In some stands treated to retain aspen, all shade-tolerant trees were removed from the vicinity of old-growth ponderosa pine, leaving very open stands (Figure 4, Photo C).

The Big Mosquito project, planned from 2013–2015 and begun in 2017, protected all western larch ≥53 cm from logging. Ponderosa pine and Douglas-fir ≥53 cm that had morphological characteristics that indicated that they were <150 years old could only be felled in order to facilitate riparian area or aspen stand

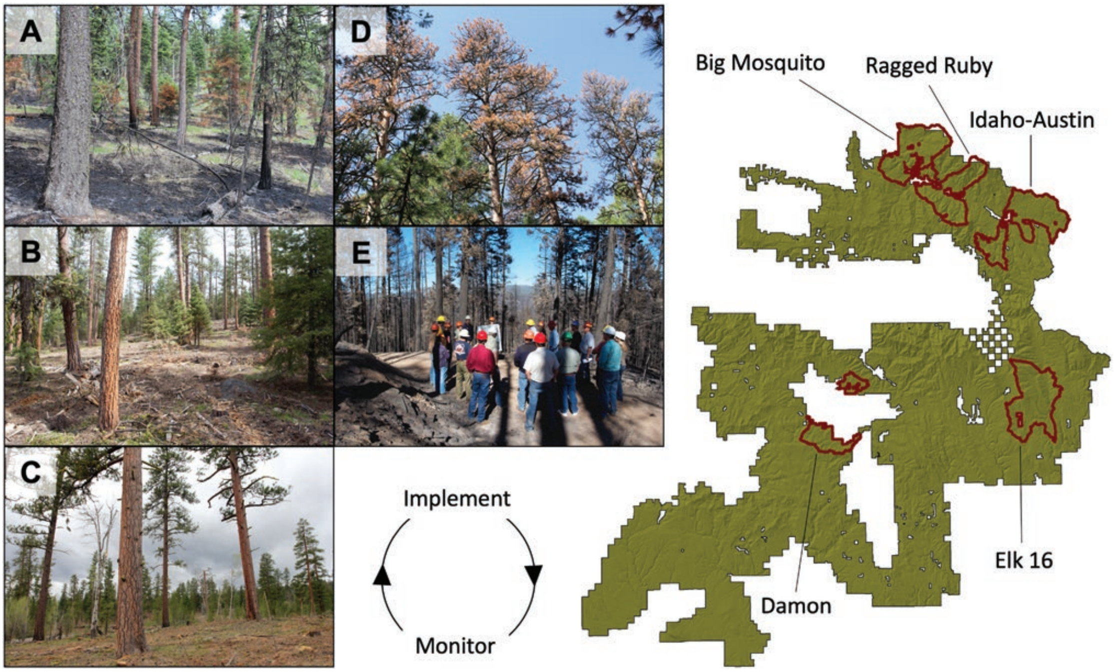

Figure 4. Adaptive management of old growth on the Malheur National Forest. A: Thinning and prescribed fire after implementation of the Damon project did not remove shade-tolerant grand fir as expected. B: Variable density thinning and leave patches following implementation of the Elk 16 project. C: Removal of all shade-intolerant species around old-growth ponderosa pine in proximity to an aspen stand following implementation of the Elk 16 project. D: Mortality of old-growth ponderosa pine from mountain pine beetle attack. E: A field trip investigating mortality from stand-replacing fire.

restoration. Grand fir ≥53 cm could be cut when they were within a distance equal to twice the dripline of older shade-intolerant species, touching the crowns of young shade-intolerant species, or to create small openings in moist stands.

In addition to evaluating silvicultural treatments, the BMFP visits natural disturbances, including wildfires of different severities and insect outbreaks, to determine the degree to which mortality patterns associated with these processes are consistent with the group's vision for conservation of old-growth trees (Figure 4, Photos D and E). Pooling observations from collaboratively designed restoration projects and natural disturbance events is building a shared understanding of ecological outcomes that result from a broad range of management actions and natural disturbance. Assimilating qualitative observations and quantitative data about the responses of trees of different species, sizes, and ages to disturbance over time is allowing the BMFP to collaboratively identify trees that require conservation and reach consensus about the types of disturbance necessary to conserve old growth. This information is currently being used to collaboratively plan two landscape-scale restoration projects that will treat more than 15,000 ha in the Ragged-Ruby and Austin-Idaho planning areas beginning in 2023 (Figure 4).

Process-based Adaptive Management of Dry Old Growth

Given legal and social demands, conservation of old growth is likely to remain an important objective of USFS managers in eastern Oregon, demanding the continued development of strategies to accomplish this objective given future change. The increasing use of age-based guidelines and a reliance on monitoring to determine treatment effectiveness in conserving old-growth trees suggests an evolution of age-based standards that emphasizes restoration of key processes within an adaptive management framework. This approach explicitly acknowledges that perpetuating old tree structure is not strictly a matter of what structure is removed and what structure is left behind following restoration treatments. Instead, perpetuating old growth is a matter of relinking pattern and process feedbacks within forest communities that create and sustain old trees over time (Allen et al 2002). In dry forests, frequent low-severity fire was the primary process that created forest structural and compositional patterns that were resistant to drought and disturbances and enabled the development and persistence of old-growth trees (Hessburg et al. 2019, Ritter et al. 2020). A process-based approach that strives to recreate pattern-process feedbacks rests on the assumption that what is good for dry forest ecosystems is good for dry forest old growth (*sensu* Henson et al. 2018). A process-based approach is also appropriate for achieving multiple management objectives, including adaption of forests to accelerating fire and insect activity associated with climate change as well as uncertainty associated with the interactive effects of rising temperatures, invasive species, novel disturbances, and social, economic, and political change (Littell et al. 2009, Millar and Stephenson 2015).

A process-based adaptive management approach requires timely and relevant data from existing data sources and a commitment to gather additional data over time. For instance, assimilation of data from region-scale inventories that cover all of eastern Oregon, including the Forest Inventory and Analysis program and the Current Vegetation Survey, will be helpful in quantifying trends in the abundance and distribution of different species, size, and age classes (Max et al. 1996, Bechtold and Patterson 2005, Davis et al. 2015). This data can used to identify classes of trees in significant decline and/or at risk from projected future disturbance patterns (Moeur et al. 2005). This data would facilitate old-growth restoration assessments at the scale of individual national forests or NEPA planning areas within national forests. Old-growth restoration assessments could use the best available information to describe treatments and natural disturbances that achieve conservation of desired forest structure. Individual national forests could rely on restoration-monitoring programs to generate information about the effects of natural and anthropogenic disturbances and incorporate this information into future restoration projects (Figure 5).

Throughout this article, we distinguish between dry forests with ponderosa pine that historically burned frequently and mesic Douglas-fir forests with long fire return intervals. Dry forests are most commonly found in eastern Oregon, although there are extensive dry forests that historically experienced frequent fire in southern Oregon and at drier landscape settings in the western Oregon Cascades (Spies et al. 2018). The dry old-growth conservation strategies we describe are most immediately relevant to

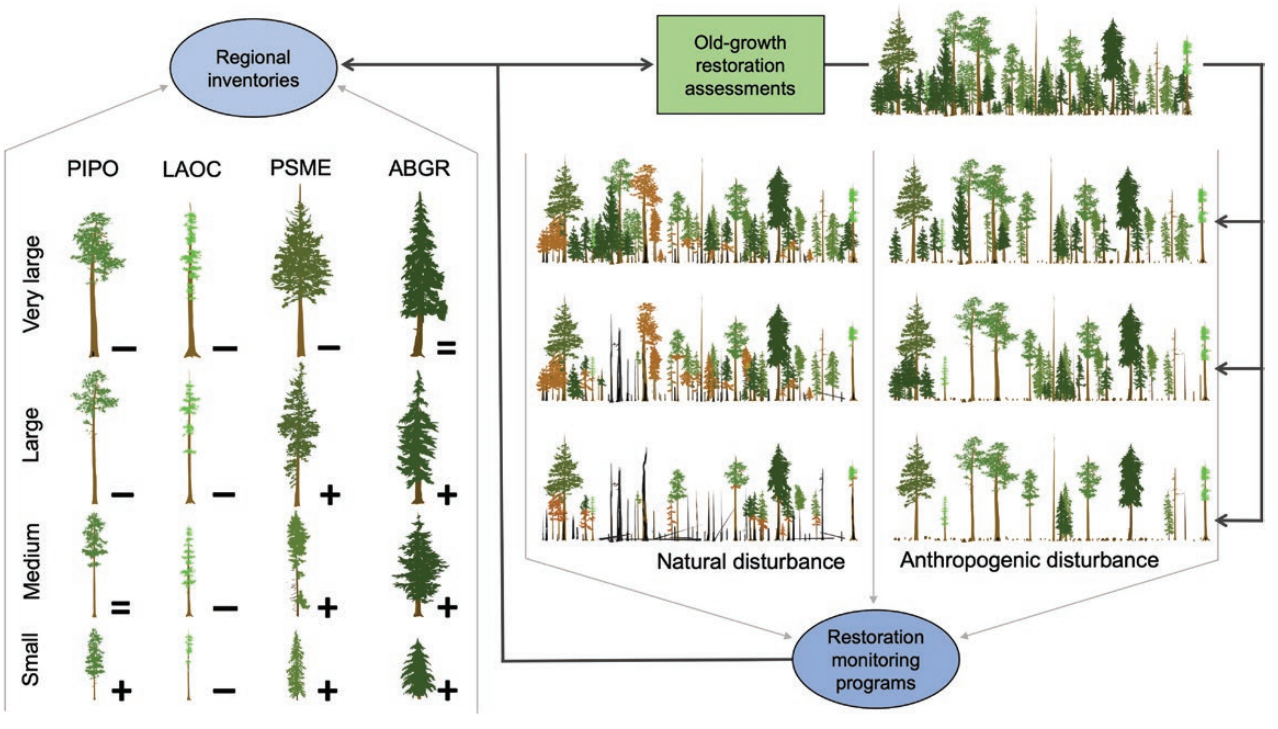

Figure 5. A potential process based adaptive management framework for old-growth conservation in eastern Oregon national forests. Regional forest inventories (left side) report trends in species and size classes to identify at-risk forest structure. In this simplified example, large ponderosa pine (PIPO) and larch (LAOC) are at risk (–) whereas larger Douglas-fir (PSME) and grand fir (ABGR) are stable (=) or increasing (+) in abundance. Regional inventory results and site-specific information from individual national forests inform old-growth restoration assessments (right side) that determine conservation objectives and restoration prescriptions for individual NEPA planning areas. Restoration-monitoring programs determine the success of different natural (e.g., wildfire) and anthropogenic (e.g., mechanical thinning and/or prescribed fire) disturbance at maintaining desired structure and inform development of future old-growth assessments.

recent policy change in eastern Oregon national forests. However, age-based and/or adaptive management conservation strategies may also be relevant to revisions to the Northwest Forest Plan that seek to better conserve dry forest old growth found west of the Cascade crest.

Adaptive management provides a potential solution to the difficult paradox of dry old-growth conservation that can also help integrate a variety of other objectives, including fire-risk reduction and maintenance of diverse wildlife habitats. Past experience demonstrates the importance of involving diverse stakeholders in defining conservation priorities and synthesizing information about the effects of treatments. Development of robust multiparty monitoring programs that regularly report results to stakeholders, managers, policy makers, and the general public is essential. The capacity to deliver these results will depend on strong long-term partnerships between the USFS, tribal governments, universities, and nongovernmental organizations.

Conclusions

Efforts to protect dry old growth in eastern Oregon are at a crossroads, with no simple or easy solutions at hand. A coarse-scale reserve strategy like the NWFP will not permit active management within older stands necessary to restore historical or desired future conditions. A fine-scale limit on cutting of trees larger than a certain diameter (e.g., ≥53 cm) does not provide managers with the flexibility to restore conditions that will be resilient to future change. Underlying these challenges is an urgency to take action to conserve old-growth trees in eastern Oregon as mortality of these trees accelerates in response to a changing climate and increasing extent of disturbance (Allen et al. 2015). Alternatives to one-size-fits-all diameter limits have been tested across tens of thousands of hectares within tribal-federal comanagement agreements and within collaborative management frameworks. Continued experimentation with adaptive management in these settings will be critical to conservation of dry forest old growth in the face of future change.

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