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Abstract

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Detailed analysis of mixed-conifer and red fir forests were made from extensive, large vegetation sampling, systematically conducted throughout the Teakettle Experimental Forest. Mixed conifer is characterized by distinct patch conditions of closed-canopy tree clusters, persistent gaps and shrub thickets. This heterogeneous spatial structure provides contrasting microclimate, habitat and resource conditions probably associated with the high diversity of understory plants, fungi, and invertebrates found in ongoing studies in the Teakettle Experiment. In contrast, red fir forests are more homogeneous with continuous high canopy cover, cooler, more consistent microclimate conditions and fewer plant species. In both forests, annual fluctuations in available soil moisture resulting from El Niño influences on snow pack depth may have a significant influence on tree establishment and understory diversity. In depth descriptions of Teakettle's mixed conifer may provide a target of historic old-growth conditions for forest management.

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In Brief

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Retrieval Terms: ectomycorrhizae, fire history, flying squirrels *(Glaucomys sabrinus),* hydrology, hypogeous fungi, incense cedar *(Calocedrus decurrens),* invertebrates, Jeffrey pine *(Pinus Jeffreyi),* old growth, pathogens, plant association, red fir *(Abies magnifica),* Sierra Nevada, soil nutrients, songbirds, sugar pine *(Pinus lambertiana),* truffles, vegetation classification, white fir *(Abies concolor).*

Mixed conifer and red fir are the dominant forest types in the Sierra Nevada and have been substantially impacted by logging and fire suppression. There are, however, only a few studies of the composition and structure of these important communities, and even fewer studies of the functional dynamics and species associated with these forests. We used a nested sampling design to quantify and describe vegetation conditions in mixed-conifer and red fir forests in the Teakettle Experimental Forest, a 1,300 ha reserve of old-growth, 80 km east of Fresno, California. We first established mapped plots on a regular grid throughout the entire forest to classify the forest types and plant associations. We then used this grid to characterize in greater detail the vegetation conditions and patch types of mixed conifer and red fir. This report also presents background environmental data and summarizes ongoing studies in Teakettle's mixed-conifer forest that describe soil nutrients, canopy and soil arthropods, breeding birds, snag dynamics, flying squirrels and truffles, lichens, pathogens and insects, ectomycorrhizae, tree regeneration, and soil moisture as a baseline for future research.

Teakettle has four main forest types. Mixed conifer comprises about 65 percent of the forest, predominantly between 1,900 and 2,300 m elevation. Jeffrey pine (5.5 percent) is prevalent on shallow soil conditions within the mixed-conifer type. Red fir (28 percent) dominates elevations above 2,300 m except for very moist locations where lodgepole pine (0.5 percent) is dominant. Within the mixed-conifer forest, we found a fine-scale mosaic of four patch types: closed canopy, shrub patches dominated by mountain whitethorn, open gaps, and areas of rock and extremely shallow soils. Each of these patches has a distinct set of growing conditions. In contrast, red fir forests are more homogenous with greater, more continuous canopy cover and higher tree basal area and density than mixed conifer.

The high spatial and temporal variability of environmental conditions in mixed conifer at Teakettle is an important influence on ecological pattern and process. Ongoing studies highlight a species-rich and diverse ecosystem structured by patch types that have high contrast microclimate and nutrient conditions. Canopy invertebrates and pathogenic insects are diverse and generally host-tree specific. Different soil substrates contain distinct species-rich communities of soil microarthropods. Organic horizons are discontinuous and, particularly in mountain whitethorn patches, are significantly enriched in available forms of soil nitrogen relative to surrounding areas. Truffles in riparian corridors are associated with high densities of flying squirrels in these areas, although overall flying squirrel densities are lower than those reported in the Pacific Northwest. Flying squirrels are also associated with high densities of large diameter snags that may also influence the large number of primary cavity-nesting birds. Epiphytic lichens are abundant and one species, *Bryoria fremontii,* provides an important winter food source for flying squirrels. Tree seedling success varies greatly by patch type and is strongly linked to soil moisture that rapidly declines after snowmelt, falling

below 10 percent on exposed sites by early July. The ectomycorrhizal community is also species-rich, with a high number of equally abundant taxa (>70), even during dry conditions.

In their old-growth seral stage, mixed-conifer forests have persistent gaps that are not colonized by regenerating conifers. Although tree clusters have high canopy cover and basal area, these groups are separated by large, persistent gaps and areas dominated by shrubs. Our research on the functional roles of mixed conifer suggests these distinct patches are dynamically linked. Management prescriptions that focus on tree aggregates or groups as the scale for thinning or fire application, scale their activity to a homogeneous unit that is but a subset of mixed-conifer conditions. It is this array of forest structure and composition that provides different microclimates, nutrient and moisture conditions, and host plant diversity that may be associated with mixed conifer's high invertebrate, fungal, and habitat diversity.

As an old-growth, mixed-conifer ecosystem, Teakettle may serve as a useful metric to gauge the effects of management practices in this forest type. Management activities that alter the scale and pattern of forest vegetation are likely to significantly influence ecosystem dynamics, particularly in these structurally diverse forests where microclimate and resource variability may be strongly associated with ecosystem productivity and diversity.

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