Fire Management Impacts on Invasive Species at the Wildland/Urban Interface in California

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The wildla/urban interface is a complex mosaic of boundaries between human habitations and wildland fuels. In southern California this interface zone is largely centered between foothill chaparral and the growing urban sprawl, a mix that poses substantial fire hazard for a huge population. Communities have also sprung up throughout the mountains, with fairly high density housing in the coniferous dominated ecosystems, creating an equally hazardous but somewhat different set of fire issues. In California one of the major impacts of fire and fire management practices is on the balance between native to non-native species. At the wildland / interface the problems between fire and aliens are intensified. Here I consider the impact of fire management practices (Table 1) on alien invasions.

Table 1. Fire management actions that have documented impacts on alien plant species invasion of natural ecosystems in California.

Fire suppression action
Prefire fuel manipulations to reduce fire hazard
Mechanical thinning or logging
Prescription burning
Prescription burning to target noxious aliens
Fuel breaks
Postfire rehabilitation

Fire Suppression Policy

For much of the past century a policy of suppressing all wildfires has ruled fire management in the U.S. In mixed conifer forests such as those that dominate the plateaus around Lake Arrowhead and Big Bear in the San Bernardino Mountains, this policy has been extremely effective and resulted in near total fire exclusion over much of this landscape (Everett 2003). From a fire hazard perspective this policy has been disastrous due to the extraordinary fuel accumulation in these forests, with levels of 15 – 150 metric tons per hectare of just dead surface fuels (Stephens 1998, 2004). From an alien plant perspective this has not been particularly bad since the dense shading and litter layer have generally discouraged alien invasion (Keeley et al. 2003). However, this is not a sustainable means of controlling aliens because the increased fuels will almost certainly lead to large high intensity crown fires (Agee 1993), which will create ideal conditions for alien plant invasion. In the southern California mountains, particularly along the immediate wildland/urban interface, the situation is very critical because of massive tree dieback (Fig. 1a), particularly ponderosa pine (*Pinus ponderosa*).

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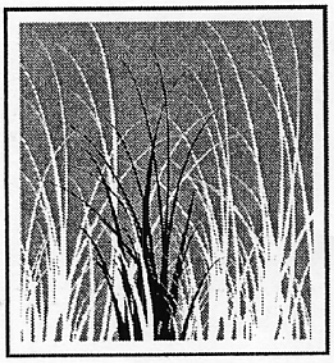

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Due to the extreme fire hazard these forests are being aggressively logged in order to removed the dead material (Fig. 1b). The

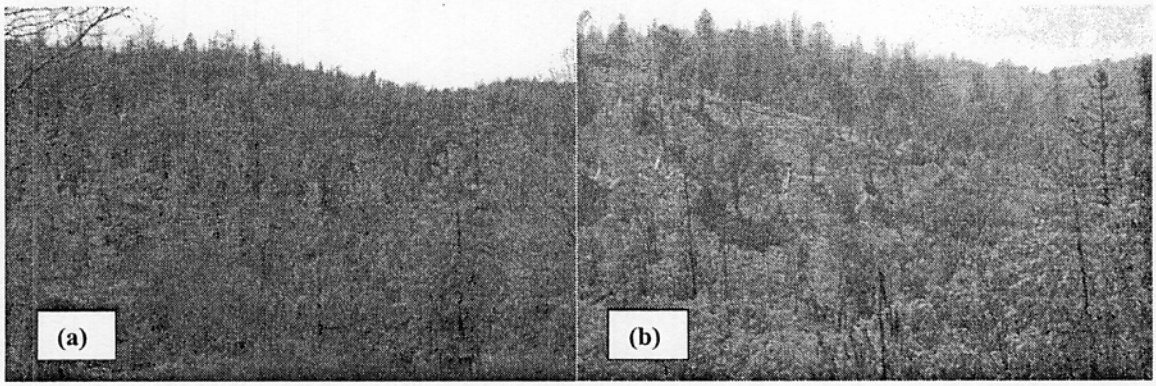

Figure 1. Ponderosa pine dominated forest at the wildland/urban interface in the community of Lake Arrowhead, San Bernardino County California. (a) Extensive pine mortality evident in the autumn of 2003, following severe drought and bark beetle attack, presumably exacerbated by the high tree density resulting from a century of fire exclusion. (b) The same forest 6 months later after dead trees removed, reflecting sites that are likely to become rapidly invaded by alien plants such as cheatgrass, which currently occupies most disturbed forests in the region (photos by J. Keeley).

resultant ecological vacuum created by these removal operations will almost certainly create a sink for alien species in the neighborhood. The most likely species to invade these perturbed forests is cheatgrass (*Bromus tectorum*), which presently is very widespread in disturbed forests in the San Bernardino Mtns. (Keeley, personal observations).

The situation, however, is somewhat different at the lower elevation foothill wildland/urban interface. In this zone a century of fire suppression has succeeded in maintaining relatively constant average levels of burning in the face of a massive onslaught of anthropogenic fires (Keeley et al 1999). Although the average fire rotation has not changed substantively, what has changed is the fire frequency along the densely populated wildland/urban interface.

Here high fire frequency has stressed the natural chaparral and sage scrub ecosystems to the point of a major state-change. Specifically, the ever increasing anthropogenic fire frequency has displaced many native shrublands with alien-dominated annual grasslands (Keeley 2001, 2004a). Within just a few years the dense postfire regrowth, particularly of fast growing suffrutescents such as *Lotus scoparius, Helianthemum scoparium* and *Calystegia macrostegia* produce massive fuel loads of fine fuels. In one study this ranged from 10 -24 metric tons per hectare, a value comparable to young sage scrub or productive grasslands (Keeley and Halsey in review).

Studies of postfire chaparral and sage scrub have shown that the major determinants of alien invasion are tied to the proximity of alien seed sources and the rate at which native shrub canopies recover (Keeley et al. 2003). When fire frequency increases to unnaturally high levels, e.g., once a decade in chaparral or several times a decade in sage scrub, native species are lost and alien annuals fill the void. These aliens alter the fire regime from a crown fire regime to a

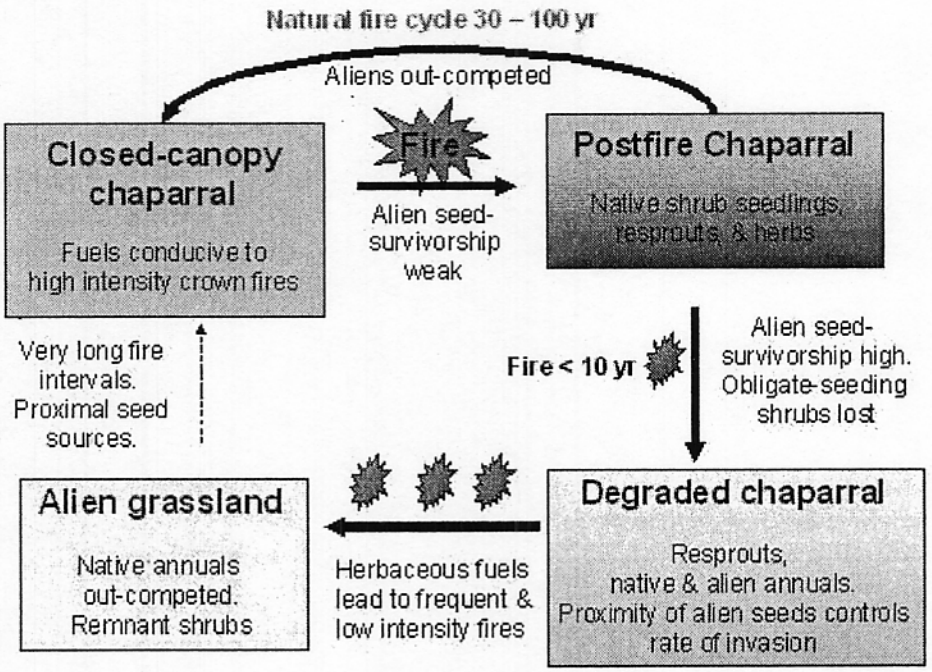

Figure 2. Model of interaction between fire regime and alien invasion in California chaparral.

mixed crown and surface fire regime, as a consequence fires can carry through these mixed shrubland/grasslands under a far greater range of weather conditions than are required to carry fire in young chaparral. In addition, the early curing of the alien grasses greatly expands the length of the fire season (Keeley and Fotheringham 2003). Lastly, the lower temperatures resulting from fires in grass/shrub mixtures means much greater alien seed survivorship, which
in turn enhances conditions for aliens in a feedback process that often ends in alien dominated annual grasslands.

Fuel Reduction Practices

Prescription burning and other fuel reduction treatments (e.g., Fig. 1b) are a necessity for life at the wildland/urban interface in conifer forests. Prescription burning is feasible because it is directed at burning understory fuels and produces low flame lengths and lower severity fires.. However, regardless of the method, any treatment that reduces canopy cover of native trees in these forests appears to enhance alien plant invasion (Griffis et al. 2001, Keeley et al. 2003). It may be a necessity of life that we are forced to choose between restoring "natural" fire regimes or altering fire regimes to less frequent fires that will favor communities of native species.

Prescription burning crown-fire shrubland ecosystems is a very different proposition than in forests. There are three main reasons. First, such treatments in chaparral are problematical because there is not an unnatural accumulation of fuels that is responsible for catastrophic fires (Mortiz et al. 2004), and thus fuel reduction is of limited value during severe fire storms that are responsible for most of the catastrophic fires in southern California (Keeley 2002). Secondly, these lower elevation chaparral landscapes are already challenged with an unnaturally high load of fires and further prescribed

application of fire potentially stresses these ecosystems. Lastly, controlling fires in these crown fire ecosystems is difficult and as a result there is strong motivation for burning during the cool winter wet season. However, there is increasing evidence that these out of season burns have potentially lethal effects on the native ecosystems, sometimes largely displacing them with a single ill-timed burn (Keeley in review).

Prescription Burning to Target Noxious Weeds

Targeting noxious aliens with prescription burning has shown some promise, specifically, repeated fires have been demonstrated to nearly eliminate yellow star thistle (*Centaurea solstitialis*) in field studies (DiTomaso et al. 1999). However, follow up studies indicate this apparent control is not sustainable and within a few years this alien weed returns with a vengeance (Kyser and DiTomaso 2002). From an ecological perspective this is perhaps not too surprising since this weed and most alien herbs are opportunistic species that capitalize on disturbance. Control of these opportunistic aliens is likely not to come about by further application of disturbances such as fire. Community restoration of the native perennial flora, bunchgrasses on some sites, shrublands on other sites, is likely the only means of restoring some quasi-equilibrium with natives as the dominants in the community.

Fuel Breaks

Fuel breaks: Fuel breaks pose a special invasive plant risk because they promote alien invasion along corridors into wildland areas (Fig. 3) and the lower fuel loads lower temperatures during wildfires generate "safe sites" for alien propagules. As a consequence, following fires these fuel breaks represent a major seed pool capable of providing a seed bank for invasion of adjacent wildlands (Merriam et al. in review).

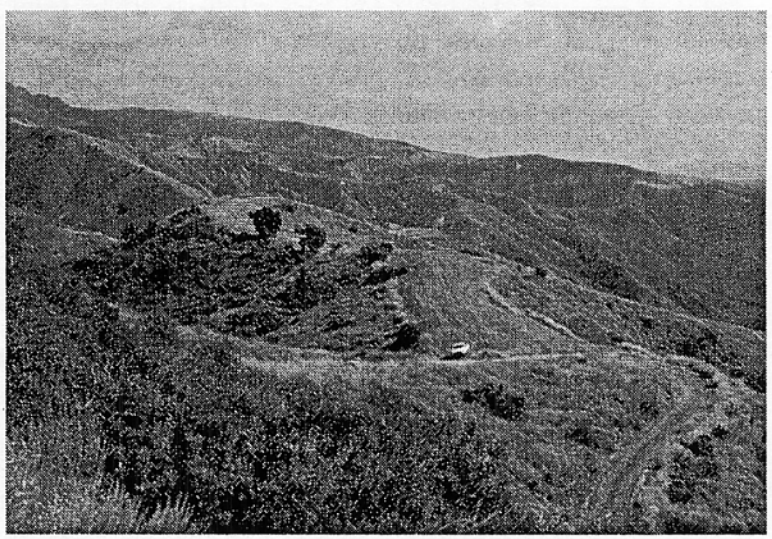

Figure 3. Recently graded fuel break through chaparral and sage scrub in the Santa Ana Mountains, Orange County, California.

Postfire Rehabilitation

Rather than solving postfire watershed problems, aerial seeding of alien species appears to be the cause of a many ecosystem problems and potentially enhances alien invasion. Historically this practice is responsible for widespread dispersion of noxious aliens such as *Brassica nigra* and related

taxa. Today those fire management practices have left a legacy on the landscape in that some of these mustards have deeply dormant seed banks that allow them to dominate postfire sites. Other less noxious species have replaced mustard, however, these species are of concern because they have the potential to out-compete native plants and inhibit the natural ecosystem recovery (Keeley et al. 1981, Barclay et al. 2004). Recently these projects have moved towards use of "sterile" or "non-persistent" varieties of cereal grains. While these species apparently do not persist on a site or spread, they do inhibit the native recovery and pose a special risk for alien invasion (Keeley 2004b). Often these grasses are seeded very densely and then their sterile or non-persistent character means they disappear in subsequent years, leaving an ecological vacuum potentially exploited by alien invaders.

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