Ecological Silviculture for Sierra Nevada Mixed Conifer Forests

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Silvicultural systems describe the types and timings of treatments, incorporating knowledge of local ecology and stand dynamics as a means to meet long-term objectives. While these systems have focused on sustained timber yield in the past, more recently several conceptual frameworks have been developed to expand them by incorporating objectives of restoration and resilience. However, constraints such as regulatory and economic boundaries have limited the large-scale implementation of these frameworks. Changes in silvicultural systems are thus slow to develop. Following the premise that silvicultural systems are thought to be improved when they more closely follow natural patterns of disturbances, this chapter in a book of ecological silviculture examples from around the world attempts to articulate how treatments in mixed conifer forests (MCF) of the Sierra Nevada could be adjusted to better align with this definition of ecological silviculture. Rather than develop a brand new system that would likely be slow to develop, the chapter presents modifications to the current dominant silvicultural systems across ownerships in the mixed conifer forest (MCF).

MANAGEMENT IMPLICATIONS

- Once a forest type's "natural development" model is developed, it can serve as the best guide for silvicultural treatments
- Because the natural development of the mixed conifer forest is defined by a frequent, low intensity fire regime, the reintroduction of fire should be the goal of ecological silvicultural systems.
- Currently, because prescribed fire does not occur at significant scales, mechanical restoration treatments are a key component of ecological silviculture.
- Combinations of fuel treatments and canopy gap disturbances are the key elements of ecological silviculture

Historically, fire was ubiquitous, resulting from lightning ignitions and Indigenous cultural burning. This regime maintained a canopy structure with an inverse relationship between the size of canopy gaps and their frequency across the landscape (Figure 1). While low-severity disturbances were most frequent, occasional disturbances with sufficient severity to support the initiation and establishment of a variety of tree species represented an essential element of this ecosystem. These disturbances were moderate in severity at local scales, serving the important ecological role of generating mid-sized (i.e. up to 2 acres) patches of tree mortality. This, in turn, created hot spots of high-quality substrate and resource availability allowing for the initiation of new cohorts of trees via natural regeneration. (Figure 2). Patches were not large and often retained a few larger trees that persisted through fires, which helped to mitigate shrub competition. This historical disturbance regime created a complex diversity of tree ages, species, and density all while maintaining a relatively low fuel load across the landscape.

Current silvicultural practices on industrial lands that rely on even-aged methods, such as clear cuts, have increased the frequency of gap sizes that are around 20 acres, which is the maximum allowed on many private lands. Meanwhile, fuel treatments such as thinning and some low-intensity prescribed fires on non-industrial and federal lands have only created gaps on very small scales (i.e. < 0.1 acres). As a result, the current canopy structure strays dramatically from what was historically present, creating a bimodal gap size distribution that is absent of moderate-sized gaps (Figure 1).

To better align with the natural disturbance model, the use of prescribed fire should be prioritized and seen as a tool to meet silvicultural objectives (i.e. "Pyrosilviculture"). However, given many social and permitting constraints surrounding the use of fire, the implementation of prescribed fire lags far behind what would best match the frequency and scale of the natural fire regime. Furthermore, if prescribed fire is finally used, it is often low-intensity because of limits on the season of application. This can result in a lack of structural development (i.e. heterogeneity) that would come from higher intensity burns. Therefore, additional non-fire treatments are likely necessary to achieve desired structural and compositional changes.

Since the distribution of appropriate canopy gap sizes is a missing element of current stand structures, adopting gap-based silviculture is proposed as the basic foundation for "ecological silviculture" in MCF. Most harvests should be in gaps large enough to initiate a new cohort, but small enough to allow for natural regeneration from wind-dispersed seeds. In the MCF, this reflects a gap size of roughly 0.2 to 2 acres. Infrequent gaps larger than 2 acres can still play a role in mirroring the natural disturbance regime if the number of larger trees retained within the gap increases with the gap area. After harvesting, sites should be mechanically prepared to lower the fuel load for the regenerating cohort. Fuel treatments within this system could include the use of prescribed fire approximately every 10 years to keep fuel loads low, decrease the density of young cohorts, and mirror the natural fire return interval. Additionally, rotation ages could be planned to be about 100-200 years to be more aligned with historic age structures.

Given that current silvicultural systems have been commonplace for decades, it is likely unrealistic to expect dramatic changes quickly. However, making alterations to current systems where feasible are steps towards aligning modern practices with the natural disturbance regime. For example, any feasible increase in planned rotation age would result in larger trees being retained for longer periods across the landscape. While this would mean longer periods before harvests, managing individual tree growth by maintaining lower stand density could result in more vigorous trees that achieve large tree status in a shorter amount of time. It is acknowledged that this could sacrifice some degree of long-term harvested yield, but it would also serve to lower wildfire severity and mitigate greater potential losses. While these changes may be presumed to have negative effects on timber yield, multi-aged silvicultural systems have so far been as productive or more productive than even-aged systems.

Fuel treatments have been used to reduce the risk of high-severity fires by lowering surface and ladder fuels. Because they more closely mimic low-severity fire, fuel treatments are more aligned with the natural disturbance regime than other silvicultural systems. However, adjusting the current approach to fuel treatments could help to imitate the impacts of moderate-severity fire that it lacks. Low-intensity prescribed fire and fuel treatments reduce fuel loads, but often do not produce the moderate to larger gaps that provide for landscape-level complexity and the initiation of new cohorts of fire-adapted species.

Fuel treatments are often intended to be maintained by low-severity prescribed fire, but in cases where it is challenging to implement, pyrosilviculture treatments that alter fuel can help prepare stands and increase future opportunities to use prescribed fire. When planning on implementing prescribed fire in the future, planting may be necessary following gap-creation harvests. This can initiate high enough densities that compensate for future mortalities from periodic low-intensity fire.

The onset of climate change has exacerbated the effects of misalignment of current silvicultural systems. It has also highlighted the unsustainable approach of conducting no treatments other than fire suppression. This hands-off approach is a type of silvicultural system, but not one that sustains forests. In disturbance-dependent ecosystems, active management in alignment with the historical disturbance regime is needed to increase resistance and resilience to climate change. Overall, ecological silviculture systems can be valuable in providing pathways for research, transition, and adaptive management in the face of climate change. Periodic density management and gap creation allows for a continued and adaptive analysis of appropriate stocking standards and gap sizes, helping to find systems that work in the future climate. Finding new and innovative ways to maintain a viable timber ecosystem becomes increasingly prevalent, as timber harvests will be an essential tool for managing density, regenerating desired species, and generating revenue for fuel treatments.

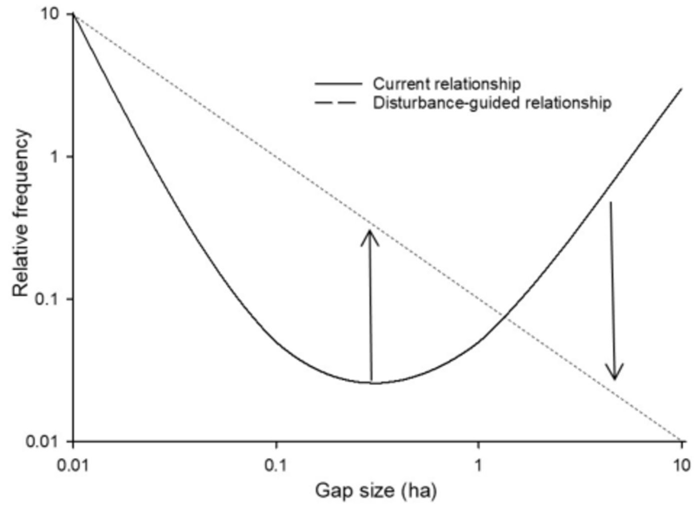

Figure 1. Relationship between frequency and gap size in current and historical management systems

Fig. 2. Mean, median, and range of the DBH of live and dead trees in each age class. Boxes represent the interquartile range, solid black lines the median, black dashed lines the mean, and whiskers 1.5 times the interquartile range. Black dots represent outliers in data.

Additional Information

This brief is based on the following book chapter:
York, Robert A. 2024. Ecological Silviculture for Sierra Nevada Mixed Conifer Forests. Ecological Silviculture Systems: Exemplary Models for Sustainable Forest Management: 156-166. https://ebookcentral.proquest.com/lib/berkeley-ebooks/detail.action?docID=30765148.

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