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Wildlife Habitat Values and Forest Structure in Southwestern Ponderosa Pine: Implications for Restoration

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Working Papers in Intermountain West Frequent-fire Forest Restoration

Ecological restoration is a practice that seeks to heal degraded ecosystems by reestablishing native species, structural characteristics, and ecological processes. The Society for Ecological Restoration International defines ecological restoration as "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability….Restoration attempts to return an ecosystem to its historic trajectory" (Society for Ecological Restoration International Science & Policy Working Group 2004).

Most frequent-fire forests throughout the Intermountain West have been degraded during the last 150 years. Many of these forests are now dominated by unnaturally dense thickets of small trees, and lack their once diverse understory of grasses, sedges, and forbs. Forests in this condition are highly susceptible to damaging, stand-replacing fires and increased insect and disease epidemics. Restoration of these forests centers on reintroducing frequent, low-severity surface fires—often after thinning dense stands—and reestablishing productive understory plant communities.

The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of frequent-fire forests of the Intermountain West. By allowing natural processes, such as low-severity fire, to resume self-sustaining patterns, we hope to reestablish healthy forests that provide ecosystem services, wildlife habitat, and recreational opportunities.

The ERI Working Papers series presents findings and management recommendations from research and observations by the ERI and its partner organizations. While the ERI staff recognizes that every restoration project needs to be site specific, we feel that the information provided in the Working Papers may help restoration practitioners elsewhere.

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Cover Photo: *An American Robin* (Turdus migratorius) *perches on a ponderosa pine branch.*
Photo by George Andreijko, Arizona Game and Fish Department

Introduction

Southwestern ponderosa pine *(Pinus ponderosa)* forests have undergone substantial changes in structure and function since the late 1800s (Cooper 1960, Covington and Moore 1994, Swetnam and Baisan 1996). Among influences of previous forest management practices, alteration of fire regimes has played the greatest role in shaping current forest conditions (Fulé et al. 2002). Pre-1900 fire return intervals in southwestern ponderosa pine forests ranged from 2-15 years (Fulé et al. 2002, Grissno-Mayer et al. 2004); however, fire has been effectively excluded from much of the landscape for the last 100 years or more. The lack of fire in these forests has resulted in increased tree densities, decreased average tree diameter, and an increased risk of uncharacteristic, high-severity wildfires. The goal of forest restoration is to return forest conditions to their natural range of variability in order to safely restore a frequent fire regime. However, many forests are currently too dense to accommodate the reintroduction of fire without mechanical thinning. Therefore, to reduce the risk of uncharacteristic fire and increase the ability of a forest to withstand fire occurrence, managers use a variety of mechanical treatments, including thinning, to reduce surface fuels, increase height to live crowns, and decrease crown density.

Restoration: Spatial Patterns and Wildlife Habitat

The spatial pattern of trees and groups of trees retained following thinning is an important factor affecting wildlife habitat quality in managed landscapes. Much of the southwestern ponderosa pine landscapes were naturally heterogeneous (Covington and Moore 1994, Allen et al. 2002, Fulé et al. 2002), with trees in groups or groups and openings between with a herbaceous understory, that gave the forest an open, meadow-like appearance. The heterogeneity in habitat was used by a diversity of wildlife species. In addition, Gambel oak *(Quercus gambelii)* provides high-quality wildlife habitat for some species in its various growth forms, and is a desirable component of ponderosa pine forests where it naturally occurs (Bernardos et al. 2004, Rosenstock 1996). Restoring the natural variability of forest composition and structure on the landscape should, in turn, restore native wildlife populations (Kalies et al. 2012). However, creation of this spatial pattern and composition has been an evolving process. In the mid-1990s, forest managers in the Southwest recognized an immediate need to reduce fire-risk in the wildland urban interface (WUI), areas of forested lands adjacent to communities and associated infrastructure. At that time, wildlife habitat objectives were often considered secondary to fuel management objectives and the forest structure and pattern resulting from WUI treatments (e.g., evenly spaced trees with little-to-no layering of canopy structure) lacked characteristics important for wildlife. In these early days of ponderosa pine restoration, wildlife managers recognized a need to better communicate wildlife habitat values to forest managers conducting restoration in southwestern ponderosa pine. Over time, wildlife fuels reduction treatments evolved to incorporate more restoration-based designs (e.g., an aggregated tree pattern with grassy openings, and a multi-layered canopy structure), creating habitat often selected by wildlife. These treatments gave greater consideration to wildlife habitat needs while still focusing on reducing fire risk.

Restoration treatments in the WUI continue to be top priority for forest managers today. In addition, recent fire-risk reduction studies suggest that restoration treatments must be strategically located across the landscape, including remote areas outside the WUI (Finney 2001, Ager et al. 2010). As the scope of forest restoration broadens to a landscape scale, there is potential to impact wildlife habitats in a way that has population-level impacts. Much of this plays out in the forest structure, pattern, and composition created at the site-specific scale.

The following discussion describes a heterogeneous, multi-aged, aggregated forest structure that reflects conditions that likely existed prior to interruption of natural fire regimes and other significant anthropogenic interventions. We incorporated the best currently available science regarding "natural" forest structure within an ecological framework (e.g., historic range of variability and reference stand conditions), and wildlife habitat relationships in southwestern ponderosa pine forests. The information provided is not intended to be prescriptive, but rather descriptive of forest condition and structures hypothesized to meet short- and long-term wildlife needs within the ponderosa pine forest type. Given the inherent variability associated with differences in soils, aspect, topography, and other variables, the information presented here must be interpreted and applied with a local ecological context. We also caution about extrapolation of information to meadows, high-elevation savannahs and grasslands, and other areas that have experienced significant pine encroachment following exclusion of fire. We recommend monitoring the described forest structure and pattern and wildlife responses, and using adaptive management to adjust treatments accordingly.

Forest Composition Varies at Different Scales

Descriptions provided are most appropriately applied at the fine- to mid-scale, which we define here as ranging roughly from <1 acre to 1000 acres. It is important to understand forest and ecological processes at different scales because landscapes are spatially dependent (Turner 1989). While an over-all aggregated, or grouped, tree pattern separated by openings is widely accepted as the dominant pattern of pre-settlement, natural tree occurrence in southwestern ponderosa pine (Fitzgerald 2005), random historic tree distribution patterns have been observed on varying soil types and settings (Abella 2008, Reynolds et al. (unpublished data), Schneider 2012). Therefore, elements such as single tree and group density become less important at the landscape scale and elements such as patches, stand density, canopy cover, and basal area become more appropriate.

We recognize that modifications to forest composition and structure may benefit some wildlife species and adversely impact others. As there is no single prescription or forest condition that will maximize habitat value for all species, tradeoffs are unavoidable. It is unclear whether some species of concern may have benefited from forest conditions that are now viewed as ecologically unsustainable. For example, Ganey et al. (1999) noted that closed-canopy ponderosa pine-Gambel oak forests are used for roosting by the federally threatened Mexican spotted owls *(Strix occidentalis lucida)*. Restoration treatments would aim to reduce the amount of closed-canopy forest on the landscape. However, Mexican spotted owls may have evolved in a landscape containing relatively few patches of such closed-canopy forest embedded in a matrix of open forest, and thus their habitat requirements may be very compatible with forest restoration at the landscape scale.

Group, patch, interspace, and opening are defined in the following figures. Please refer to the two figures for spatial arrangement of defined terms. "Openings" should not be confused with meadows, which are characterized by moist conditions, soil type, thinner O horizons, thinner A horizons, and higher pH, and a lack of historical tree evidences (Kerns et al. 2003). Openings and interspaces differ from meadows because they shift from a treeless state to a treed state, in the same dynamic process by which groups and patches shift from a treed state to a treeless state. Openings should also not be confused with "regeneration openings," a prescriptive designation applied to 10–20% of a given stand per the northern goshawk guidelines in the U.S. Forest Service Southwestern Region Forest Plans (USDA 1995).

Conclusion

Through scientific inquiry and adaptive management, managers have learned to reduce the risk of uncharacteristic, high-severity fire and increase resilience using the tools of forest restoration. Managers use a variety of mechanical treatments, including thinning, to reduce surface fuels, increase height to live crowns, and decrease crown density. Restoring the natural variability of forest composition and structure on the landscape should, in turn, restore native wildlife populations. It is feasible to reduce fire risk, restore natural fire regimes, and improve habitat quality for a variety of wildlife species if strategic thought is given to the spatial pattern of trees and groups of trees retained following thinning. Table 1 synthesizes available studies on wildlife habitat management prescriptions and provides management recommendations designed to restore forest heterogeneity and improve wildlife habitat.

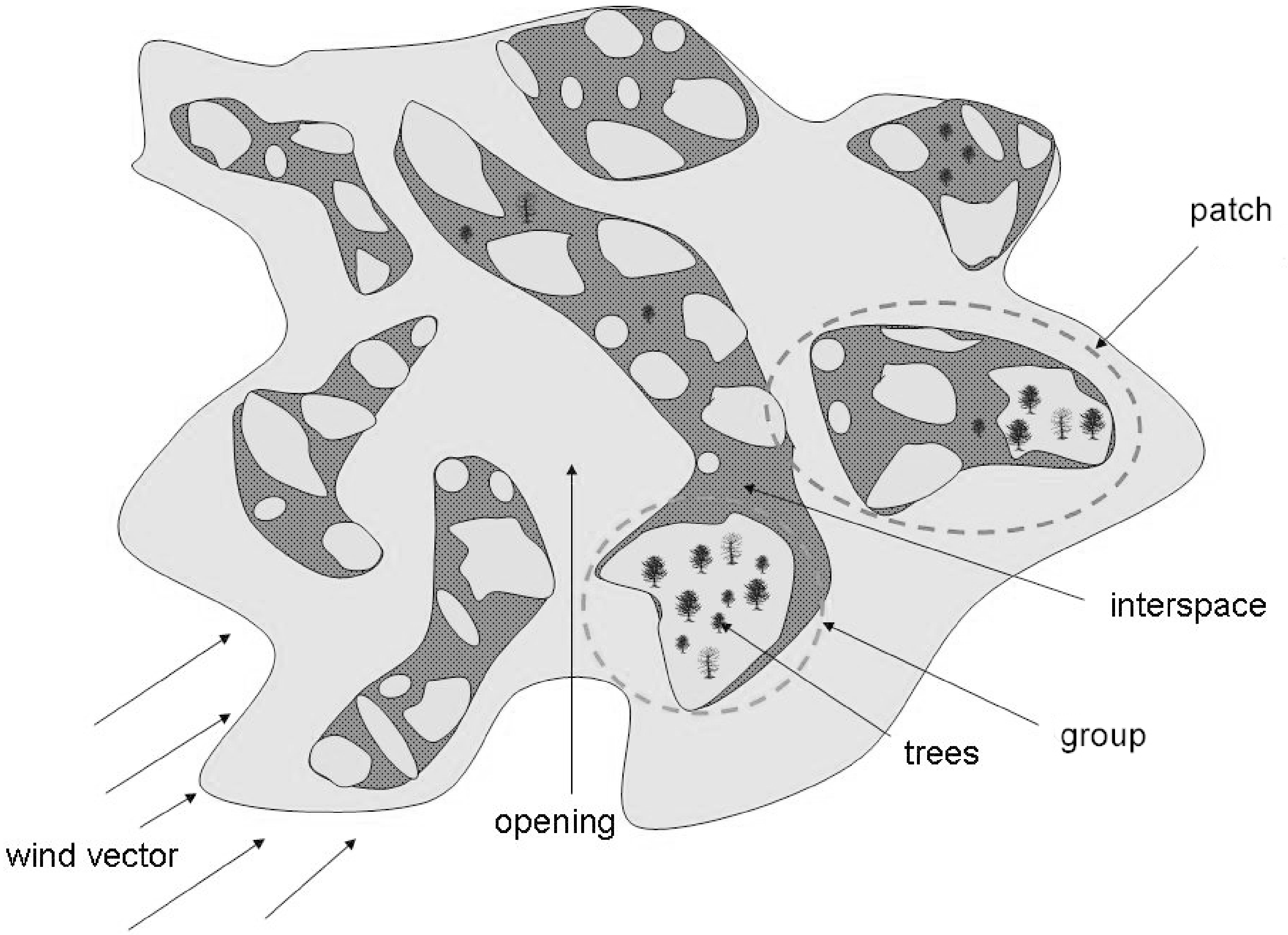

Figure 1. Example spatial configuration of groups, interspaces, patches, and openings within a ponderosa pine site in a wildland (or equivalent word) setting. Groups of trees with interlocking canopies vary in size and are separated by interspaces. Patches of grouped trees vary in size, and larger patches are oriented perpendicular to the prevailing wind vectors and are separated by large openings up- and downwind. Not drawn to any scale.

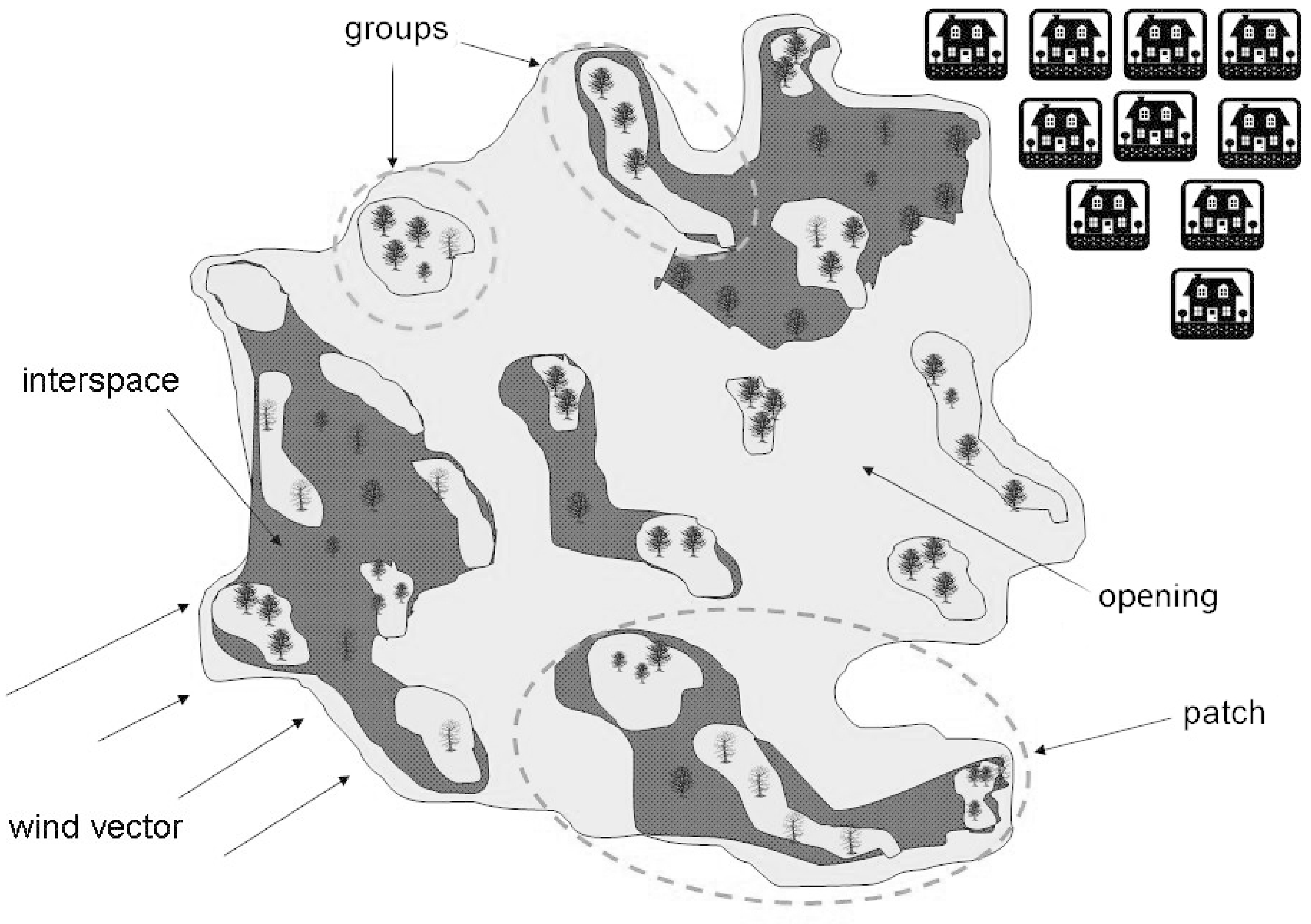

Figure 2. Example spatial configuration of groups, interspaces, patches, and openings within a ponderosa pine site in an urban interface setting (e.g., City Wellfield, Flagstaff). Groups of trees with interlocking canopies vary in size and are separated by larger interspaces compared to sites outside the interface. Patches of grouped trees may be smaller in size compared to sites outside the interface, and large patches, where appropriate, are oriented perpendicular to the prevailing wind vectors and are separated by large openings up- and downwind. Tree density may be lower near dwellings and structures. Not drawn to any scale.

Structural Elements	Aggregation	Age Structure	Interlocking Canopies	Separation	#Trees/ Aggregation	Area (acres)	Recommendations*	Wildlife References
Group	• Small size and relatively dense aggregation •Should be based upon the size and frequency distributions of natural disturbances[28]	• Can be similar (e.g., a group of yellow pines), but a mixture of uneven and even age structure is desirable[29, 30, 37] •Snags retained[5] •Regeneration in and along edge of group, in "safe sites" (micro-sites with reduced overstory and herbaceous competition, e.g., the ash bed of a consumed log where seedlings establish above lethal flaming zone)[30]	• Desired for all trees in the group • Must be maintained for older, larger trees • Can allow for some growth in groups with smaller trees	• Break in canotpy (inter-spaces)	• 3-44 trees if dbh >36 cm or yellow-bark*[52] • Some groups of smaller trees may have >44 stems[52] • 88% of trees ≥106 years old occurred in groups of 3 or more trees in Gus Pearson Natural Area[52]	• 0.1 – 0.5[36] • 0.15 – 0.35[8] • Can be ~2x height of mature trees [47]	• Manage for a range of sizes and density in groups • Retain existing group structure informed by pre-settlement evidences and natural disturbance regimes when available[3, 16] • Avoid removing trees within the group, particularly those that encourage vertical diversity[40] • Retain snags and down woody debris within groups[7, 12, 39, 55] • Retain some percentage of trees with dwarf-mistletoe brooms[26] • Retain shrub and oak components[20, 33, 37, 44]	• Turkey >30 trees/group[50, 51] • Breeding birds – uneven aged within groups[44] • Foliage-gleaning songbirds – favor denser groups[44] • Tassel-eared squirrels – >5 trees/group[10, 11], positively associated with interlocking trees[12] (although evidence exists for no effect of tree aggregation[35]) • Mule deer – ≥0.10 acres (range 0.05-0.10)[20] , ≥ 0.098 acre[6] • Down woody debris – lizards[22], small mammals[6, 24, 43], bears[47] • Interspersion of age classes within group: American robin – high, band-tailed pigeon – moderate, chipmunks – moderate, cottontails – high, mourning dove – high, northern flicker – high, tassel-eared squirrel – moderate[40] • Oak retention – songbirds[44, 45] bear [33], deer[20] • Mogollon voles and Botta's pocket gopher associated with aggregated tree arrangement[24]
Patch	• Large in size and more loosely aggregated • Contains 2 or more groups and individual trees scattered throughout	• Uneven aged across the patch[30] • The goal should be toward at least 4 age classes intermingled intimately in the same group • Snags retained[5] • Regeneration in "safe sites" (see definition in group) [52]	• In groups embedded in the patch but not across the patch	• Openings	• Varies based on density and spatial arrangement of groups and single trees	• Varies based on density and spatial arrangement of groups[45] • Should be >0.75 acres up to any acreage • Larger groups downwind of larger openings	• Create a mosaic (a patchwork) of groups and openings, of variable size and shape • Retain snags and down woody debris within groups[7, 12, 39, 55] • Retain shrub and oak components[20, 33, 37, 44]	• Breeding birds – ≥5 acres in size, high density of VSS6[44] • Bats – larger, older, denser groups; patches of Gambel oak; patches of snags[4, 38] • Down woody debris – lizards[22], small mammals[6, 43], bears[37] • Oak retention – songbirds[23, 44, 45], bears[33], deer[20] • No association between 8 bird species and spatial arrangement of Gambel oak[23]
Inter-space†	• Break in canopy between groups	• Little to no regeneration maintained by frequent fire	• None	• Groups	• Extremely low; little to no regeneration progress to tree-size[36]	• Small in size[26]	• Enhance inter-spaces between existing groups[26] • Retain down woody debris[7, 12, 39, 55] • Retain shrub and oak components[20, 33, 37, 44]	• Raptors – increased small mammal forage availability with high interspace-to-group ratio [37] • Oak retention – songbirds[23, 44, 45], bears[33], deer[20]
Opening†	• Break in canopy between groups	• Regeneration events controlled by restoration of a more frequent fire interval • Snags retained[4]	• None	• Patches	• None; should remain treeless	• Large in size • 100' to 150' wide, 0.25-0.5 acres[36]	• Create a mosaic (patchwork) of openings and tree groups, with larger openings surrounding, and upwind of large tree groups • Orientation should be perpendicular to prevailing wind; more and larger openings desirable; can be larger than 10% of stand; can be >200 feet wide; create irregular shapes • Retain down woody debris[7, 39, 55] • Retain shrub and oak components[20, 33, 37, 44] • Maximize herbaceous species diversity	• Northern goshawks – ¼ to 4 acres[40] • Turkeys – ≤0.15acre[50] • Bears – ≤1 acre, <25% in openings[33] • Oak retention – songbirds[44, 45], bears[33], deer[20] • Mexican spotted owls – 1 to 2 acres[55]

Table 1. Structural elements of ponderosa pine forest affecting wildlife in the Southwest. Ranges of numbers are provided for each structural element to demonstrate variability; the intent is not to have one number drive implementation. Structural elements are referenced from published ecological studies of the historic range of variability in southwestern ponderosa pine forests. Wildlife responses to those structural elements are referenced from published wildlife ecology studies in southwestern ponderosa pine forests, and are supplemented with un-cited management recommendations that may enhance heterogeneity in wildlife habitat.

* Thinning projects should emphasize the rare VSS classes and ages within the group, patch, and stand, and focus fuels reduction on the most common VSS class.

† Very little information is available on the historic range of variability for forest interspaces and openings, particularly in terms of size and proportion of the stand or landscape. However, a preponderance of literature exists on wildlife use and selection for forest openings on the landscape scale. If a particular spatial arrangement of groups does not meet fuel-reduction objectives, we recommend increasing the size of openings rather than decreasing the size of heterogeneity of groups and patches.

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Notes

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