Collaboration for Environmental Evidence

Systematic Review CEE 10-012

DO NON-NATIVE PLANTS INVADE BURNED PONDEROSA PINE FORESTS MORE INTENSELY AFTER PRESCRIBED OR WILD FIRES?

Protocol

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Cover Sheet

Title	**Do non-native plants invade burned ponderosa pine forests more intensely after prescribed or wild fires?**
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1. Background

Fire plays an integral role in ponderosa pine (*Pinus ponderosa*)-dominated forests by maintaining low tree densities, a diverse understory, sparse litter accumulation, and regulating many ecosystem processes (Weaver, 1951; Cooper, 1960; Hart et al., 2005; Laughlin and Fulé, 2008). Native ponderosa pine forests, which range from southern British Columbia south to northern Mexico, historically supported frequent, low-intensity fires that burned unevenly across the landscape. Starting in the late 1800s, land managers actively disrupted the historical fire regime in forests dominated by ponderosa pine. Ponderosa pine forests were heavily grazed by livestock, reducing the fine fuels generated by perennial grasses that carried surface fires through the system. The removal of perennial grasses by grazing also created germination sites for woody species, especially ponderosa pine seedlings, resulting in a denser canopy. The reduction in fine fuels and increases in woody species shifted the fire regime away from frequent surface fires to less-frequent crown fires. In the early twentieth century, active fire suppression reduced the acreage burned with each new ignition (Cooper, 1960; Covington and Moore, 1994). As a result, these forests have become densely stocked with ponderosa pine trees and have a sparse understory community. The increased density of trees, coupled with changes in climate, has led to an increase in the number of hectares burned annually by wildfire (Swetnam, 1990; Covington et al., 1997; Westerling et al., 2006). In addition, more land is treated each year for fuels management with prescribed fire (Interagency Fire Center; www.NIFC.gov), often in combination with mechanical tree thinning prior to burning. Disturbances created by these treatments may facilitate the spread of undesirable non-native plant species (hereafter non-natives) into the burned landscapes (D'Antonio and Vitousek, 1992; Keeley, 2006). Regardless of whether the fire is prescribed or wild, non-natives have been documented in the post-fire understory community of ponderosa pine forests.

Many non-natives are well adapted to fire (D'Antonio and Vitousek, 1992; Brooks et al., 2004) and are generally considered an undesirable component of the post-fire plant community (Allen et al., 2002; D'Antonio and Meyerson, 2002). They are often early successional species that can capitalize on open niches created by fire faster than their native counterparts (Rejmanek, 1995). The impact of non-natives in the post-fire community is highly variable. Some species, such as prickly lettuce (*Lactuca serriola*) and common dandelion (*Taraxacum officinale*), tend to have a subordinate role in the disturbed ecosystem. More aggressive invaders, such as cheatgrass (*Bromus tectorum*), can dominate an ecosystem, changing herbaceous diversity, fire cycles, and belowground processes (Whisenant, 1990; Knapp, 1996; Evans et al., 2001; Belnap et al., 2005). While the fire return interval in a heavily-invaded ponderosa pine forest is often not altered, the fires tend to burn more evenly across the landscape, leaving few unburned areas.

Increasingly, thinning and burning treatments are implemented with a focus on ecological restoration in addition to fuels reduction. While ecological restoration treatments are intended to reinvigorate all aspects of forest health, including the native understory community, there is a growing concern among land managers, scientists, and other stakeholders about the risk of encroachment by non-natives into these systems (Moore et al., 1999; Allen et al., 2002). Implementation of ecological restoration usually involves an elevated level of disturbance. Prescribed fire and mechanical removal of excess trees are common restoration practices which can perturb the soil and disturb vegetation (D'Antonio and Meyerson, 2002). The disturbances generated by thinning and burning treatments can create openings for the invasion of highly competitive non-native species (Hobbs and Huenneke, 1992).

Research has shown that areas burned in wildfires can be more susceptible to nonnative invasion than those burned in prescribed fires (Crawford et al., 2001; Griffis et al., 2001, Keeley et al., 2003). Other evidence suggests that past and present land management practices, overall level of disturbance on the site, and proximity to invasive species seed sources can be more important in determining the likelihood of invasion. Research in the Southwest has shown high levels of non-native invasion in prescribed slash pile burns with long fire residence time (Korb et al., 2004). Conversely, low levels of plant invasion were detected within the perimeters of wildfires in remote areas with comparatively little anthropogenic disturbance (Laughlin et al., 2004).

While there have been many studies examining non-native response to wildfires and prescribed burning, both with and without thinning, there has been no comprehensive systematic review of non-native encroachment into ponderosa pine forests throughout the native range of these forests. Land management agencies are expected to minimize the spread of non-natives into public lands. It is, therefore, important that information be available to practitioners about the risk of non-native invasion in response to prescribed burning treatments compared to wildfires. In this review we will examine levels of non-native invasion in response to prescribed burning treatments, with and without tree thinning, in ponderosa pine forests through North America. We will then compare these results to levels of invasion reported in wildfires. Lastly, we will look for common factors in prescribe burned areas and wildfire areas that did not experience high levels of non-native invasion.

2. Objective of the Review

2.1 Primary question

In ponderosa pine forests do prescribed fire treatments, with and without tree thinning, or wildfire lead to greater increases in non-native plant establishment?

2.2 Secondary question *(if applicable)*

In ponderosa pine forests that are not invaded by non-natives after prescribed fire treatments, with and without tree thinning, or wildfire are there detectable similarities among sites (fire behaviour, the pre- or post-fire vegetation community, soils, etc.) that can explain the lack of invasion?

In ponderosa pine forests do prescribed fire treatments, with and without tree thinning, or wildfire lead to greater persistence or non-native plants as a dominant component of the understory?

3. Methods

3.1 Search strategy

Databases supported by Cline Library at NAU:
- Web of Science
- JSTOR
- AGRICOLA
- Forest Science Database (Ovid)
- Proquest (Theses and dissertations)

General web search:
- Google Scholar

U.S. government databases:
- Treesearch

Search strings:
As our searches are focused on a single species, which clearly orients the search engines towards very precise articles, we chose to combine the results of two simple search strings

(Ponderosa pine OR *Pinus ponderosa*) AND (prescribed burn* OR prescribed fire* OR thinning OR wildfire)

(Ponderosa pine OR *Pinus ponderosa*) AND (non-native OR exotic OR invasion OR invasive)

3.2 Study inclusion criteria

- **Relevant subject(s):** Ponderosa pine-dominated forests that have been treated with tree thinning and prescribed burning or have burned in wildfires.
- **Types of intervention:**
  - Tree thinning and prescribed burning
  - Burned in wildfire
- **Types of comparator:**
  - Prescribe burned v. no treatment
  - Thinned and prescribe burned v. no treatment
  - Wildfire v. unburned
  - Prescribe burned v. wildfire
  - Thinned and prescribe burned v. wildfire
  - Heavy invasion v. slight or no invasion
- **Types of outcome:**
  - Cover of non-native plants
  - Biomass of non-native plants
  - Non-native species richness
  - Relative abundance of non-natives compared to total abundance
  - Persistence of non-natives after disturbance

- **Types of study:** We will use all research articles reporting data on non-native establishment in treated or burned areas and untreated or unburned areas. Observational studies, expert opinion, and anecdotal reports that do not report data will only be considered if the qualitative information is presented in a ranked system (e.g. high, medium, or low) that allows for cross-study comparisons.

3.3 Potential reasons for heterogeneity:

There is tremendous variability in ponderosa pine forests across the native range of the species. Heterogeneity is driven by latitudinal and elevational differences in forests, management history, and historical levels of disturbance. Additionally, there is typically a high level of variability in burn severity within a single wildfire. Understory response to thinning and burning treatments can vary depending on thinning intensity, prefire fuel loads, and season of burn. Lastly, there is not ubiquitous agreement on the nativity of some species (i.e. *Poa pratensis*). When possible, we will adjust all data to be consistent with nativity as listed in the USDA PLANTS database (USDA, NRCS 2010). In most instances, we will be dependent on the original authors' determination of which species are non-native.

3.4 Study quality assessment

Studies will be evaluated based on the types of methodology comparator, with the greatest weight given to replicated, randomized experiments.

3.5 Data extraction strategy

All studies included at full text will be read by two members of the review panel. We will compare the level of agreement on study inclusion between reviewers using Kappa analysis. We will assemble review information in a master spreadsheet, recording qualitative and quantitative aspects of the studies. Key variables include non-native plant cover, non-native biomass, non-native species richness, and the contribution of non-native species to the total understory for all variables. If sufficient data are obtainable from the reviewed articles, we will examine specific non-native species or certain common growth habits (annual grasses, perennial forbs, etc.).

3.6 Data synthesis and presentation

Data synthesis will be done by the review panel after reading the studies. We will assemble basic data about the studies reviewed (e.g., number of studies identified in the search, number and percent deemed relevant for review, distribution of geographic locations and information type). We will focus on studies reporting a quantitative response in non-native vegetation to wildfire or thinning and burning. Assuming we have sufficient studies with comparable data, we will use meta-analytical methods, such as Cohen's d effect size analysis, to test the data. Lastly, we will draw inferences about the similar and different non-native response to prescribed burning versus wildfire and highlight areas where further research is needed.

4. Potential Conflicts of Interest and Sources of Support

We foresee no potential conflicts of interest.
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