Using Historical Reconstructions of Moist Mixed Conifer Forests to Inform Forest Management on the Malheur National Forest

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ABSTRACT.—The Malheur National Forest works collaboratively with diverse stakeholders to accelerate the pace and scale of forest restoration. Both informal joint fact-finding, empirical research, and multi-party monitoring are used to inform planning and adjust implementation of restoration treatments in an adaptive management framework. Knowledge of historical dynamics is often used to guide restoration on the Malheur because scientists, managers, and stakeholders believe restoring forest structure and composition to the historical range of variability will make forests more resilient to future climate and disturbance regimes. There is a strong shared understanding of the role of frequent, low-intensity fire in fostering resilience of dry, ponderosa pine dominated forests. However, there has been little empirical research describing historical disturbance dynamics in moister landscape settings. USDA Forest Service silviculturists and researchers from Oregon State University investigated historical fire patterns, forest structure, and composition in moist mixed conifer stands on the Malheur National Forest. The findings of this partnership demonstrate that moist mixed conifer forests historically experienced similar fire return intervals, had similar basal area, and in most cases are more departed from historical conditions than dry ponderosa pine forests. Tools were also developed to aid in selection of large-diameter, fire-intolerant species for removal. This research and ongoing fact-finding and dialogue with stakeholders have been used to adapt silvicultural prescriptions over time. A multi-party monitoring program is being implemented to answer stakeholder questions about the effects of restoration treatments, while generating baseline data to answer questions about intermediate and long-term environmental effects.

INTRODUCTION

Congressional legislation including the Healthy Forest Restoration Act of 2003 and the Collaborative Forest Landscape Restoration Program (CFLRP) (16 USC §6501 et seq., 16 USC §7303 et seq) directs the Forest Service to reduce fuels and foster resilient forest conditions (Stephens et al. 2016, USDA Forest Service 2012). The Malheur National Forest (MNF) in the southern Blue Mountains of eastern Oregon (Fig. 1) has met this challenge by working with the Blue Mountains Forest Partners (BMFP) and Harney County Restoration Collaborative (HCRC) to secure $4 million annually under the CFLRP to accomplish accelerated forest restoration treatments within an 800,000-acre area within the MNF boundary (Schultz et al. 2012).

Use of the best available science is critical to maintaining the support of diverse stakeholders for accelerated restoration (Shindler et al. 2004). Informal joint fact-finding with the BMFP and HCRC, empirical research, and multi-party monitoring contribute to an adaptive management cycle in which managers and collaborative stakeholders are learning from restoration treatments and adjusting management practices accordingly.

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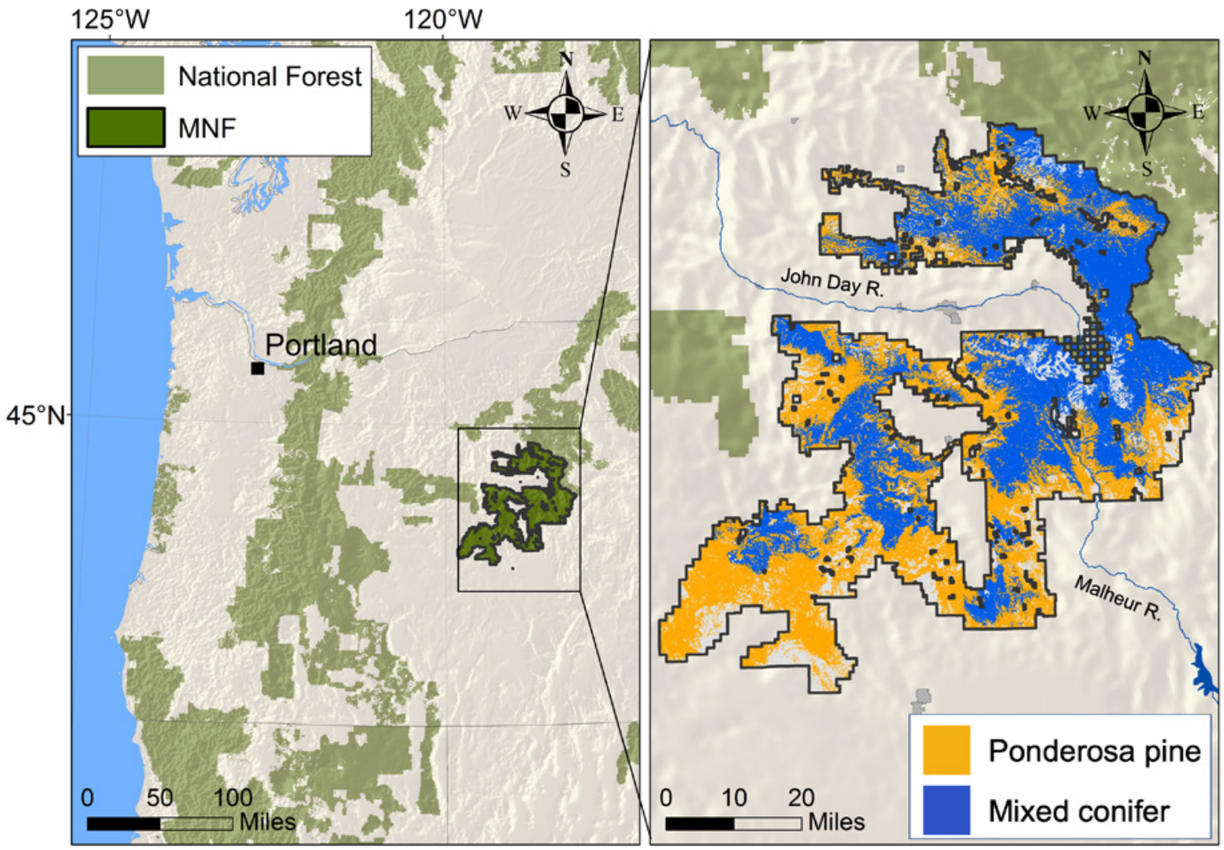

Figure 1.—Ponderosa pine and mixed conifer distributions across the Malheur National Forest in the Blue Mountains of eastern Oregon.

MNF projects generally seek to restore historical structure, composition, and disturbance processes because restoring historical conditions lowers fire risk and promotes resilience to anticipated future climate and disturbance regimes (Franklin and Johnson 2012). There is also strong stakeholder support for returning forests to their natural, presettlement condition (Cannon et al. 2018, Hessburg et al. 2015, Shindler and Mallon 2009, Thompson et al. 2009, Urgenson et al. 2017).

Researchers, managers, and the general public have a strong shared understanding of the role of frequent low-intensity fire in fostering resilience of dry ponderosa pine (*Pinus ponderosa*) dominated forests. They also have strong agreement around the historical structure and composition that frequent fire created and maintained across the landscape (Brown et al. 2004, Stephens et al. 2015). Early collaborative projects on the MNF focused on shared agreement around restorative actions in dry ponderosa pine forests. However, as restoration efforts were accelerated with augmented funding, it was necessary to plan projects within moist mixed conifer forests (Stine et al. 2014, Tiedemann et al. 2000). This forest type is found on deeper ash soils and cooler and moister aspects and is currently dominated by grand fir (*Abies grandis*), with smaller components of Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine, western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), Engelmann spruce (*Picea engelmannii*), and western white pine (*Pinus monticola*). Grand fir, Douglas-fir, and Engelmann spruce are less fire tolerant late seral species on the MNF, while ponderosa pine and western larch are highly fire tolerant early seral species.

A critical challenge to restoring historical conditions is being able to identify trees that established before Euro-American settlement disrupted frequent fire that maintained open stands of early seral, fire tolerant species. The Regional Forester's Eastside Forest Plan Amendment 2 (USDA Forest Service 1995), also known as the "Eastside Screens," amended the Forest Land and Resource Management plans of eastern Oregon and Washington NFs to generally prohibit the harvest of live trees greater than or equal to 21 inches diameter at breast height (d.b.h.) Since this amendment, the MNF has shifted from a focus on timber production to a focus on forest restoration with timber removal being a byproduct of restoration activities. To accomplish forest restoration, younger trees that have established since fire suppression often need to be removed, while trees 150 years of age and older need to be conserved to provide old forest structure. However, it became evident over time that many late seral trees that had become established since the beginning of fire suppression often grow rapidly, exceed 21 inches d.b.h., and need to be removed to accomplish restoration goals. Late seral trees contribute to the death of large, old early seral trees by competing for resources and promoting spread of contagious disturbances like fire and insects. They also exacerbate drought stress by transpiring water at proportionately higher rates, providing proportionately higher shade, and casting large amounts of seed when compared to early seral trees.

In response to this management situation, several dendroecological research projects and a multi-party monitoring program have been undertaken to determine:

- To what extent did fire historically shape moister mixed conifer forests?
- What magnitude of change has occurred in moister mixed conifer forests since fire suppression?
- How do managers identify trees to be removed in order to restore historical conditions?
- How are forests responding to treatments over time?

METHODS

Dendroecological Research

Two empirical research studies were conducted to answer the first three questions above. The first study (Johnston et al. 2017) reconstructed historical fire occurrence using fire-scarred trees to characterize historical fire-climate relationships and to determine if climatic influences on fire differed among dry ponderosa pine sites and more productive grand fir sites. The second study (Johnston 2017) used dendro-ecological methods to quantify historical structure and composition in diverse forest types and to describe the magnitude and direction of succession in these forest types in the absence of fire.

To address the shortcomings of diameter-based tree retention guidelines under the eastside screens, the MNF worked with collaborators and researchers to develop a multi-variable system for quickly aging trees in the field based on morphological characteristics that could be incorporated into restoration contracts. Guidelines for identifying old trees published by Van Pelt (2008) are helpful for this purpose and were initially used for projects on the MNF to determine old trees, and allow for the removal of young, late seral trees greater than or equal to 21 inches d.b.h. These guides work well for all species being removed on the MNF, except grand fir, which is the most common species in need of removal for restoration purposes.

Figure 2.—USDA Forest Service managers and members of the BMFP and HCRC discuss the results of thinning treatments on a field trip. Photos by James Johnston, Oregon State University, used with permission.

Multi-Party Monitoring and Adaptive Management

BMFP and HCRC staff and volunteers organize regular (usually once a month during spring-fall) meetings, workshops, and field trips to explore treated areas and develop recommendations for changes to silvicultural prescriptions (Fig. 2). These recommendations are memorialized in technical papers and "zones of agreement" documents that inform National Environmental Policy Act (NEPA) planning.

The BMPF, HCRC, MNF, and Oregon State University have also partnered to create a forest vegetation and fuels monitoring program that is currently monitoring changes to forest structure and composition, surface fuels, and understory vegetation in approximately 500 systematically located plots in 72 random located units of 12 MNF planning areas. Plot based monitoring will allow managers and stakeholders to answer a variety of questions about the effects of treatment, including but not limited to:

- How does treatment affect surface fuel accumulation over time?
- How does treatment affect future fire, drought, and insect disturbance patterns?
- What natural regeneration results from different treatment intensities in different landscape settings?
- What density of trees and what tree species can persist over time in different landscape settings under different climate and disturbance regimes?
- How do "leave" patches and openings respond over time to treatment?

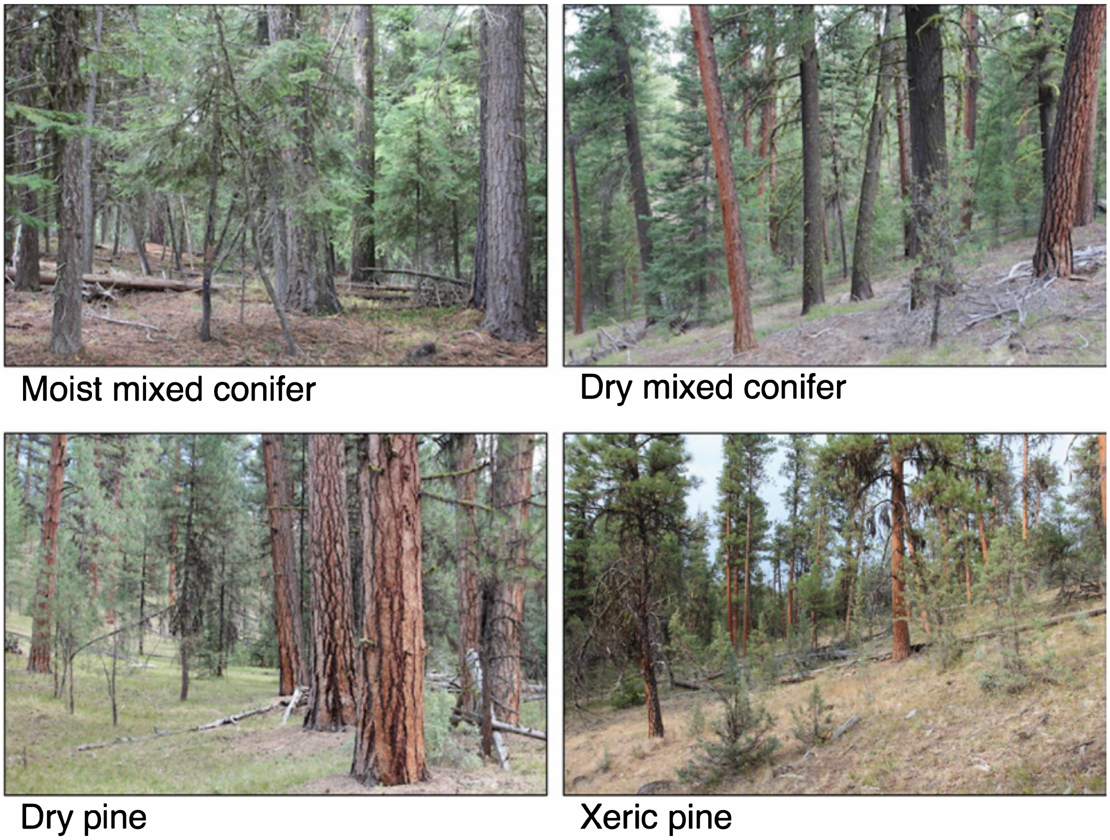

Figure 3.—Examples of different forest types found on the Malheur National Forest. Photos by James Johnston, Oregon State University, used with permission.

RESULTS

Dendroecological Research

Johnston et al. (2017) found that historical (1650–1900) mean fire return intervals (MFRIs) for dry ponderosa pine sites ranged from 10.6 years to 18.4 years, which was not statistically significantly different than MFRIs for moist grand fir sites that ranged from 11.8 years to 21.2 years. The authors also found there was no difference in reconstructed temperature or precipitation in historical fire years across dry ponderosa pine and moist grand fir sites on the MNF. Based on these results, the authors concluded that even though moist grand fir sites are inherently more productive than dry ponderosa pine sites, both forest types were historically fuel-limited systems that burned whenever ignitions coincided with fuel sufficient to carry fire.

Johnston (2017) classified the MNF into four forest types based on historical conditions and stand structures: (1) old-growth pine (stands dominated by pines over 300 years old); (2) transitional pine (stands dominated by younger pine); (3) dry mixed conifer (stands historically dominated by pine with some Douglas-fir, grand fir, and western larch); and (4) moist mixed conifer (stands historically dominated by western larch, Douglas-fir, and grand fir) (Fig. 3). Although the pine types differed from the mixed conifer types with respect to soil water availability, summer vapor pressure deficits, and contemporary tree biomass, this study found that in 1880 there was no statistically significant difference in tree basal area (BA) between these forest types. Although BA in all forest types has increased in the past 150 years, grand fir settings have experienced a far greater change in species composition and forest density than ponderosa pine settings (Figs. 4 and 5).

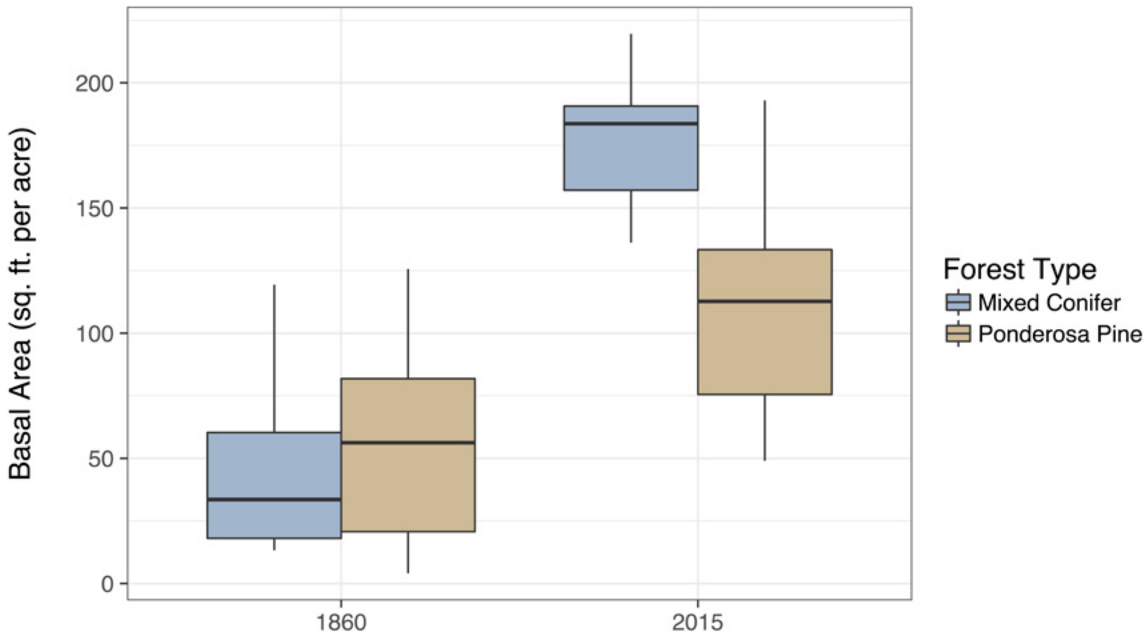

Figure 4.—Difference in basal area between mixed conifer and ponderosa pine in 1860 and 2015.

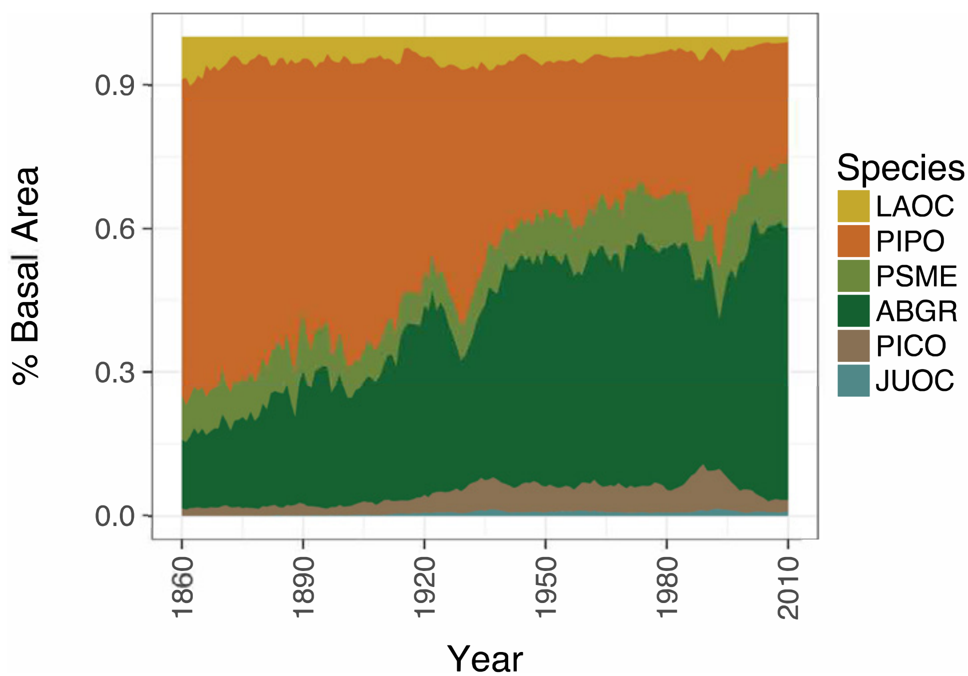

Figure 5.—Change in reconstructed species composition in mixed conifer stands over time. Legend refers to species' Latin names: LAOC= western larch; PIPO = ponderosa pine; PSME = Douglas-fir; ABGR = grand fir; PICO = lodgepole pine; and JUOC = western juniper.

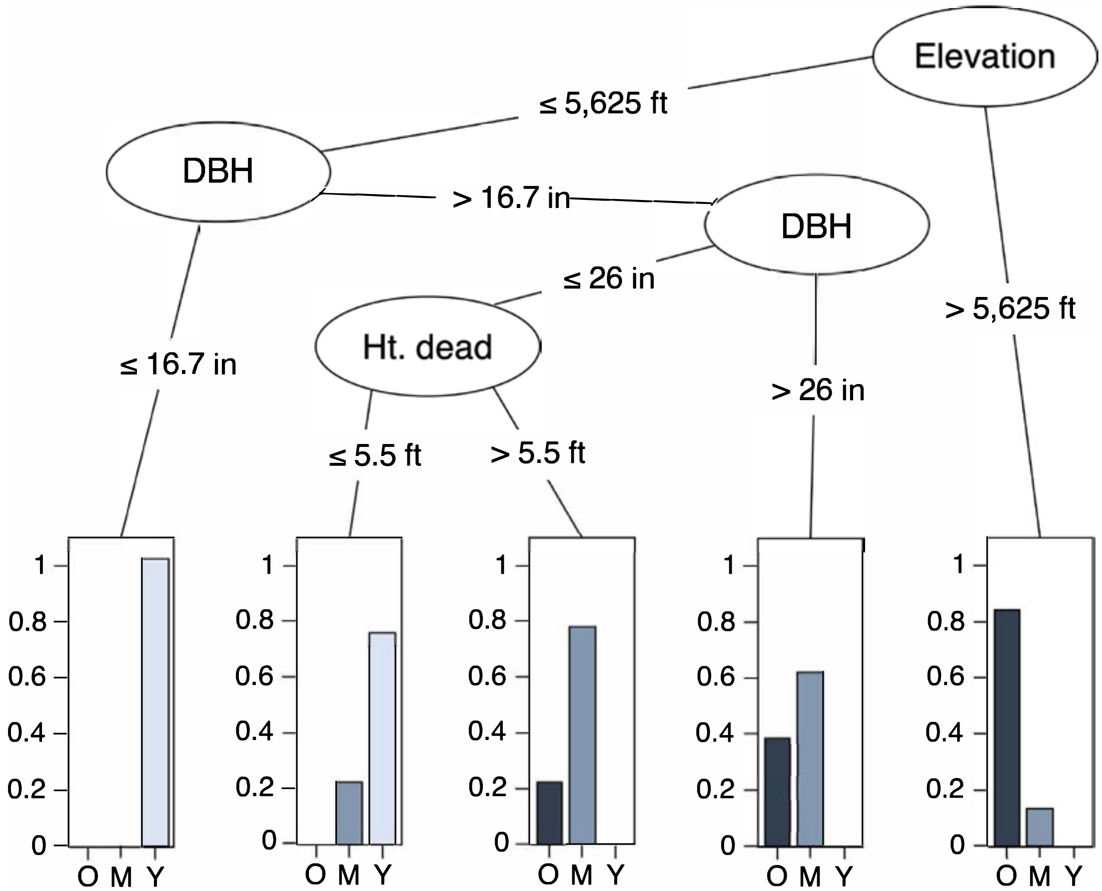

Figure 6.—Example of a conditional inference decision tree to determine the relative age of Douglas-fir based on elevation, d.b.h., and height to dead branches. O = old (older than 175 years old); M = mature (175–125 years old), Y = young (less than 125 years old).

Johnston et al. (2018) found that variables such as elevation, tree height to live foliage, and height to dead branches can be good predictors of grand fir and Douglas-fir age (Fig. 6), the two most common shade tolerant and relatively fire intolerant species targeted for removal by restoration treatments. These variables are also easy to measure in the field and incorporate into silviculture prescriptions. Moist mixed conifer treatments are now being planned using the Van Pelt (2008) guidelines for aging early seral trees and using the variables determined by Johnston et al. (2018) for aging late seral trees. These variables include species, d.b.h., elevation, height to live foliage, and height to lowest dead limb.

Monitoring and Adaptive Management

Initial moist mixed conifer treatments accomplished resilience goals through commercial thinning, noncommercial thinning, and fuel treatments. Commercial thinning prescriptions included a variable density thinning matrix with created openings and leave patches. The goal of variable density thinning was to decrease stand density while maintaining a multi-storied stand after treatment to provide for vertical structure. The specifications for variable density thinning included:

- Thin approximately 55 to 75 percent of each unit by thinning throughout the diameter range to a target of 60 to 140 square feet per acre BA.
- Leave approximately 15 to 35 percent shade tolerant and relatively fire intolerant trees and 65 to 85 percent shade intolerant and fire tolerant trees.

The goals of openings were to (1) regenerate early seral species either through natural regeneration or planting and (2) provide opening sizes that were consistent with historical stand replacement patches created by wildfire. Specifications for openings included:

- Approximately 10 to 20 percent of each treatment unit will be in one or more openings.
- Openings will be 1 to 10 acres in size and will leave 0 to 40 square feet per acre BA of healthy, shade intolerant and fire tolerant trees.

The goals of leave patches were to provide the best available wildlife habitat, protect resources, and maintain forest structure in moist areas. The specifications for leave areas included:

- Approximately 15 to 25 percent of each treatment unit will be left unthinned.
- Patches will be 1 to 10 acres in size.
- Leave patches in areas that would have historically had the potential to be skipped over during a fire event or that provide specific wildlife habitat.

Noncommercial thinning included thinning of small trees to meet preference standards of keeping shade intolerant and fire tolerant species and removing shade tolerant and relatively fire intolerant species. Fuels treatments included piling and burning of piles.

The BMFP and HCRC have undertaken more than 40 field trips, meetings, and workshops to assess restoration treatments over the past 3 years. This work led to the realization that the initial moist mixed conifer treatments undertaken were not adequately shifting species composition from shade tolerant and relatively fire intolerant species to shade intolerant and fire tolerant species, or creating spatial heterogeneity at fine spatial scales. It was evident that both tree markers and equipment operators selecting cut and leave trees tended to create the same target BA at fine spatial scales across the stand resulting in relatively even-spaced residual tree structure despite the variability built into prescriptions.

Moist mixed conifer prescriptions for commercial thinning are now being developed that do not specify BA targets, but instead specify leave tree requirements in which all trees not meeting requirements are removed. Specifications include leaving all old trees, all shade-intolerant and fire-tolerant trees greater than or equal to 21 inches d.b.h., all trees within 30 feet of old grand fir and Douglas-fir, all healthy early seral trees, wildlife trees, and all Douglas-fir within 30 feet of ephemeral draws. Although this leave-tree prescription has not been implemented yet, sample marking conducted within the project area resulted in increased spatial heterogeneity and fewer late seral trees, while still maintaining a similar BA as the targets specified in the initial moist mixed conifer treatments.

DISCUSSION

Results from dendroeclogical studies align with similar studies in the dry forests of central and eastern Oregon and Washington (Hagmann et al. 2014, Merschel et al. 2014, Merschel et al. 2018). Taken together, managers have strong confidence that shifts in stand structure, density, and species composition have occurred across almost all forest types found in eastern Oregon. Fire suppression, historical logging and overgrazing, and a cooler and moister climate were the important drivers of forest change over the past century and a half (Hessburg et al. 2005). Frequent, low-severity fire was historically the dominant disturbance factor across the landscape that tended to equalize forest structure and composition across a wide range of productivity gradients. Current fire patterns have changed from historical conditions: Instead of large, low-severity fires that burned at frequent intervals, the MNF is now experiencing smaller, less frequent, and more severe fires.

Goals of landscape restoration projects on the MNF include shifting the landscape back toward the historical range of variability and improving forest resiliency to disturbance. Accomplishing these goals involves treatments to reduce fuel loadings, reduce tree density, shift species composition from late seral to early seral species, protect old trees and old-growth conditions, and increase spatial heterogeneity at fine and coarse scales. Treatments have been developed over the past 10 years to address this need on moist mixed conifer sites, and these treatments have evolved through an adaptive management process involving USDA Forest Service managers and the BMFP and HCRC.

Mechanical fuel reduction is accomplished by thinning trees, removing ladder fuels, and piling and burning slash generated by thinning. However, after all of these treatments are completed, there is still the need to reduce fine fuels and restore fire cycles on the landscape. The MNF accomplishes this objective through prescribed burning in the spring and fall. Although the MNF has a fairly aggressive prescribed fire program, it has become evident that because of narrow burn windows and a declining workforce and budget, the Forest is not keeping up with the amount of prescribed fire needed to restore fire as a natural process across the landscape. At the current rate of burning, it will take over 150 years to prescribe burn the entire forest once, while Johnston et al. (2017) demonstrated that fire return intervals were much shorter than that.

The BMFP, HCRC, and MNF are working closely with the State of Oregon regulatory agencies to widen the weather parameters during which prescribed burning can occur. Managing wildfire is also being planned during environmental analysis of large landscape projects to increase the amount of burning that can be accomplished each year. Several considerations inform the decision to directly attack and extinguish a wildfire or manage it for restoration purposes. These considerations include weather forecasts, fuel densities and conditions, threats to property and structures, firefighter safety, and adequate holding lines. Restoration projects on the MNF have the long-term goal of restoring large enough blocks of land that managed wildfire can be used to help restore and maintain fire across the landscape at a rate that is closer to historical fire cycles.

CONCLUSIONS

Where restoration of historical conditions is a goal of forest management on national forests, it is critical to understand historical disturbance processes and the composition and structures those processes developed and maintained. Partnerships among managers, researchers, and collaborative groups have helped to inform management prescriptions for moist mixed conifer on the MNF and built understanding and agreement around the need for restoration and the types of treatments in this forest type. Monitoring of the effects of restoration treatments will help to inform the adaptive management process and refine management practices around restoration. All of this work was conducted within the MNF boundary, and although similar studies have been conducted within eastern Oregon and Washington, local information and science is important for developing the social license around site-specific prescriptions in controversial forest types.

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