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Research Brief for Resource Managers

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# Effects of conifer encroachment on fuels and fire in white oak woodlands

*Engber, E.A., Varner, J.M., Arguello, L.A., and N.G. Sugihara. 2011. The effects of conifer encroachment and overstory structure on fuels and fire in an oak woodland landscape. Fire Ecology, 7(2): 32-50.*
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Like many prairie and savanna ecosystems throughout the world, the white oak (*Quercus garryana*) woodlands of northwestern California are adapted to and dependent on frequent fire. Fire maintains woodland structure and composition, limits competition from invading fire-sensitive vegetation, and is a critical process in the sustained existence and function of these important ecosystems.

A century of fire exclusion in the western United States has altered oak woodland landscapes, resulting in severe compositional and structural changes that influence species diversity and distribution, fuel loading, and fire behavior and effects. These patterns are widely recognized and discussed within the management community, yet they are not well studied nor well understood, and important questions remain about the nature and extent of change within oak woodland ecosystems.

This study investigated the effects of conifer encroachment and overstory structure on fuels and fire in the white oak woodlands of Redwood National Park (RNP), comparing live and woody fuel loading, fire behavior, and species composition across a gradient from open grassland to oak woodlands to conifer-invaded woodlands.

## Management Implications

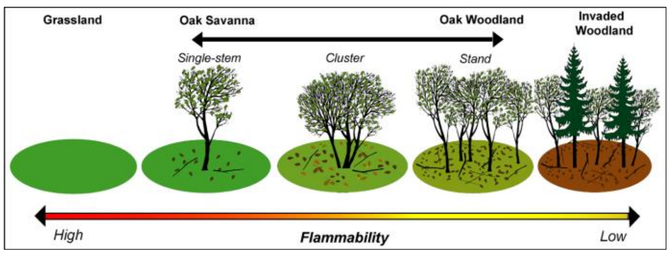
- Douglas-fir encroachment dampens fuelbed flammability, altering the nature and potential of prescribed fire as a management tool in invaded woodlands
- Prescribed fire may be most effective early in the invasion trajectory, when fuelbeds are more conducive to fire spread and young conifers are still sensitive to fire
- The restoration of stand and fuel structures in encroached areas (through thinning and other silvicultural treatments) may be a prerequisite for longer-term management goals aimed at maintaining species richness and restoring historic fire regimes

***Methods***

This study took place in the Bald Hills of RNP, a 4200 acre area dominated by Oregon white oak woodlands and open grasslands and bordered by Douglas-fir (*Pseudotsuga menziesii*)-tanoak (*Notholithocarpus densiflorus*) forests, which were historically confined to more mesic areas but have expanded dramatically over the last century. Since the early 1990s, managers at RNP have used prescribed fire to maintain prairies and woodlands and limit conifer establishment, yet significant encroachment sill occurs at woodland and prairie margins.

Plots were established in and adjacent to three major burn units that were prioritized for burning in fall 2008 and fall 2009. Plots were randomly installed in 5 different structural communities within those areas, including open grassland, oak savanna, oak cluster, oak woodland, and Douglas-fir-invaded woodland. Additional plots were installed in woodlands with an understory dominated by California fescue (*Festuca californica*), a notably flammable native grass.

In each plot, data were collected on fuel loading (including woody fuels, leaf litter, and herbaceous and shrub fuels), fire temperature during prescribed fire (using pyrometers, or thin copper tags coated with a range of temperature-sensitive paints), and species composition (overstory and understory). Fuel moisture data were also collected on the days that prescribed burns were conducted. These data were compared across the range of structural communities to determine the influence of overstory structure and composition on fuels and fire behavior.




### *Results*

Fuelbed characteristics varied significantly across the structural gradient, with herbaceous mass decreasing markedly from grassland to oak woodland to invaded woodland, and leaf litter and woody fuels showing the opposite pattern, increasing significantly along the same gradient. Percent cover of bare ground, fuelbed bulk density, and overstory basal area all increased drastically from grassland to invaded woodland, and basal area was negatively correlated with herbaceous mass.

Oak woodland plots with a California fescue understory had the highest mean herbaceous mass of any community type, with more than twice the mean herbaceous mass of grassland plots and over 250 times the mean herbaceous mass of Douglas-fir-invaded woodland plots.

Fuel moisture also increased from grasslands to invaded stands, with live herbaceous fuel moisture and ten hour woody fuel moisture significantly higher in invaded stands on all sampling dates.

Pyrometers revealed a decreasing (though not statistically significant) trend in fire temperatures from grassland to invaded woodland, with mean temperatures of over 400°F in grasslands and 370°F in oak woodlands and mean temperatures of less than 170°F in invaded woodlands.


*Typical Douglas-fir invaded (A) and intact (B) Oregon white oak woodland, illustrating differences in understory vegetation and fuels, RNP, California, USA.*

### *Discussion and conclusion*

As this research demonstrates, conifer encroachment and increasing stand densities can dampen flammability and alter fire regimes in oak woodland ecosystems. Invaded stands are less flammable than grasslands and woodlands – their fuelbeds are dominated by compact woody fuels, in contrast to the flashy herbaceous and leaf litter fuels typical of more open community types, and they also maintain higher fuel moistures. Thus, it is not surprising that fire temperatures recorded in invaded stands were much lower than those recorded in the other community types.

Dampened flammability presents a major challenge to managers hoping to reintroduce fire, limit conifer encroachment, restore oak woodlands, and mitigate wildfire severity through the reduction of woody fuels. Large patches of bare ground and a lack of fine, flashy fuels can inhibit fire spread and complicate the use of prescribed fire in encroached areas. Likewise, young conifer survival is much higher under a patchy, low-intensity fire regime, so conifer encroachment and dampened flammability contribute to a positive feedback cycle, wherein more encroachment results in lower flammability which enables further encroachment and even lower flammability. It is difficult to break this cycle without mechanical treatments that open up the canopy, reinvigorate the understory, and increase the continuity and availability of fuels.