Characterizing variation in forest structure, composition, and disturbance over time on the Malheur National Forest

Overview

This paper addresses five questions:

- How can forests in the southern Blue Mountains be divided into distinct forest types?
- How can we distinguish moist mixed conifer forests from other forest types?
- What did different forest types look like prior to fire exclusion?
- How did fire frequency differ between different forest types?
- How have different forest types changed relative to historical conditions?

Methods for characterizing forest variation

Plant association group typologies

There are at least two methods for characterizing variation in forest structure and composition on the Malheur National Forest. The first method relies on identifying associations of overstory trees and understory vegetation that occupy different sites in the absence of disturbance. Because the growth and establishment of different plant species is controlled by different environmental tolerances, characteristic assemblages of overstory trees and understory plants can serve as surrogates for different temperature and moisture regimes (Powell et al. 2007, Johnson and Clausnitzer 1992).

Different assemblages of overstory trees and understory plants (plant associations) are grouped into different temperature and moisture regimes (plant association groups or PAGs), for example, hot/dry, warm/dry, and cool/moist PAGs. These different temperature and moisture regimes are in turn often assumed to predict characteristic forest successional and disturbance dynamics, and hence, appropriate restoration treatments (Stine et al. 2014, Franklin and Johnson 2012).

Hot/dry and warm/dry PAGs within the Malheur National Forest generally encompass sites with overstories of ponderosa pine, Douglas fir, or grand fir and understories dominated by grasses and sedges. Cool/moist plant association groups include forests with overstories dominated by grand fir and understories with plants like twinflower (*Linnaea borealis*) and grouse huckleberry (*Vaccinium scoparium*). Forests typed to cool/moist plant associations may be synonymous with moist mixed conifer sites (Figures 1 and 2).

	Moisture			
Temperature	**Wet**	**Very moist**	**Moist**	**Dry**
Cold	Cold wet	Cold very moist	Cold moist	Cold dry
Cool	Cool wet	Cool very moist	Cool moist	Cool dry
Warm	Warm wet	Warm very moist	Warm moist	Warm dry
Hot	Hot wet	Hot very moist	Hot moist	Hot dry

Figure 1. Temperature and moisture matrix (from Powell 2007). Common plant associations/temperature-moisture regimes on the Malheur National Forest are indicated by gold boxes. The cool/moist plant association, which may be synonymous with moist mixed conifer forests, is identified with a blue box.

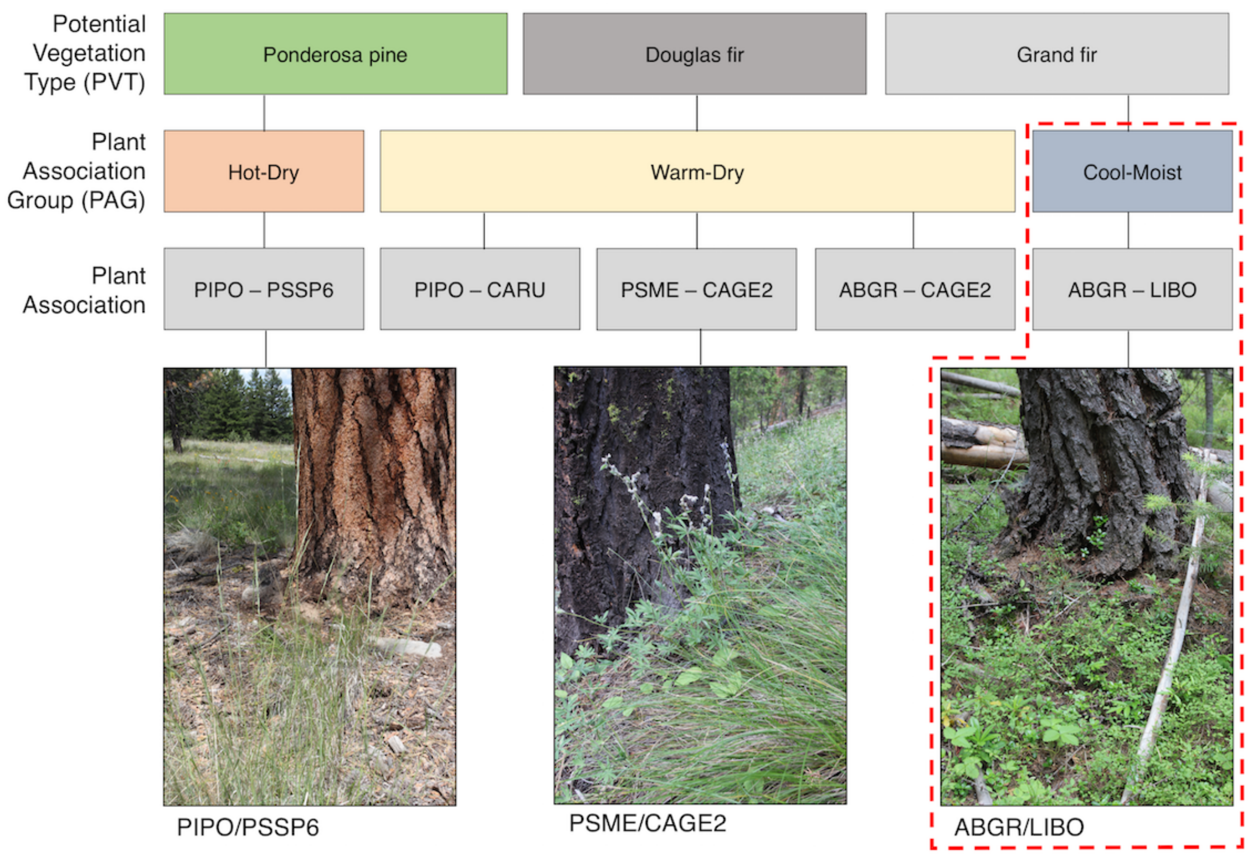

Figure 2. Examples of hot/dry, warm/dry, and cool/moist plant associations commonly found on the Malheur National Forest. An example of a cool/moist plant association is identified with a dashed red box. PIPO = ponderosa pine, PSSP6 = bluebunch wheatgrass, CARU = pinegrass, PSME = Douglas-fir, CAGE2 = elk sedge, ABGR = grand fir, LIBO = twinflower.

Overstory tree structure and composition typologies

Recent research in eastern Oregon uses tree ring-based reconstructions to categorize forests based on the structure and composition of overstory trees (Johnston et al. in press, Johnston in review, Merschel et al. 2014). A disadvantage of dendroecology studies is that they are typically limited in spatial extent. An advantage is that they allow scientists to evaluate change over time.

A recent study on the Malheur National Forest evaluated change between 1860 and 2010 in 20 plots within randomly selected sites in unmanaged roadless areas. A total of four plots were selected from cool/moist PAGs, 14 plots from warm/dry PAGs, and two plots from hot/dry PAGs. Sites were categorized based on basal area of different species of live trees in each site. Forest types derived from this analysis are depicted in Figure 3. They include:

1. "Transitional pine": Generally low tree biomass sites dominated by younger ponderosa pine.
2. "Old-growth pine": Moderate tree biomass sites dominated by older ponderosa pine.
3. "Dry mixed conifer": High tree biomass sites dominated by a mix of ponderosa pine, grand fir, and Douglas fir.
4. "Moist mixed conifer": High tree biomass sites dominated by grand fir with scattered Douglas fir, larch, and lodgepole pine.

In both pine types, almost all overstory trees are ponderosa pine. Younger regeneration is a mix of early seral species like ponderosa pine and late seral species like Douglas fir, grand fir, and lodgepole pine.

In mixed conifer types, overstory trees are a mix of early seral species (ponderosa pine and western larch) and late seral species (grand fir, Douglas fir, and lodgepole pine). Younger regeneration is almost entirely late seral species like grand fir and Douglas-fir.

Moist mixed conifer forests can be distinguished from dry mixed conifer forests in that moist mixed conifer forests have less ponderosa pine and more western larch in the overstory than dry mixed conifer forests.

Historical vs. contemporary structure, composition, and fire disturbance dynamics in different forest types

Tree-ring reconstructions in randomly selected stands on the Malheur National Forest demonstrate that mixed conifer stands had approximately the same basal area as ponderosa pine stands in the late 1800s (Figure 4). Moist mixed conifer stands had some of the lowest reconstructed basal areas in the late 1800s of any stands where historical basal area was reconstructed (Table 1).

Frequent fire in all forest types probably explains why more productive sites historically had the same or less basal area than less productive sites. A recent study of fire occurrence in 13 sites on the Malheur National Forest showed that mean fire return intervals between 1680 and 1900 ranged from 10.6-18.4 years within ponderosa pine sites and from 11.8 to 21.2 years within mixed conifer sites (Johnston et. al. in review). Although forests on the Malheur National Forest are very different with respect to inherent productivity and today have very different structural and compositional attributes, historically all sites experienced similar fire disturbance regimes, which tended to equalize stand biomass across the landscape (Figure 5).

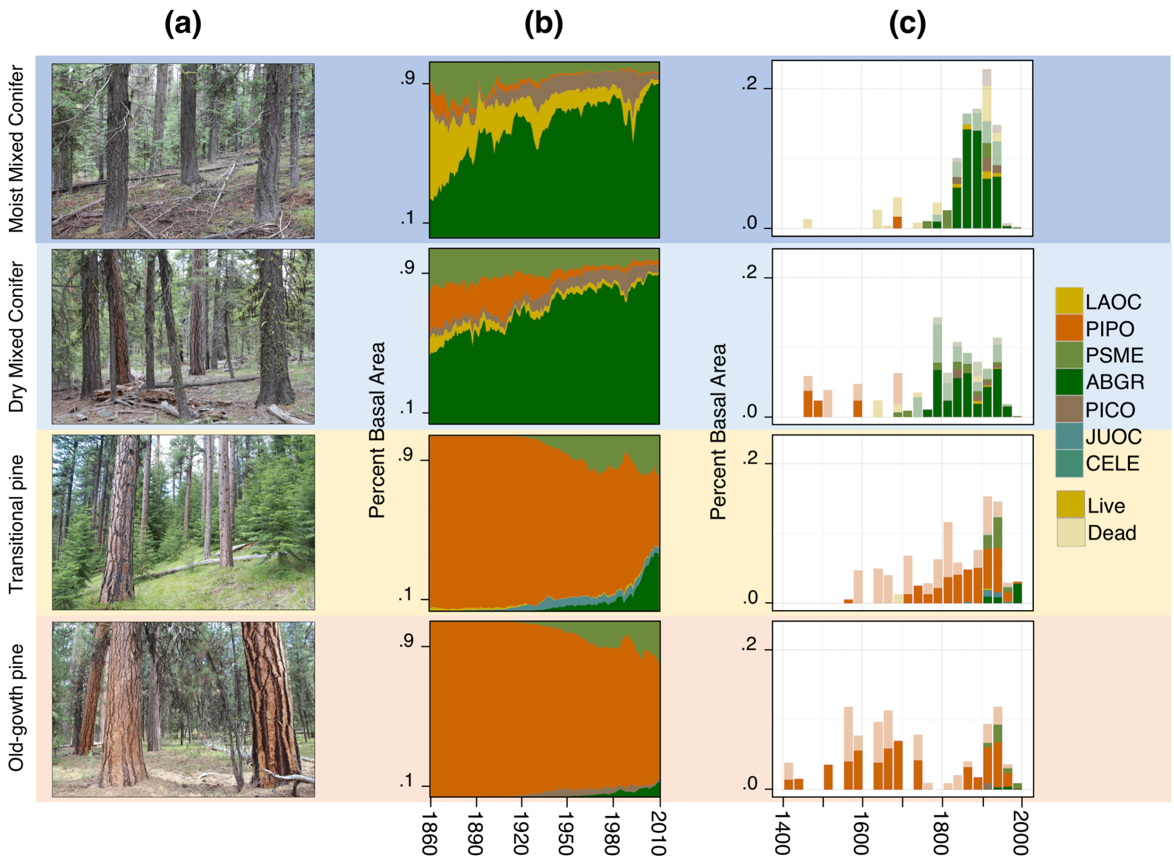

Figure 3. Successional change in different forest types. Panel (a) shows example photographs of plots in different forest types. Panel (b) shows basal area as a proportion of total stand area over the last 150 years. Panel (c) shows establishment of basal area as a proportion of total stand basal area over time. LAOC = western larch, PIPO = ponderosa pine, PSME = Douglas-fir, ABGR = grand fir, PICO = lodgepole pine, JUOC = juniper, CELE = mountain mahogany. Lighter shades of each color denote dead trees. Note that moist mixed conifer stands were formerly dominated by a few large western larch, but that most current basal area consists of young grand fir. Dry mixed conifer stands were formerly a mix of grand fir, ponderosa pine, and Douglas fir but are now dominated by younger grand fir. Ponderosa pine remains the dominant species in ponderosa pine types, although Douglas fir and to a lesser extent grand fir is infilling in these sites.

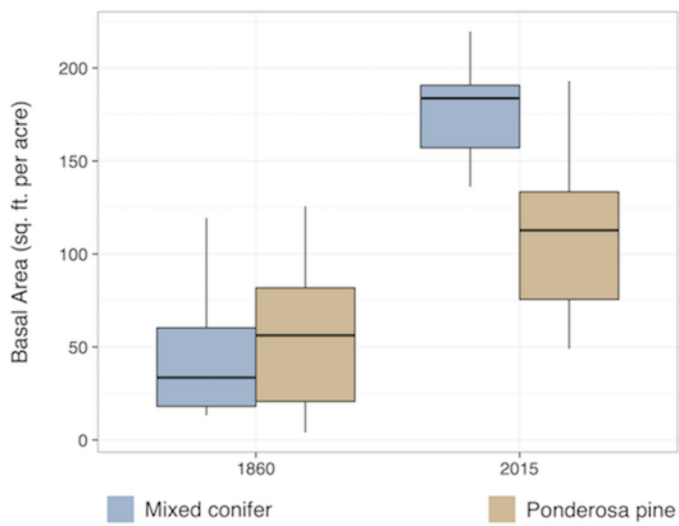

Figure 4. The range of basal areas found in mixed conifer and ponderosa pine sites in 1860 and 2015. Note that mixed conifer sites currently have significantly more basal area than ponderosa pine sites, but stand basal areas were historically similar between these forest types.

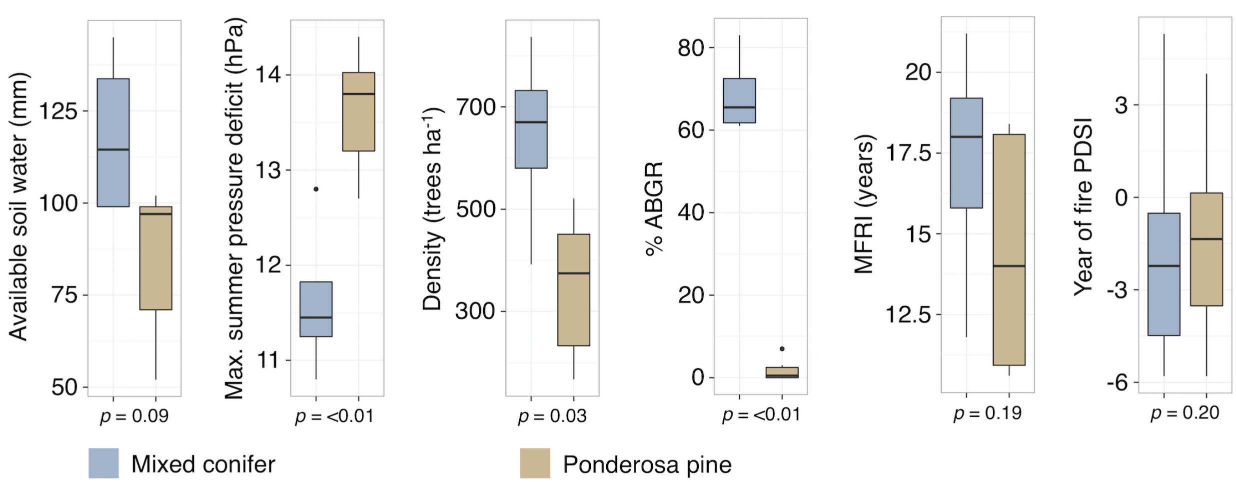

Figure 5. Comparison of common measures of site productivity and fire disturbance history between mixed conifer and ponderosa pine sites: From left to right: Available soil water, maximum summer vapor pressure deficit (an important constraint on tree transpiration related to temperature), forest density, percentage of contemporary stands composed of grand fir, historical (1680-1900) mean fire return interval, and Palmer Drought Severity Index (PDSI—a measure of aridity) during historical fire years. Note that mixed conifer and ponderosa pine sites are very different with respect to inherent productivity, but similar with respect to historical fire disturbance dynamics.

Group	1860	2010	% change
Density trees ≥6 inches			
MMC	12 ±0	180 ±33	1400%
DMC	31 ±8	155 ±16	400%
TRP	20 ±6	91 ±18	355%
OGP	30 ±4	94 ±13.6	213%
All Plots	23 ±3	122 ±13	430%
Density trees ≥21 inches			
MMC	3 ±2	13 ±2	333%
DMC	11 ±4	19 ±4	73%
TRP	4 ±1	10 ±4	150%
OGP	15 ±2	14 ±2	-7%
All Plots	8 ±2	14 ±2	75%
Basal area trees ≥6 inches			
MMC	19.6 ±3.5	179.9 ±15.7	818%
DMC	70.6 ±17.4	173.8 ±12.6	146%
TRP	28.7 ±9.1	90.6 ±18.7	215%
OGP	89.3 ±10.0	132.9 ±7.4	49%
All Plots	50.1 ±8.3	135.9 ±11.3	171%
Basal area trees ≥21 inches			
MMC	9.6 ±5.7	54.9 ±12.6	473%
DMC	53.1 ±16.6	87.1 ±10.9	64%
TRP	10.9 ±3.5	33.5 ±12.2	208%
OGP	69.7 ±13.1	90.2 ±11.8	29%
All Plots	33.5 ±7.4	62.7 ±8.3	87%

Table 1. Reconstructed forest density and basal area in four different forest types (MMC = moist mixed conifer, DMC = dry mixed conifer, TRP = transitional pine, OGP = old-growth pine). Smaller script after each tree density and basal area estimate is a standard error for the estimate.

A working definition of moist mixed conifer forests

Dendroecological reconstructions show that both mixed conifer and ponderosa pine forests were significantly less dense than they are today (Figure 4 and Table 1). Mixed conifer stands have experienced significant shifts in overstory tree composition over the last 150 years in which early seral fire tolerant species have declined relative to late-seral fire intolerant species. The most dramatic decline in dry mixed conifer forests as defined by overstory tree structure has been a decline in ponderosa pine. The most dramatic decline in moist mixed conifer forests has been a decline in western larch (see Figure 3, panel b).

The Blue Mountains Forest Partners are interested in creating forest structure and composition that will be resilient to future drought, insect attack, and fire disturbance. This implies significantly reducing forest density and shifting species composition from fire and insect intolerant to fire and insect tolerant species.

In summary, dry mixed conifer stands are those stands where there are opportunities to create resilient forests conditions by restoring older ponderosa pine structure while maintaining older late seral structure that is likely to be persistent in the future. Moist mixed conifer forests are those forests where there are opportunities to restore significant older larch structure while maintaining older, persistent late seral structure.

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