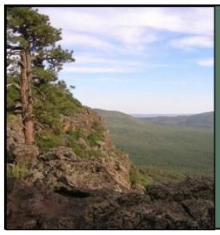

The Wallow Fire and its effects on mixed conifer forest: A comparison with reference conditions

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A blackened patch of mixed conifer forest in Arizona due to high-severity burning within the Wallow Fire. *Photo by David Huffman, Ecological Restoration Institute*

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Executive Summary

Portions of mixed conifer forests have undergone changes in disturbance regimes, species composition, and forest structure since European settlement and have been impacted by recent landscape-scale fires which have burned large patches with high severity. The Wallow Fire, the largest fire recorded in Arizona, burned a total of 217,741 ha (538,050 ac) in Arizona and New Mexico in the summer of 2011.

The purpose of this study was to evaluate high-severity burn patch characteristics in the Wallow fire and determine if they were within the historical range of variability (HRV) for southwestern mixed conifer forests. We used a spatial pattern analysis program to evaluate patch metrics by severity for mixed conifer forests within the Wallow Fire perimeter. The major findings from this analysis indicate that:

- The Wallow Fire burned 31,643 ha (78,191 ac) of mixed conifer forest; 16,677 ha (41,210 ac), or 53%, were classified as dry mixed conifer; 14,966 ha (36,981 ac), or 47%, were classified as wet mixed conifer.
- About 50% of the mixed conifer forest was classified as high severity based on the four-class RAVG layer; 48%, or 8,005 ha (19,780 ac), of dry mixed conifer forest, and 53%, or 7,932 ha (19,600 ac), of wet mixed conifer forest was classified as high severity.
- Less than 1% of high-severity patches in dry mixed conifer forest were greater than 50 ha (> 123.5 ac) in size, however, these patches comprised 28% of the area classified as high severity. The largest patch classified as high-severity in dry mixed conifer was 221 ha (546 ac) in size.
- Only 2% of high-severity patches in dry mixed conifer forest were greater than 50 ha (> 123.5 ac) in size, however, these patches comprised 41% of the area classified as high severity. The largest patch classified as high-severity in dry mixed conifer was 387 ha (955 ac) in size.
- Between 28% and 69% of the dry mixed conifer forest burned outside the HRV based on our analysis of high-severity patches.
- Wet mixed conifer forests in the Wallow Fire were entirely within the HRV based on our analysis of high-severity burn patches.

This study focused on the evaluation of high-severity patch characteristics to evaluate how mixed conifer forests burned in relation to reference conditions, however, it should be noted that areas that burned at lower severities, particularly, moderate severity, may have had beneficial effects consistent with outcomes observed following restoration treatments.

Alternatively, although the analysis indicates that large patches of high-severity fire may be normal in wet mixed conifer forests, this does not mean that low- or moderate-severity burn patches are not normal nor would it preclude implementing forest treatments in wet mixed conifer areas if other values (e.g., private property, human structures) were in need of protection.

Ultimately, managers, policy makers, and the public will have to decide what level of high-severity fire is acceptable and assess the tradeoffs of forest treatments in mixed conifer forests.

Introduction

Mixed conifer forests occur across a broad continuum of climatic zones and have variable stand structure, species composition, and spatial patterns (Evans et al. 2011). Common overstory tree species in mixed conifer forests include fire-tolerant species such as ponderosa pine, southwestern white pine and Douglas-fir, and fire-intolerant species such as white fir, subalpine/corkbark fir, aspen, and spruce. Mixed conifer forests in the western United States have undergone changes in disturbance regimes, species composition, and forest structure since European settlement (Stephens and Collins 2004, Heyerdahl et al. 2005, Beaty and Taylor 2008, Lydersen et al. 2013). Recent landscape-scale fires (e.g., Rodeo-Chediski Fire [2002], Hayman Fire [2002], Wallow Fire [2011]) have burned large patches within mixed conifer forest.

In Arizona, mixed conifer forests cover approximately 191,000 ha (472,000 ac), or about 3% of the state's total land cover. They generally occur between lower elevation pine stands and higher elevation stands of spruce and fir (Moir and Ludwig 1979, USGS 2004). While relatively rare in Arizona, mixed conifer forests provide important wildlife habitats, valuable biodiversity, and numerous recreational opportunities including hiking, camping, hunting, and skiing (Dolan and Rogstad 2007).

Forest ecologists have identified two subtypes of mixed conifer forests: warm-dry mixed conifer (hereafter "dry mixed conifer") and cool-moist mixed conifer (hereafter "wet mixed conifer") (Romme et al. 2009). Historically, dry mixed conifer, which are generally found at lower elevations, was a relatively open forest that experienced frequent (< 50-year fire-return interval), low- to moderate-severity surface fires with high-severity fire occurring occasionally across a limited spatial extent (Smith 2006, Smith et al. 2008, Romme et al. 2009). Ponderosa pine was usually dominant or at least present in dry mixed conifer forests prior to fire exclusion (Reynolds et al. 2013). Contemporary dry mixed conifer forests are often dominated by mesic species due to the lack of surface fires during the last century (Reynolds et al. 2013). Wet mixed conifer, which are generally found at higher elevations, historically experienced infrequent, mixed-severity fires (> 50-year fire return interval) with stand-replacing events occurring across large portions of this forest type (Romme et al. 2009). Due to this type of fire regime, the forest structure in wet mixed conifer was typically comprised of even-aged stands of shade-tolerant species with a closed canopy (Smith et al. 2008). Ponderosa pine was usually absent with mesic species dominant in wet mixed conifer forests prior to fire exclusion (Reynolds et al. 2013). Disturbance regimes in contemporary wet mixed conifer forests have not been severely altered, thus, these ecosystems are generally in a condition similar to their evolutionary environment.

As is the case throughout the western United States, the stand structure, species composition, and fire regimes in most dry mixed conifer forests in the Southwest are currently outside the historical range of variability (HRV) (Dahms and Geils 1997, Landres et al. 1999). Many studies in the Southwest have focused on the dry mixed conifer subtype (Dieterich 1983, Touchan et al. 1996, Brown et al. 2001, Fulé et al. 2004a, Fulé et al. 2006, Heinlein et al. 2005). For example, Swetnam and Baisan (1996) summarized 24 tree-ring based studies conducted in mixed conifer forests in Arizona and New Mexico and reported historical mean fire intervals ranging from about 4-26 years. Likewise, Reynolds et al. (2013) studied the historic forest structure at 15 southwestern dry mixed conifer sites and reported that average tree density ranged between 51.6-245.6 tph (20.9-99.4 tpa) while the average basal area was 9.1-28.5 m^2/ha (39.6 -124 ft^2/ac).

Information about reference conditions in southwestern wet mixed conifer forests is somewhat limited when compared to that of dry mixed conifer forests. Nonetheless, some good studies do exist. For

example, in a fire history study in mixed conifer forest at the North Rim of Grand Canyon National Park, Fulé et al. (2003) found a mixed-severity fire regime with surface fire occurring predominantly on south aspects (dry mixed conifer) and evidence of fire-initiated stands (i.e., stand-replacing fire) occurring on wetter sites (wet mixed conifer). Meanwhile, Smith et al. (2008) report a fire-return interval between 22-150 years in wet mixed conifer forests.

Information about the historical spatial extent of high-severity fires in southwestern mixed conifer is likewise limited. For example, Brown et al. (2001) sampled dry mixed conifer forests in the Sacramento Mountains of New Mexico and obtained long-term inventories of past fires at the stand-scale (10 – 30 ha) and did not find evidence of historic crown fires. Similarly, Fulé et al. (2009) did not find evidence of historical high-severity fire in a stand-scale study in a southwestern Colorado mixed conifer forest. Although the study by Fulé et al. (2003) at the North Rim of the Grand Canyon did not explicitly differentiate between dry and wet mixed conifer, it can be inferred from their findings that high-severity burning historically occurred mostly in wet, not dry mixed conifer because fire-initiated plots were generally found on cool/wet north aspects. Williams and Baker (2012) used historical land surveys to reconstruct forest structure and predicted that substantial high-severity fire occurred historically in dry mixed conifer forests of Arizona. Direct historical evidence of broad-scale (100 ha to > 1000 ha or ≈250 to > ≈2500 ac) patches of stand-replacing fire has been documented in southwestern wet mixed conifer forests (Margolis et al. 2007, 2011).

The Wallow Fire, the largest fire recorded in Arizona, burned approximately 217,741 ha (538,050 ac) in Arizona (97% of the area) and New Mexico (3% of the area) during the summer of 2011 (www.inciweb.org). Prior to the fire, about 27,841 ha (68,796 ac) were classified as mixed conifer based on LANDFIRE data (Wadleigh 2011). Following the fire, managers and researchers raised questions regarding how mixed conifer forests burned in relation to reference conditions. The purpose of this study was to evaluate wildfire effects in mixed conifer forests of the Wallow Fire compared to reference conditions. Specifically, our goal was to evaluate high-severity burn patch characteristics and determine if they were within the HRV for southwestern mixed conifer forests.

Methods

In order to meet our goal of understanding how mixed conifer forests responded to the Wallow Fire compared to reference conditions, we employed two different methods: 1) undertaking a review of the literature to identify site-specific reference conditions, and 2) use of a spatial pattern analysis program to evaluate fire severity within the Wallow Fire perimeter.

Historic forest structure

We performed a literature review to confirm that site-specific reference conditions for structure, species composition, and disturbance in mixed conifer forests within, and adjacent to, the Wallow Fire were similar to general reference conditions for mixed conifer forests. Although we did not find any studies reporting site-specific reference conditions for stand structure and species composition, we obtained three, 0.5-0.8 ha (1.2-2.0 ac), historic stem maps from 1911 showing all tree structures in three mixed conifer areas within or directly adjacent to the Wallow Fire perimeter (Figure 1; Sánchez-Meador, unpublished data). We counted the overstory structures by species on the plot maps to determine historical stand structure and composition.

Evaluation of patch metrics

We used the mid-scale dominance type classification produced by the USDA Forest Service (Triepke et al. 2005) as the base layer for the analysis. (Dominance type classifications are a way to organize plant communities according to existing, as opposed to potential, natural vegetation). We selected the dominance type descriptors "douglas-fir", "white fir", and "aspen-evergreen tree mix" to create a "mixed conifer" layer. We subdivided the mixed conifer layer into dry mixed conifer and wet mixed conifer using the "vegetation type" field from the Terrestrial Ecosystem Survey (TES) layer (USFS 1998) in ArcGIS (ESRI 2011). Vegetation types that included mixed conifer species (e.g., Douglas-fir, white fir, etc.) plus ponderosa pine were classified as "dry mixed conifer," while those that included mixed conifer species without the presence of ponderosa pine were classified as "wet mixed conifer." We then intersected the dry and wet mixed conifer layers with the Rapid Assessment of Vegetation Condition after Wildfire (RAVG) layer, which uses immediate basal area (BA) loss to determine fire severity (USFS 2011). We used the four-class RAVG layer that classified severity as follows: unburned (0% BA loss), low (≤ 25% BA loss), moderate (> 25% and ≤ 75% BA loss), and high (≥ 75% BA mortality). We clipped all layers to a truncated perimeter (area = 210,170 ha or 519,342 ac) that excluded Apache Reservation lands and areas of New Mexico that burned in the Wallow Fire because those data were unavailable. We used FRAGSTATS (v4), a spatial pattern analysis program, to evaluate patch metrics by severity for mixed conifer forests within the Wallow Fire perimeter. FRAGSTATS is designed to compute a wide variety of landscape metrics for categorical map patterns (McGarigal et al. 2012). We imported the ArcGIS files for dry and wet mixed conifer into FRAGSTATS and ran the program to produce the following patch metrics for each severity class: area, proportion of the landscape, area-weighted mean patch size, largest patch index, and patch density (Table 1).

Criteria for determining historical range of variability in southwestern mixed conifer forests

We reviewed existing literature to determine if the size of high-severity burn patches in the Wallow Fire were within the HRV for southwestern mixed conifer forests. For dry mixed conifer forests, evidence from the North Rim of the Grand Canyon (Fulé et al. 2003) indicated that some high-severity fire occurred historically at the stand-scale (< 10 ha or 25 ac). We did not find evidence that broad-scale (> 50 ha or 123.5 ac) high-severity fires occurred historically. We, therefore, determined that high-severity burn patches less than 10 ha (25 ac) were within the HRV while burn patches greater than 50 ha (123.5 ac) were outside the HRV for dry mixed conifer forests in the Wallow Fire. We were less certain about high-severity burn patches from 10-50 ha (25-123.5 ac) in size and evaluated this category as both within and outside HRV for comparison. For wet mixed conifer, high-severity patches from 0 to greater than 1000 ha (0 to greater than 2471 ac) were considered within the HRV.

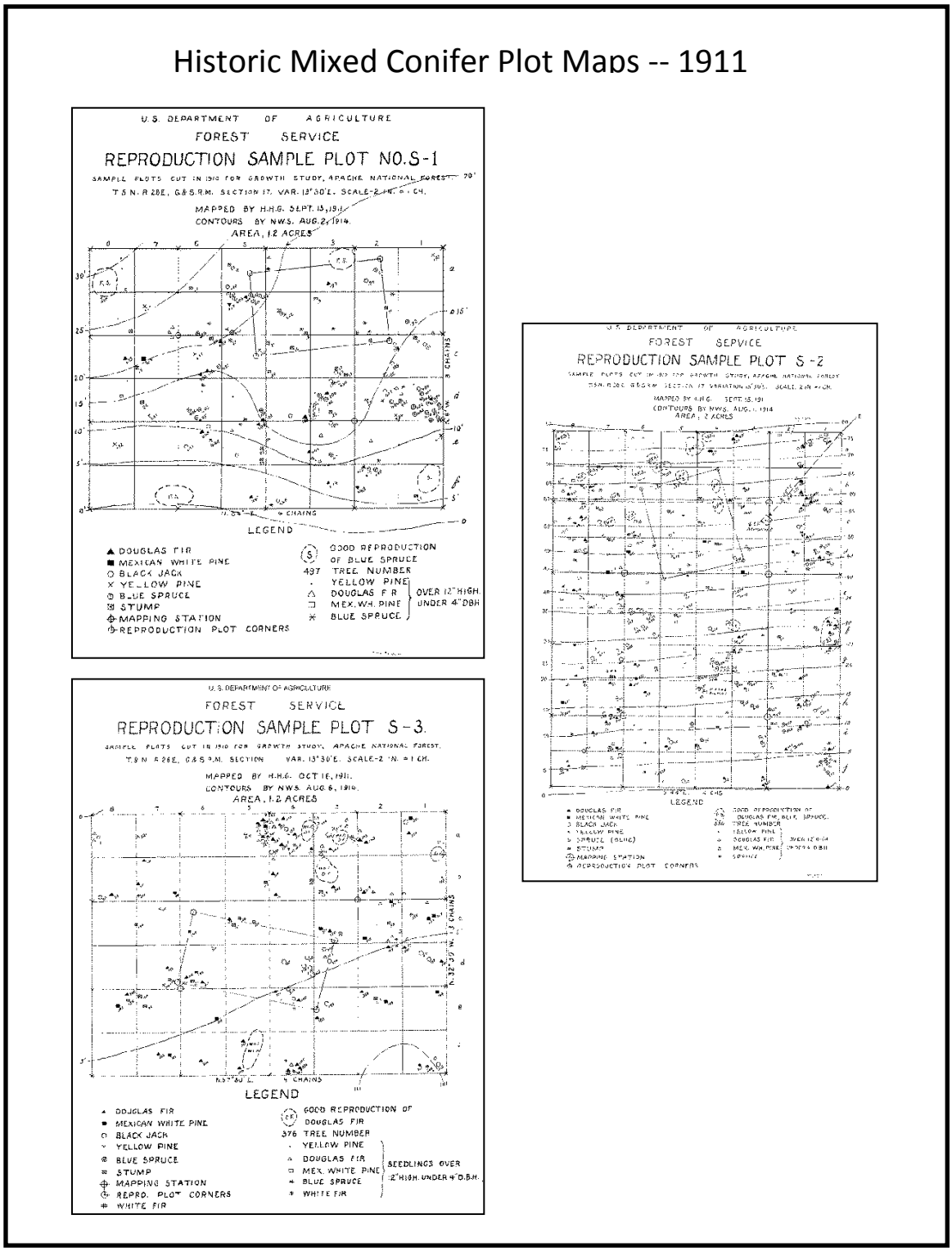

Figure 1. Three historic plots, originally mapped in 1911, were used to determine site-specific reference conditions for stand structure and composition in mixed conifer stands located within or directly adjacent to the Wallow Fire perimeter.

Table 1. Patch metrics used in this study.

Metric	Description	Units
Area	The combined area of the patches in each severity class	ha/ac
Proportion of landscape	The sum of the areas of all patches in each severity class divided by the total landscape area	%
Area-weighted mean patch size	The area-weighted average size of patches for each severity class	ha/ac
Largest patch index	The area of the largest patch in each severity class divided by the total landscape area	%
Patch density	The number of patches in each severity class divided by the total landscape area	# per 100 ha

Results

Verification of mixed conifer reference conditions for the Wallow Fire

We did not find any studies that documented site-specific reference conditions for structure or species composition in mixed conifer forests within or directly adjacent to the Wallow Fire. However, using unpublished data from three historical plots originally mapped by T.S. Woolsey, Jr. in 1911, we were able to determine site-specific information for overstory tree density and species composition for the dry mixed conifer subtype (Figure 1, Table 2). Mean tree density for all species was 328.4 trees per hectare (132.9 trees per acre) and ranged between 29.5-369.4 tph (120-149.5 tpa) on the three historic plots (Table 2). We found one fire history study that was conducted in a dry mixed conifer forest within the Wallow Fire. Dieterich (1983) reported a mean fire interval of 22 years prior to 1900 in the Thomas Creek Experimental Watershed. We did not find any information documenting site-specific reference conditions for wet mixed conifer forests within or adjacent to the Wallow Fire.

Mixed conifer

The Wallow Fire burned 31,643 ha (78,191 ac) of mixed conifer forest based on the mid-scale dominance type classification (Triepke et al. 2005). This figure accounts for about 15% of the area within the Wallow Fire perimeter used in this study (Figures 2 and 3). Based on RAVG burn severity rating, about 16% of mixed conifer forest was classified as unburned, about 19% as low severity, about 15% as moderate severity, and about 50% as high severity.

Dry mixed conifer patch metrics

Based on TES data, about 16,677 ha (41,210 ac), or 53% of the overall mixed conifer forest, were classified as dry mixed conifer (Figure 2, Table 3). Sixteen percent of the dry mixed conifer within the Wallow Fire perimeter was classified as unburned, 21% as low severity, about 15% as moderate severity, and about 48% as high severity (Table 3).

The area-weighted mean patch size in dry mixed conifer forest was less than 20 ha (< 50 ac) for unburned, low, and moderate severity classes compared to high-severity patches, which averaged more than 40 ha (> 100 ac) in size (Table 3). The largest patch classified as high-severity in dry mixed conifer

Table 2. Tree density for three historical plots originally measured in 1911 by T.S. Woolsey, Jr.

Plot	PSME		PIST		PIPO		PIEN		ABCO		Stump		Total	
	(tph)	(tpa)	(tph)	(tpa)	(tph)	(tpa)	(tph)	(tpa)	(tph)	(tpa)	(tph)	(tpa)	(tph)	(tpa)
	Trees > 10.2 cm (4 in) dbh													
S-1	37.1	15	2.0	0.8	45.5	18.4	69.9	28.3	0	0	47.4	19.2	201.9	81.7
S-2	51.9	21	13.6	5.5	64.2	26.0	35.8	14.5	0	0	51.9	21	217.4	88
S-3	86.5	35	24.7	10	43.2	17.5	0	0	16.6	6.7	37.1	15	208.1	84.2
	Trees < 10.2 cm (4 in) dbh													
S-1	20.5	8.3	10.4	4.2	26.7	10.8	37.1	15	0	0	0	0	94.6	38.3
S-2	49.4	20	38.3	15.5	25.9	10.5	38.3	15.5	0	0	0	0	152.0	61.5
S-3	57.6	23.3	28.9	11.7	10.4	4.2	0	0	14.3	5.8	0	0	111.2	45
	All trees combined													
S-1	57.6	23.3	12.4	5	72.2	29.2	107.0	43.3	0	0	47.4	19.2	296.5	120
S-2	101.3	41	51.9	21	90.2	36.5	74.1	30	0	0	51.9	21	369.4	149.5
S-3	144	58.3	53.6	21.7	53.6	21.7	0	0	30.9	12.5	37.1	15	319.3	129.2

Note: Plots were 0.5 – 0.8 ha (1.2 – 2 ac) in size and were located within or directly adjacent to the Wallow Fire. Species codes are: PSME = Pseudotsuga menziesii, PIST = Pinus strobiformis, PIPO = Pinus ponderosa, PIEN = Picea engelmannii, ABCO = Abies concolor. No species were given for stumps.

was 221 ha (546 ac) in size. The largest patch index, or the percentage of the landscape comprised by the largest patch, was greater than 1% for areas classified as high severity and less than 1% for areas classified as unburned, low, or moderate severity. Patch density, or the number of patches of the corresponding patch type divided by the total landscape area, ranged between 13.5-29.0 patches per 100 ha, and was highest in the moderate severity areas of dry mixed conifer forest (Table 3).

The distribution of high-severity burn patches by size class for dry mixed conifer forest is shown in Figure 4. About 71% of high-severity patches in the dry mixed conifer forest type were less than 1 ha (2.5 ac), although the area of these patches accounted for only 6% of the area classified as high severity (Figure 4). About 22% of high-severity patches were 1-10 ha (2.5-25.0 ac) in size and about 6% were 10-50 ha (25.0-123.5 ac) in size, but these patches comprised 66% of the area classified as high severity (Figure 4). Less than 1% of high-severity patches were greater than 50 ha (> 123.5 ac) in size, and these patches comprised 28% of the area classified as high severity (Figure 4).

Wet mixed conifer patch metrics

Based on TES data, about 14,966 ha (36,981 ac), or 47% of the overall mixed conifer forest, were classified as wet mixed conifer (Figure 3, Table 3). About 16% of the wet mixed conifer within the Wallow Fire perimeter was classified as unburned, 17% as low severity, about 14% as moderate severity, and about 53% as high severity (Table 3).

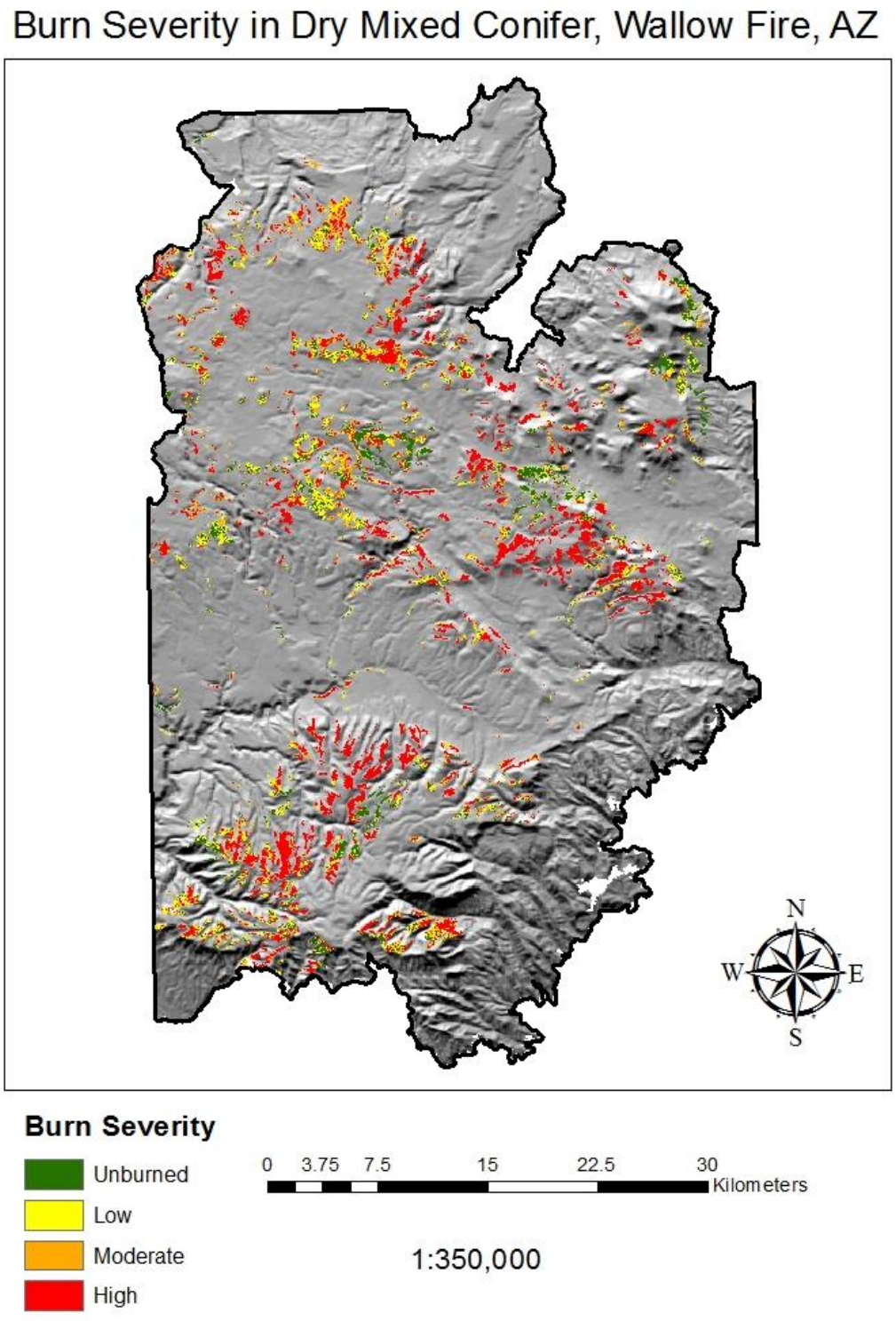

Figure 2. About 7,967 ha (19,686 ac) of dry mixed conifer forest were classified as high severity in the Wallow Fire. The largest patch classified as high severity was 221 ha (546 ac) in size.

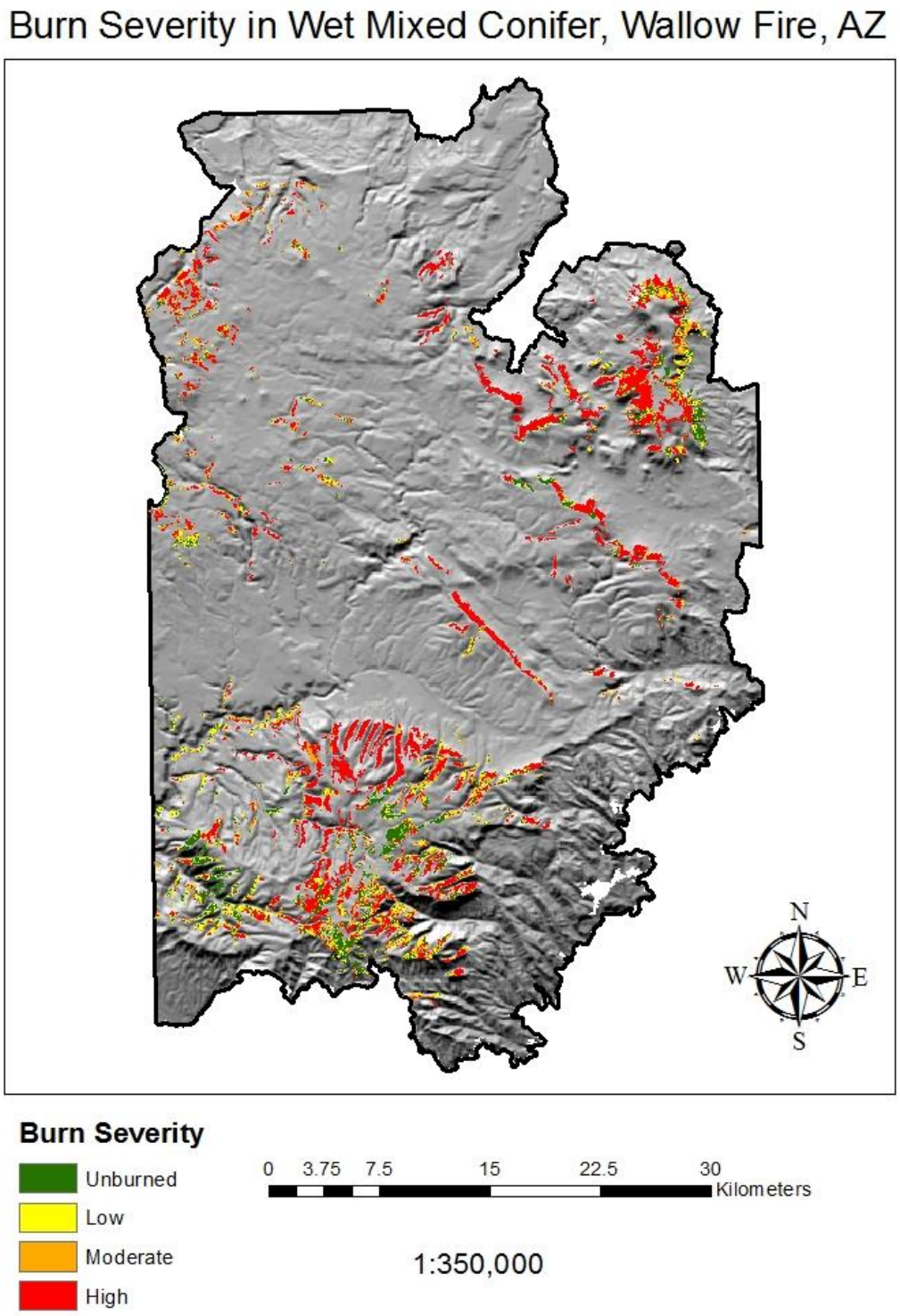

Figure 3. About 7,963 ha (19,676 ac) of wet mixed conifer were classified as high severity in the Wallow Fire. The largest patch classified as high severity was 387 ha (955 ac) in size.

Table 3. Area burned by severity class and associated patch characteristics for dry and wet mixed conifer forests in the Wallow Fire.

Severity	Area		Proportion of Landscape	Area-Weighted Mean Patch Size		Largest Patch Index	Patch Density
	(ha)	(ac)	(%)	(ha)	(ac)	(%)	(#/100 ha)
Dry Mixed Conifer							
Unburned	2675.9	6612.1	16.0	18.0	44.4	0.54	13.5
Low	3506.7	8665.0	21.0	10.7	26.4	0.67	22.9
Moderate	2528.1	6246.9	15.2	3.8	9.4	0.31	29.0
High	7966.7	19685.7	47.8	43.6	107.8	1.32	15.3
Total	16677.4	41209.8	100				
Wet Mixed Conifer							
Unburned	2409.8	5954.5	16.1	26.4	65.2	1.05	11.2
Low	2539.5	6275.2	17.0	6.2	15.3	0.42	21.5
Moderate	2053.9	5075.2	13.7	4.6	11.3	0.29	26.4
High	7962.9	19676.4	53.2	66.1	163.4	2.58	11.0
Total	14966.1	36981.2	100				

The area-weighted mean patch size in wet mixed conifer forest was less than 30 ha (< 74 ac) for unburned, low, and moderate severity classes compared to high-severity patches, which averaged about 66 ha (163 ac) in size (Table 3). The largest patch classified as high severity in wet mixed conifer was 387 ha (955 ac) in size. The largest patch index was more than 2.5% for the high severity class and 1% or less for all other severity classes. Patch density ranged between 11.0-26.4 patches per 100 ha, and was highest in the moderate-severity areas of wet mixed conifer forest (Table 3).

The distribution of high-severity patches by size classes is shown in Figure 5. Nearly two-thirds of high-severity patches in the wet mixed conifer forest type were less than 1 ha (2.5 ac), although the area of these patches accounted for less than 4% of the area classified as high severity (Figure 5). About 26% of high-severity patches were 1-10 ha (2.5-25.0 ac) in size and about 8% were 10-50 ha (25.0-123.5 ac) in size, but these patches comprised about 55% of the area classified as high severity (Figure 5). Only 2% of high-severity patches were greater than 50 ha (> 123.5 ac) in size, and these patches comprised about 41% of the area classified as high severity (Figure 5).

Discussion

Verification of mixed conifer reference conditions in the Wallow Fire

Mixed conifer forests are one of the most variable and complex forest types in terms of stand structure, species composition, and disturbance regimes (Romme et al. 2009). Due to the limited geographical scope of this study, our approach was to use regional and local reference conditions for the Wallow Fire, if possible, rather than using more general information from other mixed conifer sites located throughout the western United States. Although forest structure variables, such as tree density and basal area, are not always directly correlated with fire severity, they contribute to the overall understanding of fire behavior dynamics.

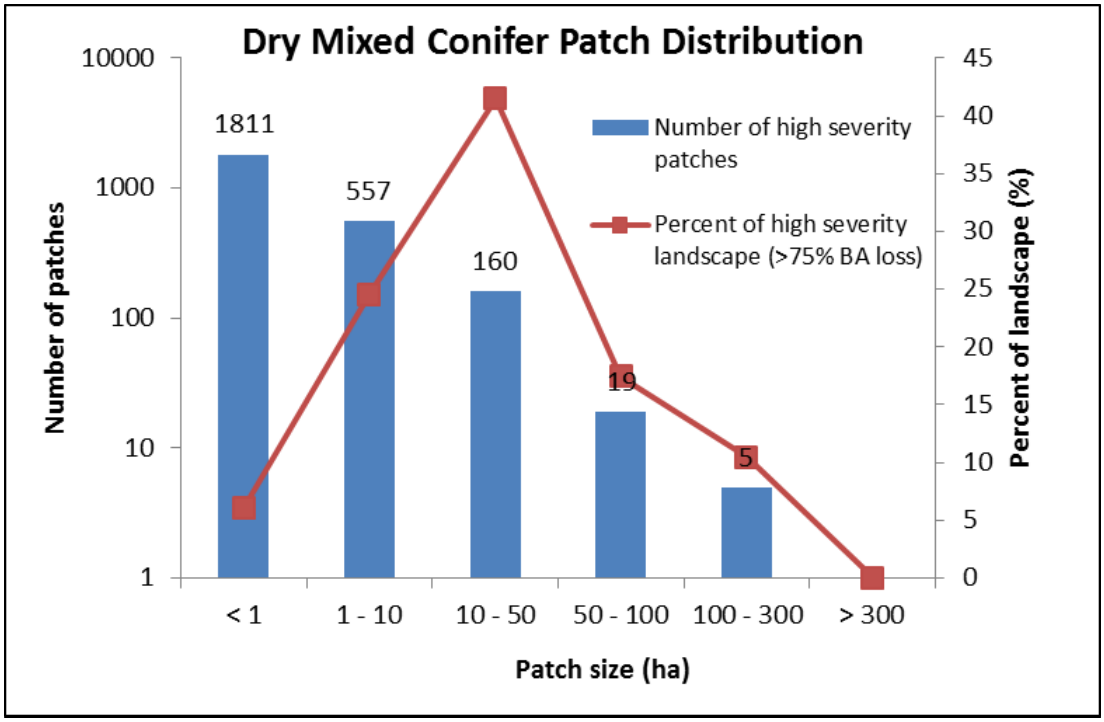

Figure 4. The distribution of high-severity burn patches for dry mixed conifer forests in the Wallow Fire. Note logarithmic base 10 scale on y-axis for number of patches.

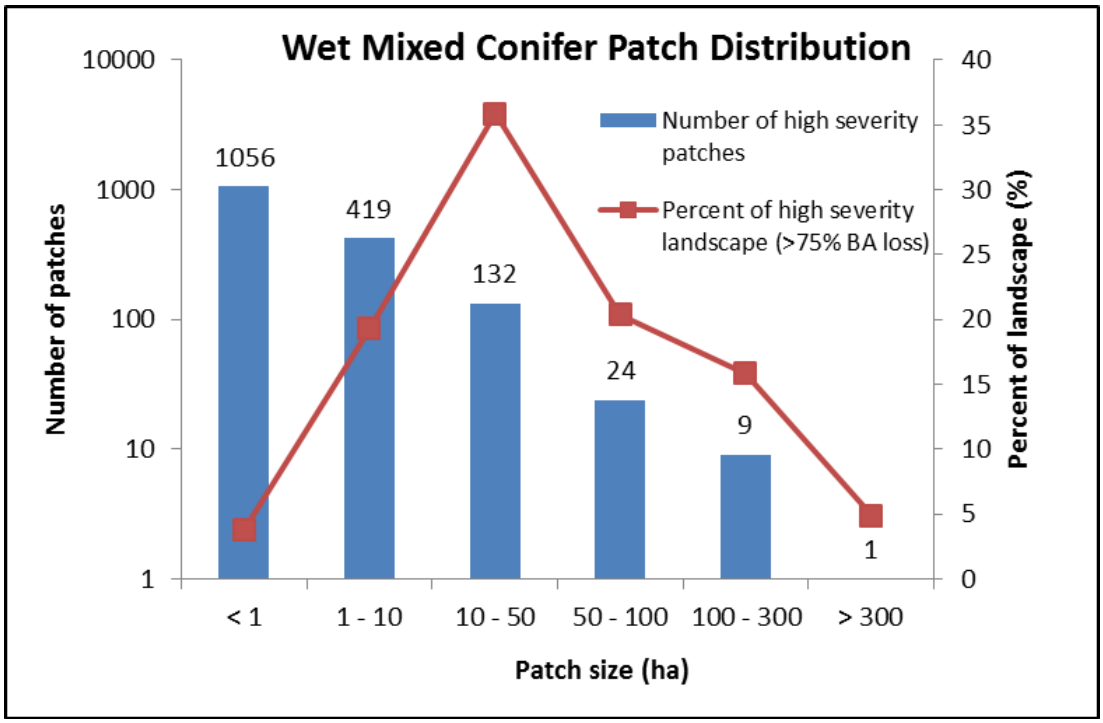

Figure 5. The distribution of high-severity burn patches for wet mixed conifer forests in the Wallow Fire. Note logarithmic base 10 scale on y-axis for number of patches.

The 15 sites summarized by Reynolds et al. (2013) provided adequate regional reference condition information for stand structure, however, we did not find any published studies reporting mixed conifer reference conditions for stand structure located within or directly adjacent to the Wallow Fire. Fortunately, we were able to obtain three detailed maps of historic plots established in dry mixed conifer sites within or near the Wallow Fire. The average tree density of 209 tph (85 tpa) for trees greater than 10 cm (> 4 in.) dbh found on the plots in 1911 (Table 2), several decades after Euro-American settlement, falls within the range of 52 – 255 tph (21 – 99 tpa) for southwestern dry mixed conifer forests reported by Reynolds et al. (2013). This is a reasonable estimate of tree density given that most of the trees less than 10 cm (< 4 in.) dbh were likely to have established in the three decades preceding plot establishment in 1911. Even if all trees from the Woolsey plots are included, the average density of 328 tph (133 tpa) is only slightly outside the range reported by Reynolds et al. (2013), thus verifying that historic tree density within and near the Wallow Fire was similar to other southwestern dry mixed conifer sites. The mean fire interval of 22 years reported by Dieterich (1983) verified that the frequent fire regime at Thomas Creek, a dry mixed conifer site within the Wallow Fire, was similar to other southwestern sites (Swetnam and Baisan 1996).

Fire severity in mixed conifer forests of the Wallow Fire compared to reference conditions

While we found studies that reported information about historical fire regimes and stand structure in southwestern mixed conifer forests, many did not explicitly differentiate between the dry and wet subtype. This, along with the fact that none of the studies reported information about the size of historic high-severity burn patches in dry mixed conifer forests, made it difficult to determine an exact patch size threshold that would indicate if observed fire severity was within the HRV in the Wallow Fire. It is likely that high-severity fire burned patches up to 10 ha (25 ac) in size and unlikely that high-severity patches greater than 50 ha (123.5 ac) occurred historically in southwestern dry mixed conifer. We are less certain about what occurred at the 10-50 ha (25.0-123.5 ac) scale.

Dry mixed conifer forests in the Wallow Fire were not entirely within the HRV based on our analysis of high-severity patches. High-severity fire burned 48% of the dry mixed conifer forest in the Wallow Fire. The mean patch size in those areas was more than 40 ha (> 100 ac), compared to the other three classes which all had a mean patch size of less than 20 ha (< 50 ac), indicating that as severity increased, the fire burned more homogeneously across the landscape. The largest high-severity burn patch was more than 200 ha (> 500 ac) in size, comprising more than 1% of the landscape—an area much larger than would have historically burned in southwestern dry mixed conifer. Although more than 90% of the high-severity patches were less than 10 ha (< 25 ac) in size, their combined area amounted to only 30% of the total area of dry mixed conifer forest. Alternatively, about 7% of the high-severity patches were greater than 10 ha (> 25 ac) in size, and comprised nearly 70% of the dry mixed conifer landscape. Assuming that high-severity patches 10-50 ha (25.0-123.5 ac) in size burned in pre-settlement dry mixed conifer, a minimum of 28% of the Wallow Fire landscape burned outside the HRV. Assuming those patches would not have burned historically, 69%, or 11,583 ha (28,621 ac), of dry mixed conifer forest in the Wallow Fire would be considered outside the HRV. Even at the low estimate, 4,660 ha (11,515 ac) of mixed conifer forest burned outside the HRV increasing the potential for erosion and flooding, loss of wildlife habitat, and loss of recreational opportunities in the Wallow Fire.

Wet mixed conifer forests in the Wallow Fire were entirely within the HRV based on our analysis of high-severity burn patches. High-severity fire burned more than half of the wet mixed conifer forest in the Wallow Fire. The mean patch size in those areas was about 66 ha (163 ac), which was more than 1.5 times larger than the mean patch size found in the dry mixed conifer forest, supporting the conclusion that the occurrence of high-severity fire was historically more widespread in wet mixed conifer forests compared to dry mixed conifer forests. The largest high-severity patch was 387 ha (955 ac) in size, more than 2.5% of the landscape, which was within the HRV for wet mixed conifer forests as reported by Margolis et al. (2007, 2011).

Conclusions

This study provides an analysis of patches across four severity classes in the Wallow Fire. The overall assessment from the analysis indicates that mixed conifer forests in the Wallow were not entirely within the HRV based on the size of high-severity burn patches compared to reference conditions. Specifically, the results suggest that portions of the dry mixed conifer burned outside the HRV and that the entire wet mixed conifer forest burned within the HRV documented in the literature. This study focused on the evaluation of high-severity patch characteristics to evaluate how mixed conifer forests burned in relation to reference conditions, however, it should be noted that areas that burned at lower severities, particularly, moderate severity, may have had beneficial effects, including reductions of tree density and surface fuels, consistent with outcomes observed following restoration treatments (Fulé et al. 2004b). Alternatively, although the analysis indicates that large patches of high-severity fire may be normal in wet mixed conifer forests, this does not mean that low- or moderate-severity burn patches are not normal nor would it preclude implementing forest treatments in wet mixed conifer areas if other values (e.g., private property, human structures) were in need of protection. Ultimately, managers, policy makers, and the public will have to decide what level of high-severity fire is acceptable and assess the tradeoffs of forest treatments in mixed conifer forests.

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