Joint Fire Science Program

Fire Science Brief

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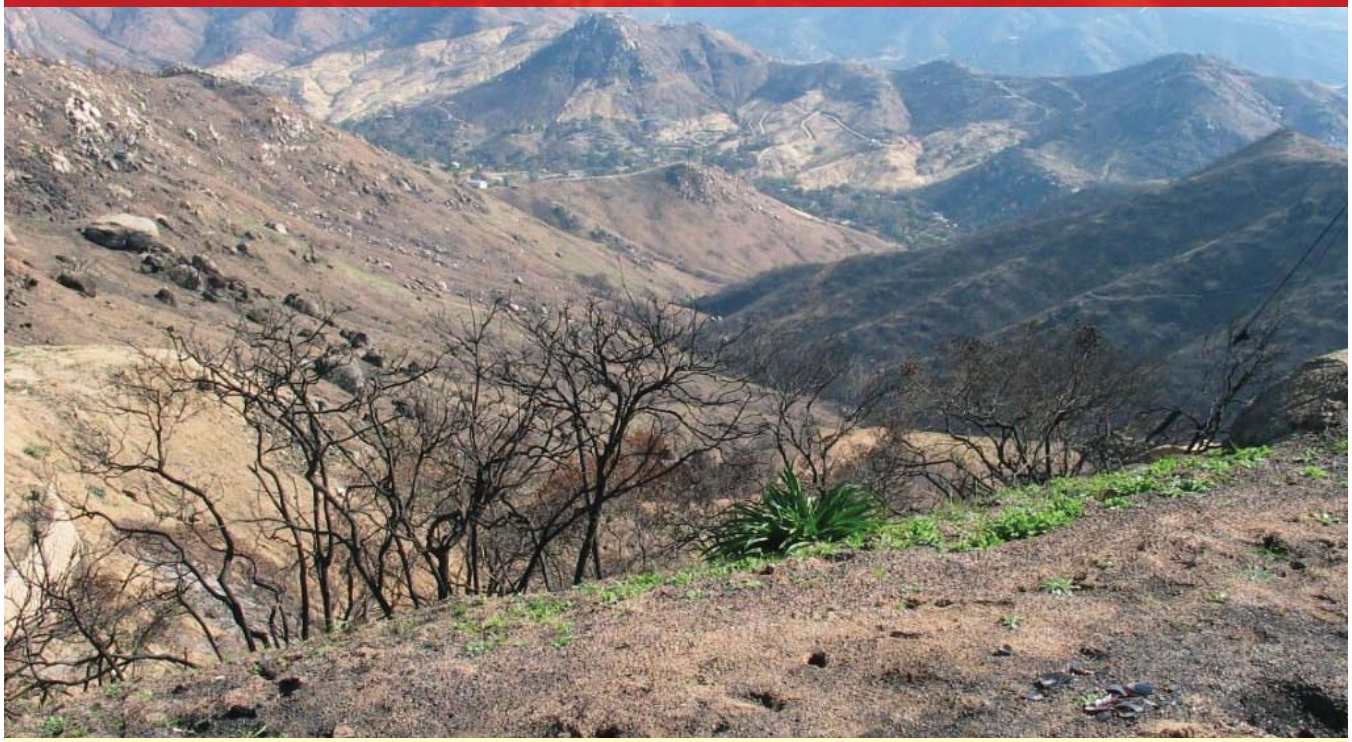

Cedar fire 2.5 months post-burn, near the community of Crest, looking east into the Cleveland National Forest. Credit: Wayne Spencer.

When Chaparral and Coastal Sage Scrub Burn: Consequences for Mammals, Management, and More

Summary

The massive Cedar and Otay fires of 2003 in southern California offered researchers an unexpected opportunity to examine the effects of fire on mammal communities. Jay Diffendorfer and his colleagues had already been sampling small mammal communities at the Rancho Jamul Ecological Reserve where the Otay fire broke out. There the researchers could see the difference in small mammal communities, pre- and postfire and the impacts of postfire, exotic grass invasion. At the Cleveland National Forest, where the Cedar fire occurred, the team examined whether the size and severity of the fire affected small mammal communities, as well as carnivores and bats.

Fire changed small mammal communities in both study areas—probably because of the subsequent shift in postfire vegetation. In general, after the fire, species specializing on open, grassy areas were present, while in unburned areas, there were more shrub-specializing species. The research suggests that the frequency and intervals of fire are likely much more important than fire severity and size, because of the potential to convert the vegetation from shrubs to grassy habitat dominated by non-natives. Since vegetation drives mammal diversity, management goals that focus on preserving native vegetation may be the key to preserving animal diversity.

Key Findings

- Small mammal communities shifted after the fires. In burn areas there were more small mammals specializing on open, grassy vegetation, while in unburned areas, there were more species specializing on shrubby vegetation.
- Burns followed by substantial non-native plant invasion (i.e., "type conversion") resulted in a simplified small mammal community.
- Distance to burn edge and fire severity had small effects on a few small mammal species but not carnivores or bats.
- Carnivore and bat distributions did not appear to be affected by fire.

Introduction

In southern California wildfire threatens people, property, habitat, and a host of different species. Managing the habitats of southern California can be challenging given its fire regime, human habitation, and the potential for the loss of native plant and animal species in that setting. Managers and planners need more detailed information on how such fires affect plant and animal populations.

Satellite image of 2003 wildfires in southern California. Credit: National Aeronautics and Space Administration (NASA).

Jay Diffendorfer, a Research Ecologist at the U.S. Geological Survey, Rocky Mountain Geographic Science Center, and his colleagues, Jan Beyers, (U.S. Forest Service), Genie Fleming (San Diego Natural History Museum), Wayne Spencer (Conservation Biology Institute), and Scott Tremor (San Diego Natural History Museum) knew immediately that the Cedar and Otay fires of 2003 in southern California offered a rich opportunity to understand more about the interaction between fire, native plant communities, and the diversity they support.

They mobilized quickly after the fires to learn more about how mammals like rodents, carnivores and bats respond to the short and long-term effects of fire. Individuals may die in the fire, move away, or find refuge. Populations and communities of mammals may respond not only to the fire itself, but also to subsequent shifts in vegetation. Diffendorfer adds, "There are many multi-species habitat conservation plans here (in southern California) and with challenges such as invasive non-native plants, lots of development, and wildfire, we need to know the best way to manage them."

The team had already been monitoring small mammal populations where the Otay fire occurred, and they knew that experimental follow-up after the wildfires could give managers valuable information on how wildfires affect mammal populations. With funding support from the Joint Fire Science Program (JFSP), the team set out to track what happened to mammals after the Cedar and Otay fires.

Coastal sage scrub: The Rancho Jamul Ecological Reserve and the Otay fire

The Otay fire burned 46,291 acres in southern San Diego County in October 2003, including portions of the coastal sage scrub habitat at the Rancho Jamul Ecological Reserve managed by the California Department of Fish and Game. "We had already been trapping animals and sampling vegetation for three years before the Otay fire at Rancho Jamul," says Diffendorfer. As a result, "we could easily see changes in abundance and presence or absence of the various small mammals at our sites from before to after the fire."

Rancho Jamul Ecological Reserve immediately after the fire. Credit: Dana Hogan.

"It is important to know that Rancho Jamul, a former ranch and farm, had been disturbed prior to the fire," he adds. "We knew from sampling that there was already invasion of the area by non-native grasses. So we wanted to

Small mammals track vegetation

Small mammal communities tend to track vegetation. In open or rocky shrub, or recently burned areas, the small mammal community is dominated by species adapted to these conditions such as kangaroo rats—who can move quickly through open areas—and deer mice, who are habitat generalists. The San Diego pocket mouse, a seed specialist, and the desert wood rat are sometimes also found in these habitats. Alternatively, in unburned areas where shrubs and chaparral still dominate, the small mammal community generally includes species that build above ground nests from woody material (large-eared woodrats), and species that forage on a blend of fruit, flowers, leaves, seeds, and insects, for instance, the California mouse, brush mice, and the California pocket mouse. Some species, such as cactus and harvest mice can be found in both types of habitat. The researchers found that at Rancho Jamul, rodent populations were more simplified than expected postfire, probably due to non-native plant invasion. Says Diffendorfer, "Since small mammals frequently track vegetation, we are not surprised to see the shift in the rodent community to one that is less diverse, less characteristic of the coastal sage scrub, and more characteristic of invaded grassland."

Open-habitat species

Deer mouse (*Peromyscus maniculatus*)
Desert wood rat (*Neotoma lepida*)
Dulzura kangaroo rat (*Dipodomys simulans*)
San Diego pocket mouse (*Chaetodipus fallax*)

Shrub-habitat species

Brush mouse (*Peromyscus boylii*)
California pocket mouse (*Chaetodipus californicus*)
California mouse (*Peromyscus californicus*)
Large-eared woodrat (*Neotoma macrotis*)

California Mouse—a shrub specialist found in unburned habitat. Credit: John Mitchell.

see what would happen to the mammals given the potential for the fire to shift vegetation composition from coastal sage scrub to a system dominated by invasive non-native plants."

After the Otay fire, they saw a shift from small mammal species that prefer the coastal sage scrub habitat, which contains many shrubs, to those that are known as more "open-habitat" species. The numbers and presence of open-habitat species increased while the shrub-preferring species decreased. The major shrub-associated small mammal species that had dominated the area prefire disappeared entirely from all study plots after the fire. At Rancho Jamul, there appears to be the first signs of type conversion (i.e., a shift in the vegetation community towards more non-native vegetation) and its impacts on the small mammals. The rodents at Rancho Jamul are simplified relative to what the researchers found on the Cleveland National Forest *and* relative to what should happen in postfire coastal sage scrub.

Chaparral: Cleveland National Forest and the Cedar fire

Meanwhile, the Cedar fire began in the Cleveland National Forest on October 25, 2003. This massive fire burned 280,278 acres and was the largest known wildfire in California's history.

The team used the Cedar fire to ask how wildfire affects mammals in chaparral habitat. Like coastal sage scrub, chaparral is dominated by shrubs, but they are larger and more densely-packed in mature vegetation. Here, the team studied small mammals like rodents, larger mammals like fox and coyote, and bats while monitoring vegetation recovery. They set up study plots in and around the Cleveland National Forest, a site they had not previously sampled. The study design included burned plots at varying distances from unburned habitat and with different degrees of burn severity as well as unburned, control plots.

Says Diffendorfer, "The size of the Cedar fire gave us the chance to ask how mammals in burned areas respond to the distance from unburned chaparral habitat and related resources." This kind of information could be important to managers planning prescribed burns. At what point does the size of a fire impact the recovery of resident mammal populations?

Similar to Rancho Jamul, they saw shifts in the small mammal community on plots that had burned. By 13 months postfire, woodrats were much less abundant on burned plots, as they prefer to nest in mature chaparral. Small mammal species that specialize on open, grassy habitats were typically found in the burned plots, whereas the species more characteristic of shrubby areas dominated the unburned plots. "Even in severely burned plots," says Diffendorfer, "we had some species whose populations actually increased.

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The Cedar fire was so big that the researchers expected to see evidence of recolonization of burned habitat from unburned areas. "We thought that mammals would be affected by how far away unburned resources were, after the fire," says Diffendorfer. However, only a few of the rodent species showed distance effects.

There appeared to be no strong impact of the fire on the carnivores or bats at the Cleveland National Forest. The team did find that coyotes tend to occur near rural homes, regardless of the burn, but there was no correlation for any of the carnivore or bat species to the distance, severity, or presence of the fire.

Postfire vegetation trajectories are the key

"We think that even with a very severe fire, there may be enough refugia for many of the mammals to scrape by, but the trajectory of vegetation recovery will determine the mix of rodents at a site," Diffendorfer adds. "We really see that vegetation dictates the small mammal community, as has been shown in other systems."

The researchers' data suggest that with prescribed fire, which is applied to much smaller areas than the wildfires studied, there would be little effect of distance or fire severity on small mammal communities. Says Diffenforfer, "From what we can see, there is probably no potential ecological impact (of prescribed fire) on the ability of mammals to colonize burned sites."

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Given the rate of postfire vegetation succession, it is too early, however, to know whether small mammal species composition will eventually return to something resembling the prefire mammal community. In both study areas (Rancho Jamul and Cleveland National Forest), the burned plot plant species composition still differs from the unburned, creating altered habitat for small mammals. If the dominant shrubs return with time, animal species that prefer them should follow.

"Our results suggest that in southern California chaparral and coastal sage scrub habitats, fire alone does not have large effects on most mammal communities. It is fire-induced changes to vegetation that drives community composition of rodents in the longer term," says Diffendorfer. "Yes, individual coyotes, rodents, rabbits, etc. are killed or displaced during the fire. But at the community level, and at longer time scales, these short-term impacts of the burn itself are not that dramatic."

Keep native vegetation to preserve biodiversity

"The biggest concern arising from their work," says Diffendorfer, "relates to how fire frequency and severity affect the potential for invasion of sites by non-native herbaceous plant species and the impact of this change in vegetation on animal diversity." A number of other studies have found that multiple fires over a short time period can increase non-native grass abundance, while decreasing native shrub cover. Still, when it comes to making management decisions Diffendorfer says, "frequency and intervals of fire are likely more important than severity and size, because of the potential to type convert the vegetation from shrubs to grassy habitat dominated by non-natives."

This may be happening at Rancho Jamul. More non-native herbaceous plants—especially grasses—cover the site after the Otay fire, native shrub recovery is slow, and the small mammal community has simplified substantially. Diffendorfer suggests that in the coastal sage scrub at Rancho Jamul, non-native species had already invaded parts of the study site prior to the fire. Whereas—in the chaparral at the Cleveland National Forest—the recovery towards native vegetation is progressing without invasion of non-natives. This may be a result of Cleveland National Forest being a less historically disturbed site, than Rancho Jamul.

Given the results of this study and others showing responses of birds, ants, reptiles and rodents to disturbance of coastal sage scrub, the team agrees that the key message for managers in southern California has to do with maintaining intact vegetation communities. "The conservation literature in southern California has mainly focused on issues like fragmentation and edge effects, yet most of the existing and planned reserves will be large enough so these issues, though real, are reduced for many species," says Diffendorfer.

Intact coastal sage scrub community. Credit: Genie Fleming.

Invasion of herbaceous non-native plant species in a coastal sage scrub community. Credit: Genie Fleming.

More recent research, including this JFSP study, suggests that preserving native vegetation may be the key management directive for a reserve system to successfully maintain regional biodiversity. Thus, fire managers need to place prescribed burns in this larger ecological context. Essentially, prescribed burns should be considered in terms of the historic fire interval and current level of non-native invasion to better maintain the native vegetation community (either chaparral or coastal sage scrub). According to JFSP final report, "…managing fire return intervals, type conversion, and the scale of patchiness in burned, unburned, and recovering vegetation across large landscapes is more important than controlling fire size or severity."

"*If* the goal is to maintain native diversity, given the interplay between fire frequency and non-native invasion, fire *suppression* on reserves that have already burned too frequently or have high levels of invasive plants, may be warranted," Diffendorfer says.

"One potential solution," says Wayne Spencer, "is to devote the majority of fire control strategies near the wildland-urban interface and in the implementation of fire resistant building codes, while using prescribed burns in a manner that matches natural fire regimes in the backcountry and in the reserve systems."

It will take careful planning to implement successful fire management strategies in such a complex landscape.

Further Information: Publications and Web Resources

Diffendorfer, J., W. Spencer, S. Tremor, J. Beyers, G. Fleming, A. Soto, and P. Schuette. Effects of Fire Severity and Distance from Unburned Edge on Mammalian Community Post-fire Recovery. JFSP Final Report. Project ID #: 04-2-1-94.

San Diego Natural History Museum; Post-Fire Studies and Mammals (Describes the research highlighted in this Brief): http://www.sdnhm.org/research/birds/postfire/b_intro.html

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Fire in California's Ecosystems. 2007. Edited by Neil G. Sugihara, Jan W. van Wagtendonk, Kevin E. Shaffer, Jo Ann Fites-Kaufman, and Andrea E. Thode. UC Press. 596. pp.

Management Implications

- Fire affected animal species composition by shifting vegetation structure and composition. Distance to the edge and fire severity, however, appeared to have much smaller impacts.
- Managers using prescribed fire can predict what kinds of species composition will emerge post-fire, but can also understand that the size and severity of the fire will likely have little impact.
- In already-disturbed areas, managers should pay special attention to non-native herbaceous plants. Fire may foster their presence and alter the diversity of small mammal communities as well as other animals.
- Fire severity is likely less important to small mammals over the long term than fire interval because of the potential for fire interval to cause significant shifts in vegetation, which in turn affects resident small mammal populations.
- Given that even the massive wildfires described here had fairly low immediate effects on mammals overall, it is likely that prescribed fires (which are usually far less intense and smaller) may have biologically insignificant effects on mammal communities unless they contribute to increased fire-frequencies.

The San Diego Wildfires Education Project: http://interwork.sdsu.edu/fire/

San Diego State University, Web Mapping Services for San Diego 2007 Wildfires: http://map.sdsu.edu/

USGS: Western Ecological Research Center (Links to Related Information): http://www.werc.usgs.gov/fire/firerelated.html

Scientist Profile

Jay Diffendorfer is a Research Scientist at the Rocky Mountain Geographic Science Center. He was a Professor at San Diego State University and an Associate Professional Scientist at the Illinois Natural History Survey during the studies reported here. He has spent approximately 10 years working on the effects of disturbance and non-native plant invasion on animal communities in southern California landscapes.

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Results presented in JFSP Final Reports may not have been peer-reviewed and should be interpreted as tentative until published in a peer-reviewed source.

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Manager's Viewpoint
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Effects of Fire Severity and Distance from Unburned Edge on Mammalian Community Post-fire Recovery

Written By: Lara Durán

Purpose of this opinion piece

Manager's Viewpoint is an opinion piece written by a fire or land manager based on information in a JFSP final report and other supporting documents. This is our way of helping managers interpret science findings. If readers have differing viewpoints, we encourage further dialogue through additional opinions. Please contact Tim Swedberg to submit input (timothy_swedberg@nifc.blm.gov). Our intent is to start conversations about what works and what doesn't.

Problem

In 1991, only 10 percent of coastal sage scrub and chaparral habitat remained in California (Soulé et al. 1991). Peter Bowler (2000) indicates coastal sage scrub exists in isolated stands as the result of habitat loss, and many species have obligate relationships to it. Hence, structural habitat changes from large fires are relevant to conserving mammal and endemic plant populations. A more thorough understanding of the relationship fire severity has on these communities is needed to assist land managers in future management efforts.

Application by Land Managers

In 1998, Schwilk and Keeley published the results from a post fire rodent study conducted six months post fire in coastal sage scrub and chaparral. According to them, previous post-fire rodent population studies were conducted by Lawrence (1966) and others, but they were limited to small fires and unreplicated. Following the results found by Schwilk and Keeley (1998), this study attempted to test for variations in "fire severity" and "burn severity" and the corresponding effects on rodent, bat, and carnivore populations at even a larger scale. Both of these studies tested for effects on mammals associated with distance from burned edges, however, it is questionable whether either study successfully tested for the fire effects of vegetation burn severity[1] or soil burn severity.

Conflicting application of fire effects terminology is rampant in the published literature and within the lexicon of practicing land managers (Safford et al. 2008). For many land managers, including soil scientists, fire fighters, fuels specialists, botanists, silviculturists, geographic information specialists, and wildlife biologists, and especially those not intensely familiar with fire behavior and fire effects terminology, this inconsistency makes application of research findings on fire effects difficult and confusing. For consistency, "vegetation burn severity" will be used in this text to describe the degree of effects to vegetation consumed by fire.

Edge effects are important factors considered when wildlife biologists are analyzing the effects from proposed project actions. This study was able to examine the impacts created by edge effect on small mammals on a scale not studied before due to the size of the Cedar fire. The results from this study related to distance from burned edges and effects on rodents, largely duplicates previous findings at smaller scales; especially with regards to deer mouse (*Peromyscus maniculatus*) as a colonizer of disturbed sites (Schwilk and Keeley 1998, Sauvajot et al. 1998, Converse et al. 2006, M'Closkey 1972).

Schwilk and Keeley detected inconsistent variation in rodent species composition between burned and unburned sites, relative to burned edges. Deer mouse was found interior of burns and desert woodrat was found at burn edges. Other species demonstrated variations. Rodent species diversity was variable. Coastal sage scrub had the highest population sizes. They suggested this variability was due to: rapid re-colonization occurring before the study commenced, high survival rates within burns, and lightly burned sites and unburned sites as refuge sources.

Schwilk and Keeley detected inconsistent variation in rodent species composition between burned and unburned sites, relative to burned edges.

The findings about habitat structural changes on rodents are similar to those found by Sauvajot et al. They determined small mammal populations were particularly sensitive to vegetation structure changes (reduced woody cover) resulting from human disturbances. Endemic chaparral small mammals were less abundant and species composition was less diverse in disturbed sites that undisturbed sites. They concluded individual habitat preferences of species were critical factors in their response to changes in habitat structure.

To complicate interpretation of the results further, Converse et al. found deer mouse (*Peromyscus maniculatus*) densities were related to annual variations in weather patterns, drought and annual precipitation, assuming this impacts food availability. They concluded lower shrub densities and higher down woody debris increased deer population densities. M'Closkey found asynchronous temporal population fluctuations in rodent species diversity and population densities naturally occurred in coastal sage scrub over a 15-month study with deer mouse exhibiting "increased survival."

Fire's Effects on Habitat

This study is able to display the relative differences in rodent abundance, composition, and richness relative between burned and unburned areas. However, currently the study is not able to support or conclude much about the relationship between vegetation burn severity, habitat changes, and the indirect impacts to mammals. Some results were provided about pre- and post-vegetation density in relation to fire severity, but the investigators portrayed doubt. Classifying the amount of vegetation consumption (vegetation burn severity) found in this study would be a very important result for wildlife biologists, botanists, and fire managers to use when considering the effects from wildfire and determining how to minimize these impacts or rehabilitate impacted habitats.

Although fire in chaparral and coastal sage scrub is usually intense across the board, managers should note that even in these fuel types, wildfires leave a mosaic burn pattern with observable differences in vegetation burn severity, soil burn severity, and the post fire vegetation population (Sampson 1944). According to Keeley et al. (2005), vegetation fire severity was greater on

south and west aspects where incident solar radiation and inclination was observed, compared to north and east aspects, but species responded differently to vegetation fire severity. Zedler et. al. (1983) found that re-burning of chaparral and coastal sage scrub that was seeded for erosion control with annual ryegrass (*Lolium multiflorum*) caused severe changes in to vegetation composition that was predicted would persist for decades after the 1979 and 1980 fires.

Tyler (1996) found less soil heat transfer resulted in higher seedling densities, plant cover, and plant biomass than soils subjected to moderate and high levels of heat, and individual plant groups may have different mechanisms that promote large abundance of seedling establishment following fire. Safford and Harrison (2004) cautioned against "assuming that fire plays the same role or produces the same resilient responses on the nutrition-poor soils that harbor edaphic endemic species as it does on the vegetation of more typical soils."

Hence, land managers concerned about wildlife habitat, plant populations, fireline intensity, and vegetation burn severity should take field notes about aspect, inclination, radiant solar radiation, soil type, plant species composition, and non-native species present if they want to extrapolate effects from published studies to their chaparral and coastal sage scrub sites in question.

Final Thoughts

This study raises several important questions including the differences in effects on habitat and mammals between wildfires in chaparral and coastal sage scrub and prescribed fire. Though intuitive to fire managers, few studies tested the direct differences between the two. Clearly the results from this study, when fully analyzed may be of tremendous value to wildlife managers and will bridge the gap of understanding with fire managers. However, caution should be raised if managers want to extrapolate the effects from wildfire events, especially those of large fires that escape initial attack, to those of prescribed fires.

Confounding the issue of the application of these results is the question about historical fire regimes in chaparral versus the fire activity observed today. Conrad and Weise (1998) suggest chaparral fires always burned under severe hot and windy weather conditions, and little evidence exists that suggests chaparral fires are growing in size. According to Keeley (1992), chaparral habitat is altered by fire only briefly until seedlings re-establish either vegetatively, or within the first season via seed. He also found late mature chaparral sites approximately 150 years old, showed similar impacts and recovery from long absence of fire as younger mature sites suggesting chaparral is resilient to fire after long absences,

Fire Effects Methodology in Chaparral and Coastal Sage Scrub

The determination of vegetation burn severity, or the magnitude of vegetation consumed by fire, is a continuously evolving science and field manager might be wondering, what methods are appropriate for determining vegetation burn severity classification in chaparral and coastal sage scrub? Field methods developed by FIREMON are appropriate and widely used for addressing such questions, though even their classification is overlapping the differences between soil burn severity and vegetation burn severity. Remotely sensed products, such as relative Natural Burned Reflectance (RdNBR) with field verification is the most appropriate and accurate measure of vegetation consumption over large areas (Safford et al. 2008). Burned Area Emergency Response team generated soil burn severity products would not be appropriate for this kind of study (Safford et al. 2008, Miller et al. 2002).

and “fire severity impacts are indistinguishable from those in younger chaparral stands” (Keeley et al. 2005).

These findings raise the question about how wildlife biologists, fire and vegetation managers today should view today’s chaparral wildfire events and their impacts on mammal populations. Are these fires outside of historic range of variability and the effects exceeding our comfort levels? Bowler suggests mitigation and restoration of coast sage scrub is lacking in land management planning, and prescribed fire should be included in long-term planning to promote fire-adapted habitat. What Keeley (2005) poses, is that increased non-native plant richness and abundance in mature chaparral sites following fire should be more worrisome to land managers concerned with conservation than wildfire effects.

Additionally, most post fire recovery efforts commence immediately after a wildfire, and sometimes even while the fire is still active. This study did not indicate whether Burned Area Emergency Rehabilitation (BAER) management efforts were conducted on any of their research sites. If BAER work done in between the wildfire event and the start of their field research included seeding, then this could influence results found for small mammals. What would be of particular interest to wildlife biologists and fire managers, is do these types of wildfires result in a long term or temporary change of habitat for these species?

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Manager Profile

Lara Durán is a Fire Planner for the Sawtooth National Forest in Idaho. Her previous positions included Fuels Specialist, Fire Prevention, and Wildlife Technician for the U.S. Forest Service in Colorado. Lara contributed to the JFSP Risk Roundtable, Manager's Reviews, and participated in the national pilot program Integrated Landscape Design to Maximize Fuel Reduction Effectiveness.

She earned a BA in Ecology from the University of Colorado at Boulder where she earned a National Science Foundation grant for undergraduate research in alpine plant development. She was a Wildlife and Plant Ecology Research Assistant at the University of Colorado, contributing to long-term studies on ponderosa pine, Abert squirrels, dwarf mistletoe, elk, American marten, and yucca plants. Since then, she's completed graduate courses in wildlife and plant ecology, law, and administration. She is interested in disturbance ecology and the effects to wildlife.

The information for this Manager's Viewpoint is based on JFSP Project 04-2-1-94; Effects of Fire Severity and Distance from Unburned Edge on Mammalian Community Post-fire Recovery; Principal Investigators were Wayne Spencer, Jay Diffendorfer, and Scott Tremor.