**Title**

# Managing Competing Vegetation following High Severity Wildfire



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# Managing competing vegetation after high-severity wildfire – Pathways to ensure the re-establishment of forested land

## *Reforestation under an altered fire regime*

As the magnitude and prevalence of large, high-severity fires in Sierra Nevada mixed-conifer forests increases, so does the need and urgency to promote the re-establishment of forested lands.

Prior to European colonization, the fire regime of Sierra Nevada forests consisted of periodic low to moderate severity surface fires via indigenous burning and lightning ignited fires (Stevens et al. 2017). This frequent-fire forest structure minimized understory competition, with shrub cover limited to less than 30% (Knapp et al. 2013), and enabled the growth of large and vigorous overstory trees at a lower density (North et al. 2022). Following a wildfire within this historically intact fire regime, mature trees persisted and provided a seed source for new trees to establish. Infrequent, small patches of high-severity fire, usually less than 10 acres (Williams et al. 2023), created openings for seedlings to establish without being too far from nearby seed trees.

Past century policies like the extirpation of indigenous communities, fire suppression policies, and past land management practices have shifted forest structure to manifest into what is now a novel disturbance pattern. The absence of frequent low-severity fire and timber harvesting that removed large fire tolerant trees created an overly dense forest with high fuels loads, increasing this structure's vulnerability to drought mortality and high-severity wildfires (Hagmann et al. 2022). As a result, contemporary fires are now increasing in frequency and severity with extensive patches of high-mortality (1,000 to 30,000 acres in size), leaving not enough mature trees left to contribute seeds for regeneration (Williams et al. 2023). With these changes in fire patterns, the predictability of how forests may be able to recover is uncertain.

The establishment, survival, and growth of conifer seedlings is dependent on a variety of factors, including: proximity to seed trees, cone crop sizes, soil conditions, climate, and competing vegetation. Following high-severity fire, the re-establishment of conifers is uniquely challenged by a lack of sufficient tree seed sources, hotter and drier climates, and early colonization of competing understory vegetation that competes for soil moisture (Davis et al. 2019).

Planting seedlings is a common practice to ensure tree establishment and augment natural regeneration. Although increasing warm and dry climatic conditions may be challenging for young trees, they can survive and thrive if they are (1) planted quickly post-fire, and (2) competing vegetation is sufficiently reduced to allow seedlings to capture the moisture, nutrients, and sunlight available on site.

## *Ecology of Competing Vegetation*

Following a disturbance, such as wildfire, the ecosystem undergoes a change in its species composition and structure over time, known as ecological succession. Two classic theories **– relay and initial floristics** – describe how plant communities generally develop (*See Figure 1)*. Within the traditional relay floristics model, groups of species replace each other over time, with each group modifying the site which facilitates the establishment of the next occupying species. Conversely, in the initial floristic model, all vegetative species are initially present following a disturbance, but their expression of dominance varies over time. Initial floristics is the most prevalent ecological establishment model after a disturbance in Sierra Nevada forests. **Understanding how initial floristics unfolds is critical after a wildfire and is the reason why planting is imperative**. If there are not enough live, mature, and cone-bearing trees present to facilitate

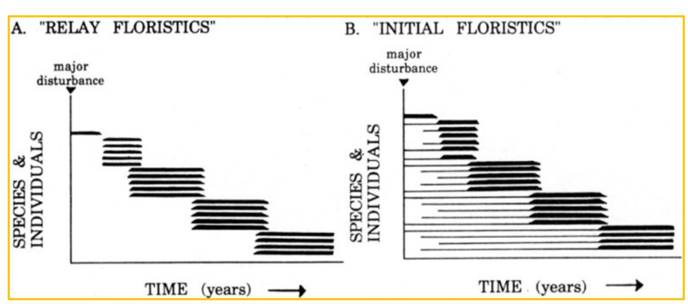


*Figure 1: Depiction of relay and initial floristic models, where each line represents a species and boldness represents when they are present over time [Credit: Clements (1916)]*

natural regeneration, then there will be no opportunity for trees to establish – unless they are planted. Once planted, tree seedlings must compete with grasses, forbs, and shrubs for both the physical space to grow and for available resources, most importantly - water. In California's Mediterranean climate, competition for water is often the most impactful to tree seedling survival, growth, and development. Under a changing climate, competing vegetation management may be essential to re-establishing forests.

In post-high-severity fire environments, rapidly growing shrubs have the advantage through two fire adaptations: 1) dormant seed banks in the soil that are activated to germinate by fire, and 2) the ability to quickly resprout. Shrub species not only outpace young conifers in height and crown growth, but they effectively take up underground resources and space via their extensive root systems that compete for water (*See Image 1*). Trees that compete with shrubs are smaller, in diameter and height, and have a restricted crown size when compared to trees that grow without shrub competition (Oliver et al. 1990, Zhang et al. 2006).

## *Management Considerations*

Competing vegetation management is commonly used in post-fire reforestation efforts to maximize the development of seedlings into mature trees and reduce competition for water resources. In addition, shrubs can act as live fuels contributing to fire hazard in planted forests. Burned areas left with standing dead trees and high shrub cover contribute to a higher fuel load, therefore risking a future high-severity reburn (Coppoletta et al. 2016). In competition with shrubs, young conifers may not be able to establish successfully nor quickly grow out of the stages where they are vulnerable to subsequent fire. This may lead to conversion of the severely burned forested area from forest to non-forested landscape (Coop et al. 2020).

*Image 1: Comparing root systems of shrubs (2-3 years post-fire) to roots of tree seedling (center) [Credit: Ryan Tompkins]*


*Image 2: Comparison of two approaches for post-fire vegetation management: herbicide use (left) produced higher rates of survival compared to the no action approach (right), [ Credit: Rob York]*

Wildfire risk is decreased by limiting the density and size of herbaceous vegetation, which reduces fuel loads and minimizes fire intensity. Enhancing vigorous tree growth for height and diameter promotes the development of fire adaptations in planted trees (e.g., tall height to crown base, thick fire-resistant bark). This not only ensures the re-establishment of forests across the landscape, but also imparts resiliency by promoting large mature trees in the future (North et al. 2022). Managing competing vegetation should include a two-fold approach, where: (1) initial floristics is invoked by **planting early** after preliminary site preparation removes down and woody debris to expose bare mineral soil, and (2) more growing space and resources are allocated to conifers by **removing competing vegetative species** via management treatments. There are many treatments available for forest managers and landowners to control competing vegetation – each has its own cost, considerations, and efficacy ( *See Table Below)*. A combination and multiple entries of treatments may be necessary for the successful management of competing vegetation, in order to enhance the growth of planted trees and promote forest re-establishment in burned landscapes. Choosing not to manage competing vegetation is a management decision that includes its own impacts and costs (*See Image 2)*.

## Competing Vegetation Management Treatment Toolbox

| Treatments | Cost/ Acre | Considerations | Effective Duration | Timeline |
|---|---|---|---|---|
| **No Action** | $0 | - Seedlings survival threatened<br>- No control over shrub resurgence<br>- High fuel load, potential for reburn | Not Effective | Could result in increased costs, and/or reduced effectiveness of long-term forest reestablishment |
| **Chemical (Herbicide)** | $-$$ | - Reliably effective suppressant shrub<br>- Low soil disturbance<br>- Weather/seasonally dependent<br>- High knowledge need | 4-6 years | Dependent on herbicide type, can be applied prior to or after planting and other treatments |
| **Mechanical** | $$+ | - Heavy soil disturbance<br>- Limited to prior to planting<br>- Not operable on high slopes | 3-5 years | Accomplished prior to planting, or once trees are of sufficient size to be avoided by heavy equipment |
| **Manual (hand-grubbing)** | DIY, or $$$ | - Time-consuming<br>- Laborious<br>- Often only possible at low acreage | 1-2 years | Optimal 1-3 years post-fire; thereafter largely infeasible |
| **Managed Grazing** | $$-$$$ | - Unmanaged grazing may cause damage to seedlings<br>- Requires supervision<br>- Shrub reduction dependent on species and grazing preference<br>- Reductions are usually short-term due to re-sprouting, inability to impact sprouting root-ball. | 1-3 years | Grazing should be timed to avoid browse damage to seedlings |
| **Prescribed Fire** | $$-$$$ | - Potentially removes shrubs/herbaceous fuels if targeted<br>- May not be suitable for young seedlings, requires trees to be old enough to withstand fire<br>- Can stimulate the growth of perennial shrubs, and release stored seeds in soil<br>- Following herbicide, can have greater consumption of fuels and influence on conifer growth | 1-6 years | Either before planting ( as site-prep) or once saplings have grown enough to withstand fire (in planted forests, roughly a decade old) |

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