Ecological Restoration Institute

***Fact Sheet**: Characterizing Spatial Reference Conditions in Southwestern Warm/Dry Mixed-Conifer Forests*

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NORTHERN ARIZONA UNIVERSITY

Ecological Restoration Institute

Characterizing Spatial Reference Conditions in Southwestern Warm/Dry Mixed-Conifer Forests

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Introduction

Reference conditions describe attributes of ecosystem structure, composition, and function and are used to inform ecological restoration efforts. Reference condition information on tree spatial patterns that occurred prior to widespread fire exclusion is limited for warm/dry mixed-conifer forests of the western U.S. (Romme et al. 2009), particularly those in the Southwest (see Table 1). Spatial patterns of trees, and groups of trees, are important because they are known to influence understory biodiversity and productivity, fire behavior, distribution of surface fuels, wildlife habitat value, and regeneration (North et al. 2007, Sánchez Meador et al. 2009, Fry and Stephens 2010), yet this information is rarely quantified. The purpose of this fact sheet is to provide an overview of the existing research on spatial patterns in warm/dry mixed-conifer forests, and provide recommendations of future research.

Photo courtesy the Ecological Restoration Institute

State of Knowledge

- While commonly dominated by ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Psuedotsuga menziesii)*, reported species composition for warm/dry mixed-conifer forests in the western United States also include Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), white fir (*Abies concolor*), western larch (*Larix occidentalis*), Engelmann spruce (*Picea engelmanii*), aspen (*Populus tremuloides*), oak (*Quercus* spp.) and other species as sub-dominate.
- Contemporarily, tree density has increased, spatial patterns have become less variable (spatial heterogeneity is often lacking) and forest gap or opening size has decreased (Reynolds et al. 2013, Churchill et al. 2013, Larson et al. 2012, Lydersen et al. 2013).
- Spatial heterogeneity results from interactions of fine- to mid-scale processes such as fire-induced mortality and regeneration patterns, and inherent site variability (Larson and Churchill 2012).
- Frequent, low-severity surface fire played an integral role by reducing surface fuel loading, thinning regeneration patches and maintaining lower tree densities by killing individuals or small groups of trees.
- Patchy, or mixed-severity, fire is believed to have also played an important role on wetter, cooler sites (Romme et al. 2009) by killing small groups of trees, thus potentially creating relatively larger areas of growing space and contributing to variability in patch size, within patch age structure, and general spatial heterogeneity. These fires were likely rare in warm/dry mixed conifer forests (Reynolds et al. 2013).

Table 1. Summary of location, method used to designate tree/stand age, sample information, patch size, and main research findings for studies which examined historical spatial patterns of warm/dry mixed-conifer forests in the western US.

Study Location (Reference)	Method of designating trees/structures "presettlement"	Sample Size (plot size in ac.)	Patch Size (ac.)	Findings
Uncompahgre Plateau, CO (Binkley et al. 2008)	Diameter/tree morphology	15 (0.5-1)	0.1 – 0.25	Varied spatial patterns with four plots exhibiting complete spatial randomness. Some plot exhibited finer-scale aggregation up to The rest aggregated up to 100ft.
Grand Canyon, N. Rim, AZ (Mast and Wolf 2004)	Diameter/ Dendrochronology	5 (0.25)	0 – 0.025[A]	Study examines ponderosa pine-white fir size and age patterns. Random and aggregated distributions were observed and overlap in patches between the species were reported.
Grand Canyon, N. Rim, AZ (Mast, and Wolf 2006)	Diameter/ Dendrochronology	10 (0.25)	≥ 0.25	Focused on more mesic mixed conifer sites. Reported evidence of larger patches of trees with relatively little aggregated patterns as compared to dry sites in Mast and Wolf (2004)
Baja California, Mexico (Fry and Stephens 2010)	Diameter/ Dendrochronology	65 (0.25)	N/A	Reports evidence of heterogeneous and patchy pattern (semivariogram analysis) but patch size(s) not reported.
Sierra National Forest, CA (North et al. 2007)	Diameter-age reconstruction	18 (9.8)	0.06 – 0.72 [A]	Aggregation up to 200 feet, random tree pattern beyond. Compares structure and spatial patterns resulting from various treatments (including thinning and burning)
Yosemite National Park, CA (Lutz et al. 2012)	Diameter	1 (65)	≥ 0.30 [A]	Large diameter tree patterns were random up to 65ft, were aggregated at all scales greater indicating very large patches.
Stanislaus-Tuolumne Experimental Forest, CA (Lydersen et al. 2013)	Historical survey in 1929	3 (10)	0.08 – 0.35 [A]	Extensive analysis of tree patches and forest "gaps." Report 35% of the plot area was in gaps and canopy cover averaged 36%; tree patches average 5.2 trees per patch, with 13% of trees being as individuals (not in groups).
Okanogan-Wenatchee National Forest, WA. (Churchill et al. 2013)	Diameter/ Dendrochronology	1 (2.5)	N/A	Spatial pattern reported as proportion of trees in different patch sizes rather than patch area. Compares structure and spatial patterns resulting from "simulated" treatments (does not include fire as a treatment).
Swan Valley, MT (Larson et al. 2012)	Diameter/ Dendrochronology	2 (2.5)	N/A	Random tree patterns found, but patch size still reported (as number of trees rather than area). Report 25% of the plot area was "outside the immediate influence zone of tree neighborhoods" (gaps) Compares structure, composition and spatial pattern resulting from "leave tree marked low thinning to a residual basal area" (thin from below to basal area target).

[A] Patch size (area in ac) derived using peaks in aggregation report in Ripley's K analysis as estimate of patch radius

FUTURE RESEARCH NEEDS

- Spatially explicit reconstructions of warm/dry mixed-conifer forests, over a wide variety of soil types, species composition, stand histories, and climatic conditions are necessary to understand reference conditions more holistically.
- Studies directly linking forest structure (e.g., size, age and spatial distributions) and disturbance history (e.g., fire scar studies) are needed to better explore the spatial pattern-process integration.
- Future studies should provide quantitative information on attributes of interest to managers such as spatial patterns (e.g., tree group sizes, numbers of groups, sizes of openings) and changes in structure (e.g., size and density) and species composition.
- Kyle Rodman, an M.S. student with the School of Forestry and the Ecological Restoration Institute, is currently working on a project to quantify reference conditions (including spatial patterns) in two warm/dry mixed-conifer forests located on the San Francisco Peaks and the Mogollon Rim of northern Arizona.

Conclusions

- Treatments based solely on density (basal area and/or trees per acre) may result in homogeneous spatial patterns and structural conditions with a high degree of canopy continuity that does not resemble reference conditions.
- Conditions resulting from treatment which ignore spatial reference conditions and site-specific variation or heterogeneity may have little effect on mitigating fire hazard or restoring ecosystem function.
- Information managers might use to guide implementation include evidences of past structure, composition and spatial patterns (e.g., location and species of snags, stumps, logs), soil surveys and habitat type maps, or silvicultural prescriptions and marking guides which explicitly incorporate spatial patterns such as the ICO (individuals-clumps-openings) method proposed by Churchill et al. (2013).

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