The Role of Fire in Promoting Plant Invasions

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The abundance of invasive plants in a landscape typically increases after large scale disturbances such as fire. Examples of where fire has promoted the dominance of invasive non-native species include giant reed grass and tamarisk in riparian habitats; brooms and gorse species in Northern California, highway iceplant in coastal chaparral; and invasive grasses and forbs in many other habitats, especially in arid and semi-arid regions of the western USA. Invasive exotic plants often become established before fire, but then become dominant components of plant communities after fire. The mechanisms by which fire promotes the dominance of invasive plants appear to be related to increased availability of soil nutrients and light and reduced competition from native species after fire.

The effect of fire on resource availability depends on fire intensity. Soil nutrient availability can increase after fire, particularly in habitats with naturally low nutrient levels such as deserts, serpentine outcrops, and some low elevation coniferous forests. Very cool fires have no effect and very hot fires decrease soil nutrient availability, but most fires include significant areas of moderate intensity that lead to increased nutrient levels. Increased soil nutrient levels are often more effectively exploited by invasive than native plants, due to their high relative growth rates and ability to quickly disperse into burned areas.

Light levels can increase after fires where levels are naturally low due to high plant cover. High plant cover prevents light from reaching the soil surface, which suppresses seed germination. When this impediment is removed after fire, seeds germinate profusely from the seedbank. In habitats such as chaparral where native plants have evolved adaptations to recover from fire, native shrubs often reestablish continuous cover within a few decades and suppress seed germination until the next disturbance event. However, an individual fire can allow invasive species to establish a foothold in new areas, although they may only be present as dormant seeds in the soil seedbank during later stages of chaparral succession. Following the next fire, invasive species can reach maximum cover more rapidly because they are already present on the burned site.

The use of limiting resources or maintenance of light limitation by native perennial plants typically decreases or is interrupted by fire due to the combustion and loss of photosynthetic biomass. This in turn may facilitate the establishment of previously suppressed exotic species in the postfire landscape. As invasive species become dominant, and reduce levels of soil water and mineral nutrients, they hinder the reestablishment of native shrub and bunchgrass seedlings. This has been observed in Great Basin, Mojave Desert, and coastal sage scrub habitats in California.

Many invasive plants are highly flammable, and can increase fire frequency to the point where native plant communities cannot recover. High fire frequency promotes high light and soil nutrient availability and reduced competition from native perennial plants, all factors that promote dominance by invasive species. Frequent fires can maintain high light availability and reduce competition from native species that cannot tolerate recurrent fire, creating ideal conditions for invasive plants. Even in habitats that evolved with fire such as chaparral, return intervals shorter than 15-20 years can convert native shrubland to invasive alien grassland.

The interrelationships between fire and plant invasions have only recently received significant attention from land managers and research scientists. Accordingly, much of what we describe here is based on studies focused on either fire or invasive plants, but not on their interrelationships. Some integrated studies are in progress, but much more of this type of research is needed. Land managers need to understand how fire and invasive plants are interrelated to avoid the often conflicting results that occur when fire and natural resource plans are not well integrated.

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Fire Regimes Changed By Exotic Plants

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Fire is one of severai important disturbance factors promoting plant invasions of natural ecosystems. This can occur even in vegetation generally regarded as "fire adapted" because species are fine-tuned to a particular fire regime. Plant invasions can occur when the natural fire regime is altered and the subsequent invasive plants often modify the fuel structure in ways that further upset ecosystem functioning. High fire frequency favors herbaceous growth forms over woody growth forms and enhances the competitive displacement of native species with non-natives. Type conversion of shrublands to grasslands alters the natural fire regime by reducing fire intensity and increasing fire frequency. The latter results from 1) increased fine fuels with greater ignitability, 2) increased seasonal window of opportunity for fires and 3) enhanced fire spread characteristics of herbaceous fuels, which spread fire both horizontally through the stand and vertically into the shrubs with very little wind.

Ecological Effects of Exotic-Altered Fire Regimes

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The frequency and intensity of disturbance in systems dominated by exotic vegetation can differ greatly from the previous regime that shaped the native vegetation community prior to conversion. Consequently, the effects on habitats and dependent animals can be magnified or changed in systems altered by exotic vegetation. The Snake River Birds of Prey National Conservation Area, which covers approximately 200,000 ha in southwestern Idaho, represents an extreme example of low-elevation shrubsteppe habitats that are in transition to a new state dominated by exotic annuaI vegetation. Over one-half of the shrubland communities existing in 1979 have been converted into extensive grasslands dominated by cheatgrass (*Bromus tectorum*). The average retum interval between fires decreased to 27.5 years between 1980 and 1994 compared to 80.5 years between 1950 to 1979. Although wildfires were the primary and immediate cause of habitat conversion, areas of greatest landcover change also had been grazed by livestock or used for military training, Using computer models to simulate spatial and temporal dynamics of vegetation, we determined that shrublands would be virtually absent from the study area within 25 years if the current fire regime were maintained. In contrast, shrublands could be restored when large fires were eliminated or suppressed. However, the lack of available seed sources for shrub restoration limited natural recovery in regions dominated by extensive grasslands; the largest grassIands still had not recovered to a shrubland state after 100 years in the simulation. Increases in dominance by cheatgrass increased the rate at which shrublands were lost as well as decreased the percent cover of shrublands in the landscape primarily by increasing fire frequency and size. Numbers of blacktailed jackrabbits (*Lepus californicus*) reflected the loss of shrublands and were successively lower during population peaks (1971, 1979-1982, 1990-1992. Total numbers of golden eagles (*Aquila chrysaelos*), which prey on jackrabbits, also have declined between 1971 and 1994. The reiationship behveen habitat change and numbers of Paiute ground squirrels (*Spermophilus mollis*) and prairie falcons (*Falco mexicanus*) was more complex