Appendix A: The Teakettle Experiment

A fundamental unknown in Sierra Nevada forests is whether thinning and controlled burning can be used to restore the ecological functions of the natural fire regime. In the Sierra, fire has historically been the dominant disturbance driving forest ecosystem composition, structure, and function. Within the last 70 years, however, fire suppression and the selective harvest of large pines have significantly altered ecosystem dynamics. These changes have deflected succession, possibly shifting ecosystem processes outside their historic range of variability. Many Sierra forests are now thickets of shade-tolerant species, which can "ladder" fire into the crowns of the overstory canopy. There is a high probability that these stands will experience a catastrophic burn in which all trees are killed and some of the soil is sterilized. Fire cannot be re-introduced into these forest conditions until stem density and ladder fuels have been reduced. Understory thinning is theorized to mimic mortality from understory burning while reducing the risk of crown fire. Although widely used as a silvicultural tool, the ecological effects of removing stem wood in place of burning it has never been studied in the Sierra Nevada.

Efforts to restore Sierra forests to pre-European conditions have focused on recreating the structure of open "park-like" stands without an equal effort to understand the functional response of basic ecosystem processes. Early reports of Sierra forests indicate some range of variability in forest structure and composition, but in general mixed-conifer forests were less dense and more dominated by large, fire-resistant pines. Paleobotanical evidence suggests frequent fires have influenced Sierra forests and their associated plants, animals, soils and microclimate for several millennia (Raven and Axelrod 1978). Forest managers in the Sierra and many other fire-dominated forests of the western U.S. often assume that recreating forests with a low density of fire-resistant species is restoring the forest ecosystem. Reliance on structural parameters alone to create this "desired" forest condition ignores the crucial effects of disturbance type and intensity on ecosystem function. A desired forest condition can only be used as a measure of ecosystem "health" if the linkages between disturbance, forest structure, and ecological function are understood.

Design

The Teakettle Ecosystem Experiment is based on a full factorial design contrasting two levels of burning and three levels of thinning treatments:

	No Burn	**Burn**
No thinning treatment	Control	Burn Only
Understory thin	Understory thin/No Burn	Understory thin/Burn
Overstory thin	Overstory thin/No Burn	Overstory thin/Burn

Each treatment unit is a 4 ha plot with three replicates for a total of 18 plots. Baseline data was collected from 1998 to 2000, and response data will be collected for at least 2 years after treatments. Multi-disciplinary research will quantify the effects on all levels of the trophic structure of the ecosystem. The experiment brings together over two dozen scientists and graduate students from nine institutions. Research is coordinated by all studies using the same experimental design, mapping data in the same core area of each plot, and sampling for the same duration. Collaborators have a commitment to sharing data, and scientists are actively involved in data archiving, integration, and project synthesis.

Treatments

Burn treatments will have two levels: no burn and an understory burn. The understory burn will be a controlled fire designed to mimic the historic disturbance regime. The objective will be to contain the flames to a ground fire and avoid overstory crown ignition.

Thinning treatments will contrast three levels of stem reduction: no reduction (present forest conditions), understory thinning (similar to thinning "from below"), and overstory thinning that removes all but a few dominant trees. Understory thinning will follow current guidelines outlined in the California Spotted Owl Report (CASPO) (Verner and others 1992), which limits thinning to trees ≤ 30 in. (76 cm) dbh. CASPO guidelines require thinnings to meet the most restrictive of three conditions: 40 percent canopy cover retention, 40 percent basal area retention or no harvest of trees ≥ 30 in. dbh (CASPO, p. 21). Analysis of plot data gathered at Teakettle indicates the last condition is the most restrictive. Retaining stems ≥ 76 cm dbh will, on average, leave 44 trees/ha with an average dbh of 91 cm. The spatial distribution of the retained trees will be random. Six of the 4-ha plots (24 ha total) will receive this treatment.

The overstory thinning treatment will follow silvicultural practices common prior to the implementation of CASPO. With overstory thinning, all stems are removed except for 18 dominant trees/ha regularly spaced 20-25 m apart. Six of the 4-ha plots (24 ha total) will receive an overstory thinning.

A critical question in the Sierra Nevada is how to use disturbance effectively to restore forest ecosystems after nearly a century of fire suppression. In spite of their widespread use, the different effects of fire and thinning on fundamental ecological processes have not been systematically examined in Sierra mixed-conifer forest. Thinning treatments may mimic fire by reducing ladder fuels, overstocking, and the number of shade-tolerant species, but differ by removing most of the large woody biomass from the site. For decades to centuries after fire, fire-killed trees can continue to play important ecological roles as habitat, sources of nutrients and water, and structural complexity in streams. Fire is also highly variable and often leaves pockets of intact forest. Although thinning may replicate the final stand composition and structure produced by fire, the ecosystem response is unlikely to be the same.

The Teakettle Ecosystem Experiment is a unique opportunity to compare these effects in an old-growth experimental forest in a replicated full factorial experiment. The combination of burning and thinning treatments will provide important insight into how the type of disturbance affects forest composition, structure, and function (for more details see http://teakettle.ucdavis.edu).