

CATASTROPHIC WILDFIRE IN CALIFORNIA

THE SEARCH FOR SOLUTIONS

2020 Woodward Fire case study:

Examining the role of fire as an ecological process in a coastal California ecosystem

Maritte J. O’Gallagher, National Park Service, Golden Gate National Recreation Area

Gregory A. Jones, National Park Service, Point Reyes National Seashore

Lorraine S. Parsons, National Park Service, Point Reyes National Seashore

Dave T. Press, National Park Service, Point Reyes National Seashore

Wende E. Rehlaender, National Park Service, Point Reyes National Seashore

Stephen Skartvedt, National Park Service, Golden Gate National Recreation Area

Alison B. Forrestel, National Park Service, Golden Gate National Recreation Area

Corresponding author

Alison B. Forrestel

National Park Service, Golden Gate National Recreation Area

201 Fort Mason

San Francisco, CA 94123

alison_forrestel@nps.gov

Abstract

Of the countless fires that burned across California ecosystems during the record-breaking and destructive 2020 fire season, the Woodward Fire, which burned nearly 5,000 acres of Point Reyes National Seashore wilderness lands, stands out as one instance in which the return of fire as an ecological process to this landscape may promote positive outcomes. Here we present the ecological narrative of the Woodward Fire as an opportunity to investigate the effects of mixed-severity fire burning across a mosaic of diverse California coastal habitat types with a complex fire history. Early observations indicate that the Woodward Fire may yield net positive ecological effects across the burn area beyond just reduction of surface fuels, such as increased heterogeneity across the landscape, shifts in vegetation types, and possible appearance of rare fire-following species.

Introduction

In the western United States, wildfires are becoming more extreme due to anthropogenic climate change (Abatzoglou and Williams 2016; Holden et al. 2018; Goss et al. 2020). In California, the 2020 fire season doubled previous records in terms of acreage (California Department of Forestry and Fire Protection 2020), creating 111.7 million metric tons of carbon emissions (preliminary estimate from California Air Resources Board, 2020). As fires roared through parched vegetation, fire-fighting resources were stretched thin both in California and nationwide. Suppression costs alone were

over \$1 billion, and this figure does not capture the immeasurable damages to affected communities and ecosystems (California Department of Forestry and Fire Protection 2020; National Interagency Fire Center 2020).

The numerous fires that burned throughout California in 2020 occurred in many different ecological contexts and varied greatly in scale and severity. The Creek Fire, which burned close to 400,000 acres on the Sierra National Forest, was devastating in both its ecological and human impact, displaying

unprecedented rates of spread as it burned through forests severely affected by the 2011–2016 drought. The Castle Fire, which burned more than 150,000 acres on and around the Sequoia National Forest, killed hundreds of giant sequoias. The CZU Complex Fire burned through Big Basin State Park, destroying historic structures and severely impacting old-growth redwood groves.

The Woodward Fire, which burned close to 5,000 acres in Point Reyes National Seashore, presents a contrasting case to these destructive fires in that the ecological benefits may outweigh the costs. The Woodward Fire burned with mixed severity across a matrix of coastal habitat types that have seldom burned in recent decades but are largely fire tolerant or fire adapted. The result of the return of fire as an ecological process to the Point Reyes landscape could be a mosaic of vegetation communities more heterogeneous, resilient, and diverse than before.

Setting the stage for the Woodward Fire: Point Reyes ecology and fire regimes, then and now

Point Reyes National Seashore is located on the Point Reyes Peninsula of Northern California, where its more than 86,000 acres of wild coastal beaches, headlands, bays, estuaries, and uplands host an incredible diversity of native plant and animal species, including high levels of endemic, rare, and special status species (Myers et al. 2000; Kraft et al. 2010; Burge et al. 2016). Predominant upland vegetation types on the Point Reyes Peninsula include coastal scrub, maritime chaparral, coastal prairie, bishop pine forest, and Douglas-fir forest. Due to highly varied topography, geology, and hydrology, as well as disturbance history, the pattern of these different vegetation communities across the landscape is a mosaic of habitat types with high levels of heterogeneity over short distances and at small spatial scales (Steers et al. 2008; Wrubel and Parker 2018). Similarly, these vegetation types are temporally variable, with type changes of vegetation communities documented following disturbance from fire (Forrestel et al. 2011). The climate can be characterized as Mediterranean with cool, wet winters and dry, but often foggy, summers. There is a brief season in the late summer and fall when fuels are drier and more receptive to fire. Lightning is rare in coastal California, so few natural ignitions occur (van Wagtenonk and Cayan 2008).

The fire history of Point Reyes—and likewise its role in shaping the ecology of the region—is extremely complex. There is extensive evidence that Native Americans throughout California used fire to manage vegetation. Groups living in areas characterized by mixed grassland and scrub vegetation used fire on an annual basis to improve seed harvests and to control scrub encroachment into grasslands (Menzies 1924; Stewart 1951; Clar 1957; Lewis 1973; Keeley 2002). Early Mexican and European ranchers continued the practice of burning, but as development expanded and land-use strategies shifted in the early to middle 20th century, these frequent surface fires ceased almost entirely (Sugnet and Martin 1984; Brown, Kaye, and Buckley 1999). Fires in the modern era have been less frequent, with large fires occurring on different locations on the peninsula or surrounding areas in 1906, 1927, 1945, and 1995 (Sugnet and Martin 1984; Forrestel et al. 2011). The 1995 Vision Fire was the most recent large fire in Marin County and burned through more than 12,000 acres of Point Reyes National Seashore and destroyed 48 structures on Inverness Ridge (National Park Service 2005). Approximately 2,000 acres that burned in the Vision Fire reburned in the Woodward Fire.

The predominant upland vegetation types on the Point Reyes Peninsula range in their fire ecology from fire dependent to fire sensitive. Both bishop pine forests and maritime chaparral species exhibit fire-dependent traits. Bishop pine, which covers 5,588 acres on the Point Reyes Peninsula, primarily along the northern portion of the Inverness Ridge and in the footprint of the Vision Fire, is a fire-dependent, serotinous species. Cones are produced each year, but remain closed until they are opened by the heat of a fire. The fire regime in this forest type can be characterized as a stand replacement regime where mature trees are killed by fire, and even-aged stands regenerate post-fire (Sugnet and Martin 1984; Harvey 2011). Similarly, several species of native chaparral scrub found at Point Reyes, including some manzanita and *Ceanothus* species, are obligate seeders: their seeds only germinate after they are exposed to the heat or smoke from a wildfire. As fire burns through the parent stand, killing the adults, it stimulates a new generation of seedlings (Odion 2000; Van Dyke and Holl 2001; Forrestel et al. 2011). Several of the vegetation communities in the region are fire tolerant, with species that can re-

sprout following fire, but do not require fire in order to persist. Examples include coastal scrub species such as coyote brush, and several oak woodland and mixed evergreen forest species such as California bay, coast live oak, huckleberry. Douglas-fir forest falls at the fire-sensitive end of the spectrum; it is able to tolerate low-intensity surface fire, but moderate or high intensity fire kills individual trees relatively easily (Agee and Huff 1988; Brown et al. 1999). The matrix of these different vegetation communities across the landscape is dynamic and shifts over time in response to a variety of factors, including succession, short- and long-term climatic trends, disease, and disturbance, including wildfire (McBride and Heady 1968; Harvey et al. 2011; Forrester et al. 2011).

This complex ecological setting is the context in which the Woodward Fire burned. Although the Woodward Fire resulted from a lightning ignition in very dry fuels and rapidly spread in part due to a critical shortage of fire-fighting resources, it poses a unique opportunity to observe the effects of fire on an ecologically rich patchwork of coastal California habitats.

Woodward fire ignition, trajectory, and containment

Although relatively small fires are not uncommon in Point Reyes, the circumstances of the Woodward Fire ignition were extremely unusual for the region. Large areas of California, including the San Francisco Bay region, experienced record-breaking high temperatures during August 14–16, 2020 (National Weather Service 2020a). On August 15, the National Weather Service issued a fire weather watch, citing the combination of lightning risk due to moist, unstable air aloft, dry fuels, and hot temperatures near the surface (National Weather Service 2020b). From August 15th to 17th, thunderstorms and dry lightning swept across large portions of the state, with over 7,000 lightning strikes sparking hundreds of wildfires. Many of these fires grew to be very large at a rapid pace due to dry vegetation and thinly stretched fire-fighting resources. At Point Reyes, the unusual weather pattern had dissipated the humid marine layer and shifted the typical northwest wind to a south/southwest direction. In addition, fuel moistures were extremely low and fire danger indices had exceeded the historic maximum values recorded for that period (National Park Service 2020).

Several ignitions occurred at Point Reyes National Seashore during the August 15–17 lightning event. On the afternoon of August 17, smoke was reported near the Woodward Trail in the Phillip Burton Wilderness. Local fire resources were assigned and were able to establish a handline around a majority of the approximately five-acre fire. The following day, a second fire was discovered nearby, which was either a spot fire or a new fire resulting from a holdover lightning strike from the previous day. On the afternoon of the 18th, due to rapidly increasing fire behavior and spread and a continued shortage of fire-fighting resources, firefighters disengaged from both fires. By evening the two fires had merged and grew to approximately 700 acres. Due to the numerous fires elsewhere in the state, there were no air resources available until Thursday, August 20, by which point the fire had grown to approximately 2,000 acres. Based on the lack of available firefighting resources, the proximity of the fire to the neighboring communities, as well as the fact that the fire was burning through designated wilderness and sensitive natural and cultural resources, a Type I incident management team was ordered and took over management of the Woodward Fire on Sunday, August 23. Figure 1 shows the overall location of the fire as well as the vegetation communities within the burn perimeter.

Much of the remaining growth of the fire occurred during burn-out operations, where firefighters set back fires from established, mostly indirect, containment lines. Evacuation orders and warnings for surrounding communities were lifted on September 3, and the fire was contained on September 30 at 4,929 acres. Intermittent flare-ups and smoldering continued on the interior of the fire in concentrations of heavy fuels for several months following containment. The fire was officially declared out on January 12, 2021.

Expected consequences of a mixed-severity fire and the role of suppression impacts

Remote sensing Burned Area Reflectance Classification (BARC) data indicate that most of the area of the Woodward Fire burned with low or moderate severity (Figure 2). The majority (67%) of the fire area was mapped as “unburned or low severity,” 25% was mapped as “moderate severity,” and only 8% was mapped as “high severity.”

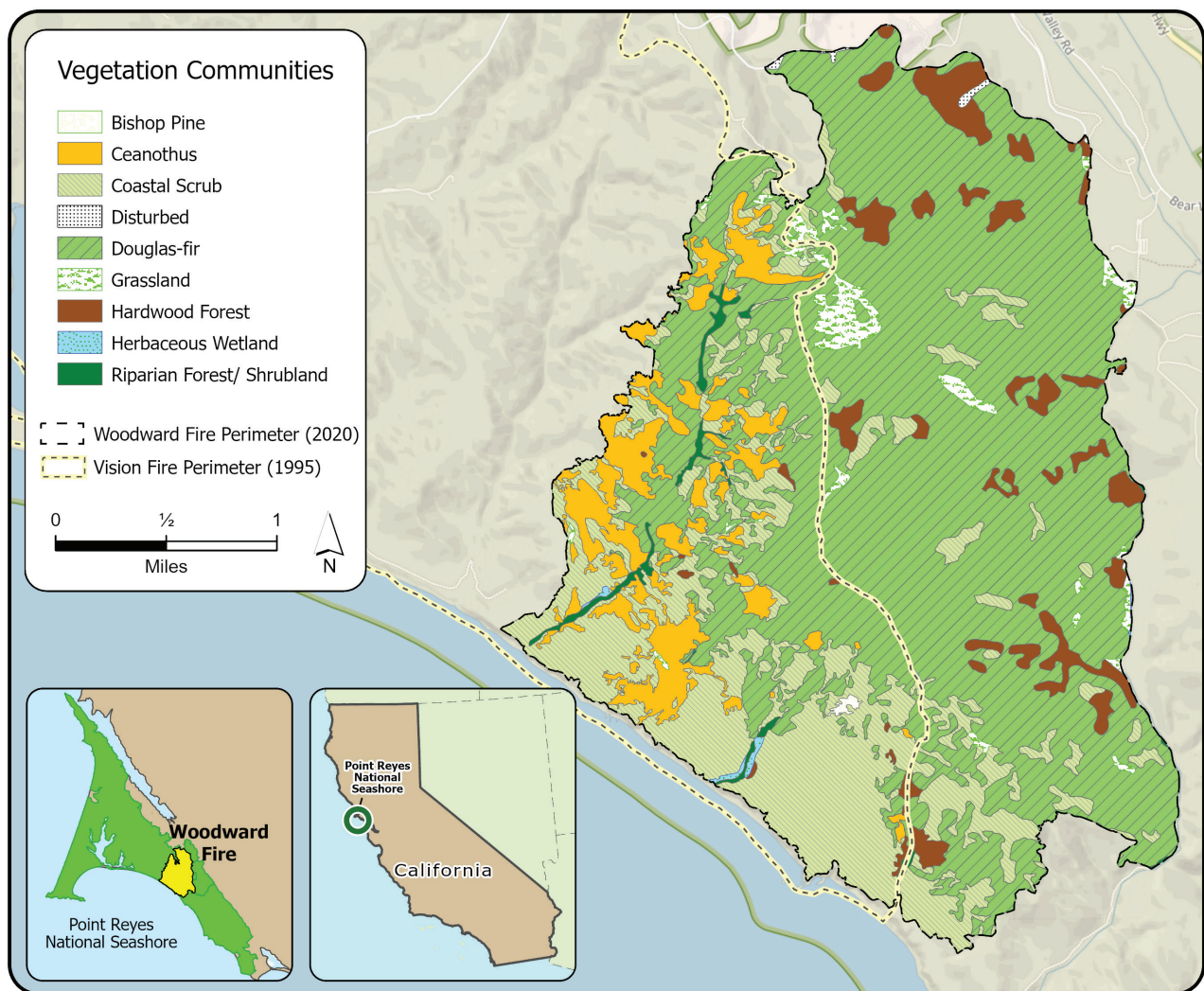


Figure 1. Woodward Fire location and vegetation communities. The Woodward Fire burned predominantly in Douglas-fir (3,059 acres), coastal scrub (1,102 acres), and *Ceanothus* (366 acres) vegetation community types.

Most of the areas that burned with the highest severity burned in the early days of the fire when it was spreading relatively rapidly. Although some areas of Douglas-fir forest burned with high severity (135 acres), most of the high-severity burning occurred in habitat characterized by coastal scrub or monodominant stands of *Ceanothus thyrsiflorus* (285 acres), which is relatively common in areas that had previously burned in the 1995 Vision Fire (Figure 3c). Coastal scrub and *C. thyrsiflorus* habitat are well adapted to high-severity fire and are expected to regenerate quickly either from re-sprouting (coastal scrub) or obligate-seeder germination (*C. thyrsiflorus*). However, early indications are that regeneration is not occurring in *C. thyrsiflorus* stands, perhaps due to inadequate germination cues. Park managers will be watching to see if germination

occurs later in the spring of 2021 or in the second year post-fire, which has been documented in other *Ceanothus* species (Keeley and Keeley 1981). Areas of Douglas-fir that burned with high or even moderate severity have experienced significant overstory mortality. Based on similar areas that burned in the 1995 Vision Fire, some of these areas may eventually regenerate as new Douglas-fir forests, but many of them will likely shift to coastal scrub or perhaps even trigger germination of a previously dormant seedbank of chaparral species such as *C. thyrsiflorus* or manzanita (Forrestel et al. 2011).

The most significant wildlife impacts also likely occurred in the high-severity areas. During the 1995 Vision Fire, significant mortality of Point Reyes mountain beaver likely occurred (Fellers 2004).

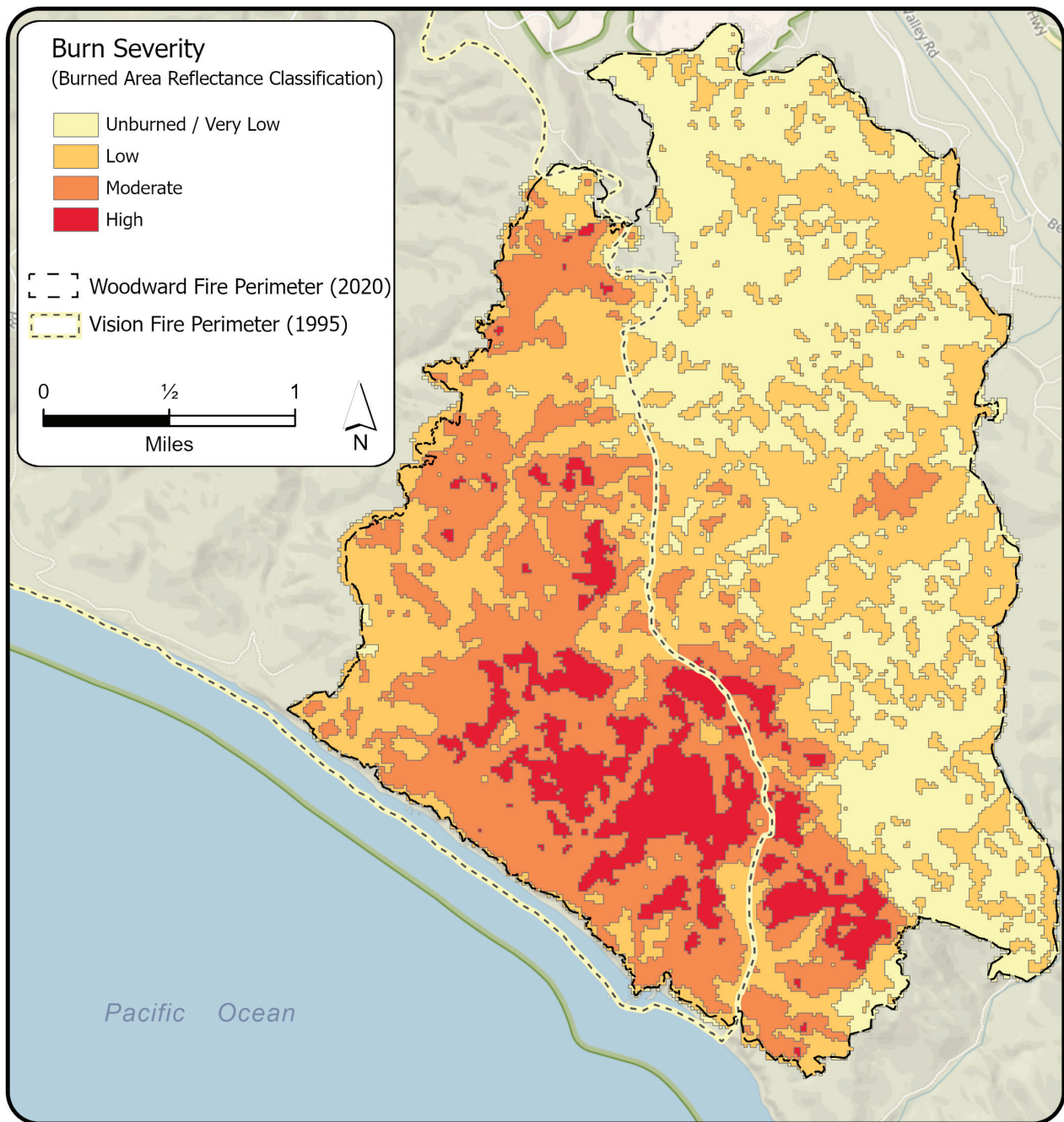


Figure 2. Woodward Fire burn severity. Burn severity was mapped from Burned Area Reflectance Classification Data as “high” (424 acres), “moderate” (1,230 acres), “low” (1,871 acres), and “unburned/very low” (1,486 acres).

Mountain beaver distribution, populations, and ecology are not well understood, but it is likely that additional mortality occurred in the Woodward Fire. The Woodward Fire also burned through several spotted owl territories. There were no known direct effects of the fire on northern spotted owl individuals, with the fire occurring outside of nesting season and burning with low or moderate severity in owl

habitat. However, the long-term and indirect effects of the fire on northern spotted owls remain to be seen. Previous research in other portions of northern spotted owl and related species’ ranges indicates the possibility of beneficial (e.g. Kramer et al. 2020), neutral (e.g. Rockweit et al. 2017), or harmful long-term impacts of fire (e.g. Jones et al. 2016). Biologists will be monitoring both the northern spotted owl

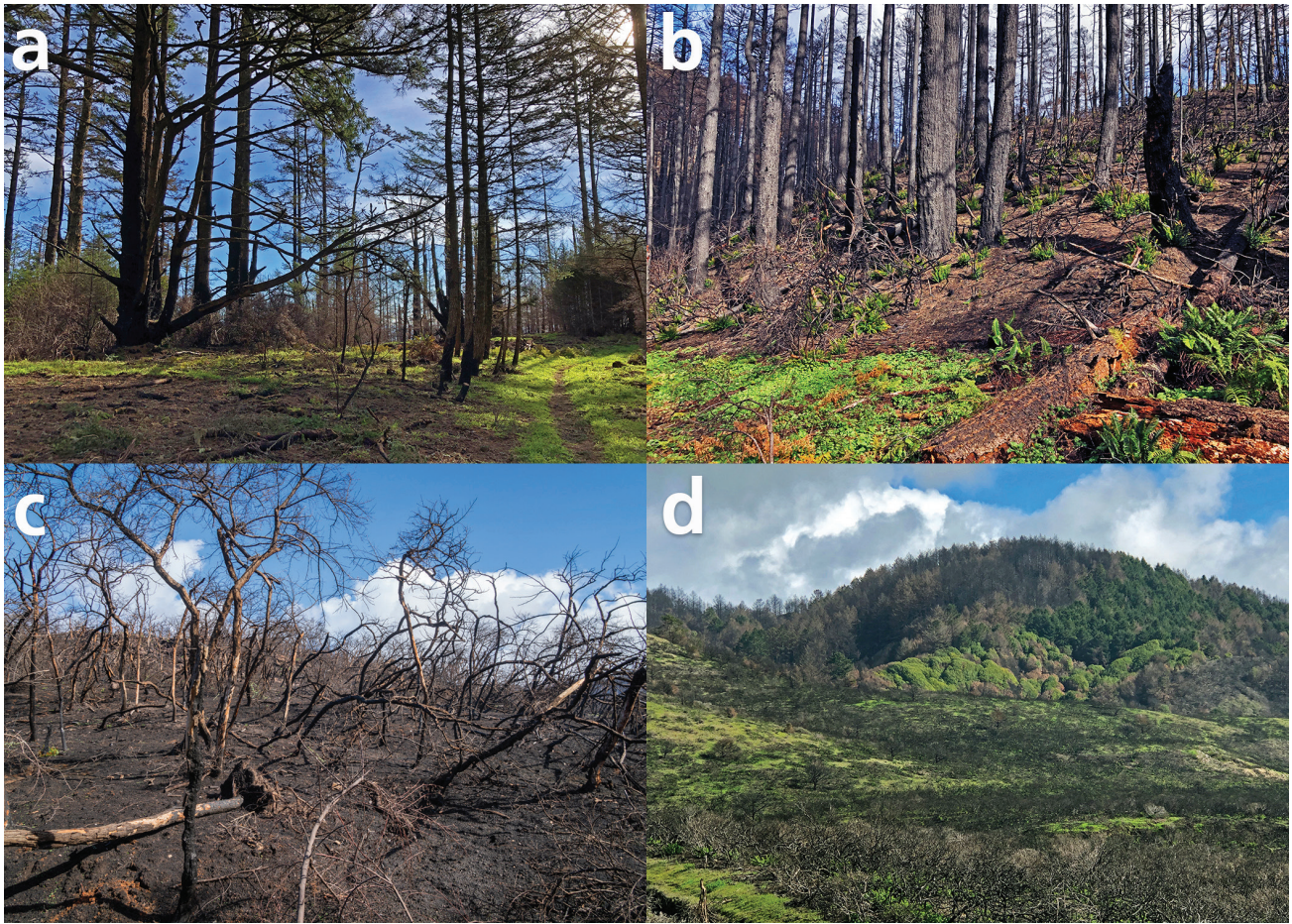


Figure 3. Different levels of fire severity affected various plant communities across the landscape.

(a) Low severity, Douglas-fir forest | ALISON FORRESTEL / NATIONAL PARK SERVICE

(b) Moderate severity, Douglas-fir forest | ALISON FORRESTEL / NATIONAL PARK SERVICE

(c) High severity, *Ceanothus* scrub | MARITTE O'GALLAGHER / NATIONAL PARK SERVICE

(d) Heterogeneous patchwork of plant communities burned with varying fire severity | ALISON FORRESTEL / NATIONAL PARK SERVICE

and mountain beaver populations following the fire, including collaboration with US Forest Service scientists on a rangewide demography study for northern spotted owls involving installation of automatic recording units (ARUs) throughout the burn footprint and other areas of the species' habitat in the region.

A large portion of the fire burned with low or moderate severity, particularly after the initial days of rapid spread and during burn-out operations. This counters the narrative that burn-out operations result in high severity patches, and is likely due to both the moderating weather conditions during the later portion of the fire and the presence of heavy fuels with ample shading. In these low-severity burn areas, fire crept through the ground cover with very little damage to the secondary canopy (primarily

oaks and bay trees) and almost no impact to the upper canopy (primarily Douglas-fir; Figure 3a). This means that these areas will remain shaded enough to provide valuable moisture retention and cover for wildlife habitat, but that the fire effectively reduced understory and surface fuels. Re-growth is already beginning, with ferns and huckleberry re-sprouting (Figure 3b). Because cover is still present in these areas and signs of regeneration are apparent, ecologists do not expect significant shifts in vegetation or wildlife activity in the low-severity burn areas.

In addition to the direct effects of the fire on the landscape, fire suppression efforts also had a large role in the overall ecological impact of the Woodward Fire. The policy at Point Reyes National Seashore is to suppress all unplanned ignitions due

to the relatively small size of the park and the close proximity of homes and infrastructure (National Park Service 2004). The Woodward Fire was burning within a few miles of the communities of Olema and Inverness Park, as well as neighborhoods on Inverness Ridge that were previously impacted by the Vision Fire. Because of this park policy and the location of the Woodward Fire, the fire was actively suppressed, in spite of the wilderness location and potential for ecological benefits. As part of the suppression efforts, 8.5 miles of bulldozer line were constructed, much in designated wilderness, 7.5 miles of handline were constructed, and more than 50,000 gallons of fire retardant were dropped across the landscape (National Park Service 2020).

Park ecologists and resource advisors worked closely with the incident management teams to minimize the ecological impacts of these suppression actions. Bulldozer lines were kept to the minimum effective width (generally this was two blades wide; approximately 15–20 feet) and were located, when possible, in the same locations as bulldozer lines that had been installed as part of the Vision Fire suppression effort. The team avoided fire retardant drops over riparian areas in order to prevent harm to aquatic species. Resource advisors worked with incident management staff to avoid the spread of invasive species and impacts to rare species. Although park staff carefully rehabilitated bulldozer lines and handlines after the fire, long-term efforts to control invasive plant species in the fire footprint will be required (Drake 2020). The spread of post-fire invasive species is of particular concern, especially around bulldozer lines, retardant drop sites, and in areas that burned with higher severity. The predominant invasive plant species documented within the burn area prior to the fire are jubata grass, panic veldt grass, and ox-eye daisy. Park staff have already begun developing monitoring plans for post-fire recovery and invasive plant management.

Ecologists expect most of the vegetation communities burned in the Woodward Fire to regenerate well. This expectation is based on the effects observed following the 1995 Vision Fire, the careful management of suppression impacts, and the overall mixed severity of the Woodward Fire. Post-fire re-growth will likely be characterized by increased heterogeneity across the landscape, shifts in vegetation types, and possible appearance of

rare fire-following species (such as *Arctostaphylos virgata*, *Ceanothus masonii*, or *Crocianthemum scoparium*) as well as reduced fuel loading. The Woodward Fire presented an opportunity to return the important ecological process of fire to the Point Reyes landscape—something that likely would not have been otherwise possible through prescribed burning given the extensive wildland-urban interface surrounding the park. However, the full ecological effects of the fire remain unknown and many factors affect how the area will recover, including weather in the few seasons immediately post-fire, availability of seed sources, and the impacts of invasive species. In particular, the 2021 water year to date has been unusually dry, with Marin County receiving less than 40% of average rainfall (Marin Municipal Water District 2021). This may have a negative impact on the trajectory of vegetation regeneration.

Conclusions

The Woodward Fire provides a unique opportunity to better understand the impacts of fire in a region where it has been relatively infrequent since the cessation of Native American burning, and provides a valuable counterpoint to the ecological devastation seen from many of the other fires that burned throughout California during 2020. Early observations indicate that minimizing damage from suppression efforts, along with the fact that the Woodward was a mixed-severity fire, may yield net positive ecological effects across the burn area. However, the post-fire trajectory remains unknown and new lessons from the Woodward Fire will surely be learned over the coming years. Much of the literature on climate change and vegetation shifts in California predicts that major climate-related shifts may occur after disturbances such as those from wildfires (Millar and Stephenson 2015; Harvey et al. 2016; Coop et al. 2020). The ecosystems of Point Reyes National Seashore are incredibly dynamic post-fire, but it remains to be seen if deleterious shifts, such as a failure of vegetation regeneration, a loss of sensitive species or habitats, or a shift towards non-native invasive species will occur.

With the complexities of climate change, longer fire seasons, and more frequent and larger fires on the horizon (Goss et al. 2020), lessons already learned from the Woodward fire have inspired managers to consider the role fire can safely play in stewarding some of California's last remaining native coastal

habitats. The challenge remains of how to balance the potential ecological benefits of fire with the political realities of managing wildlands in close proximity to residential communities and urban development.

References

- Abatzoglou, J.T., and A.P. Williams. 2016. Impact of anthropogenic climate change on wildfire across western US forests. *Proceedings of the National Academy of Sciences of the United States of America* 113: 11770–11775. <https://doi.org/10.1073/pnas.1607171113>
- Agee, J.K., and M.H. Huff. 1980. First year ecological effects of the Hoh Fire, Olympic Mountains, Washington. In *Proceedings, Sixth Conference on Fire and Forest Meteorology, April 22–24, 1980*. Washington, DC: Society of American Foresters.
- Avery, C. 2009. *Tomales Bay Environmental History and Historic Resource Study: Point Reyes National Seashore*. San Francisco: National Park Service, Pacific West Region.
- Brown, P., M.W. Kaye, and D. Buckley. 1999. Fire history in Douglas-fir and coast redwood forests at Point Reyes National Seashore, California. *Northwest Science* 73(3): 205–216. <http://hdl.handle.net/2376/1149>
- Burge, D.O., J.H. Thorne, S.P. Harrison, B.C. O'Brien, J.P. Rebman, J.R. Shevock, E.R. Alverson, L.K. Hardison, J.D. Rodriguez, S.A. Junak, T.A. Oberbauer, H. Riemann, S.E. Vanderplank, and T. Barry 2016. Plant diversity and endemism in the California Floristic Province. *Madroño* 63(2): 3–206. <https://doi.org/10.3120/madr-63-02-3-206.1>
- California Air Resources Board. 2020. California wildfire emission estimates. <https://ww2.arb.ca.gov/wildfire-emissions> (accessed February 18, 2021).
- California Department of Forestry and Fire Protection. 2020. Suppression costs. <https://www.fire.ca.gov/stats-events/> (accessed February 23, 2021)
- Clar, C. 1957. *Forest Use in Spanish-Mexican California*. Sacramento: Division of Forestry, Department of Natural Resources, State of California. <http://ccd.claremont.edu/cdm/ref/collection/cwd/id/13975>
- Coop, J.D., S.A. Parks, C.S. Stevens-Rumann, S.D. Crausbay, P.E. Higuera, M.D. Hurteau, A. Tepley, E. Whitman, T. Assal, B.M. Collins, K.T. Davis, S. Dobrowski, D.A. Falk, P.J. Fornwalt, P.Z. Fulé, B.J. Harvey, V.R. Kane, C.E. Littlefield, E.Q. Margolis, M. North, M.a. Parisien, S. Prichard, K.C. Rodman 2020. Wildfire-driven forest conversion in western North American landscapes. *BioScience* 70(8): 659–673. <https://doi.org/10.1093/biosci/biaa061>
- Drake, C. 2020. *Woodward Fire Suppression Repair Plan*. Point Reyes Station, CA: National Park Service, Point Reyes National Seashore.
- Fellers, G.M., D. Pratt, and J.L. Griffin. 2004. Fire effects on the Point Reyes mountain beaver at Point Reyes National Seashore, California. *Journal of Wildlife Management* 68(3): 503–508. [https://doi.org/10.2193/0022-541X\(2004\)068\[0503:FEOTPR\]2.0.CO;2](https://doi.org/10.2193/0022-541X(2004)068[0503:FEOTPR]2.0.CO;2)
- Forrestel, A.B., M.A. Moritz, and S.L. Stephens. 2011. Landscape-scale vegetation change following fire in Point Reyes, California, USA. *Fire Ecology* 7: 114–128. <https://doi.org/10.4996/fireecology.0702114>
- Goss, M., D.L. Swain, J.T. Abatzoglou, A. Sarhadi, C.A. Kolden, A.P. Williams, and N.S. Diffenbaugh. 2020. Climate change is increasing the likelihood of extreme autumn wildfire conditions across California. *Environmental Research Letters* 15(9). <https://doi.org/10.1088/1748-9326/ab83a7>
- Harvey, B.J., D.C. Donato, and M.G. Turner. 2016. High and dry: Post-fire tree seedling establishment in subalpine forests decreases with post-fire drought and large stand-replacing burn patches. *Global Ecology and Biogeography* 25: 655–669. <https://doi.org/10.1111/geb.12443>
- Harvey, B.J., B.A. Holzman, and J.D. Davis. 2011. Spatial variability in stand structure and density-dependent mortality in newly established post-fire stands of a California closed-cone pine forest. *Forest Ecology and Management* 262: 2042–2051. <https://doi.org/10.1016/j.foreco.2011.08.045>
- Holden, Z.A., A. Swanson, C.H. Luce, W.M. Jolly, M. Maneta, J.W. Oyler, D.A. Warren, R. Parsons, and D.

- Affleck. 2018. Decreasing fire season precipitation increased recent western US forest wildfire activity. *Proceedings of the National Academy of Sciences of the United States of America* 115(36): E8349–E8357. <https://doi.org/10.1073/pnas.1802316115>
- Jolly, W.M., M.A. Cochrane, P.H. Freeborn, Z.A. Holden, T.J. Brown, G.J. Williamson, and D.M.J.S. Bowman. 2015. Climate-induced variations in global wildfire danger from 1979 to 2013. *Nature Communications* 6: 7537. <https://doi.org/10.1038/ncomms8537>
- Jones, G.M., R. Gutiérrez, D.J. Tempel, S.A. Whitmore, W.J. Berigan, and M.Z. Peery. 2016. “Megafires: an emerging threat to old-forest species.” *Frontiers in Ecology and the Environment* 14(6): 300–306. <https://doi.org/10.1002/fee.1298>
- Keeley, J.E., and S.C. Keeley. 1981. Post-fire regeneration of Southern California chaparral. *American Journal of Botany* 68(4): 524–530. <https://doi.org/10.2307/2443028>
- Keeley, J.E. 2002. Native American impacts on fire regimes of the California Coast Ranges. *Journal of Biogeography* 29: 303–320. <https://doi.org/10.1046/j.1365-2699.2002.00676.x>
- Kraft, N.J.B., B.G. Baldwin, and D.D. Ackerly. 2010. Range size, taxon age and hotspots of neoendemism in the California flora. *Diversity and Distributions* 16: 403–413. <https://doi.org/10.1111/j.1472-4642.2010.00640.x>
- Kramer, A., G.M. Jones, S.A. Whitmore, J.J. Keane, F.A. Atuo, B.P. Dotters, S.C. Sawyer, S.L. Stock, R.J. Gutiérrez, and M.Z. Peery. 2021. California spotted owl habitat selection in a fire-managed landscape suggests conservation benefit of restoring historical fire regimes. *Forest Ecology and Management* 479: 1–12. <https://doi.org/10.1016/j.foreco.2020.118576>
- Lewis, H. 1973. *Patterns of Indian Burning in California: Ecology and Ethnohistory*. Ramona, CA: Ballena Press.
- Marin Municipal Water District. 2021. Water Watch (February 21). <https://www.marinwater.org/watch> (accessed May 10, 2021).
- McBride, J., and H. Heady. 1968. Invasion of grassland by *Baccharis pilularis* DC. *Journal of Range Management* 21: 106–108. <https://www.jstor.org/stable/4218292>
- Menzies, A. 1924. California journal excerpts. *California Historical Society Quarterly* 2(4): 302.
- Millar, C.I., and N.L. Stephenson. 2015. Temperate forest health in an era of emerging megadisturbance. *Science* 349(6250): 823–826. <https://doi.org/10.1126/science.aaa9933>
- Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403(6772): 853–858. <https://doi.org/10.1038/35002501>
- National Interagency Fire Center. 2020. National Large Incident Year-to-Date Report. *Geographic Area Coordination Center (Report)*. Boise, ID: National Interagency Fire Center.
- National Park Service. 2004. *Vision Fire: Lessons Learned from the October 1995 Fire*. Point Reyes Station, CA: National Park Service, Point Reyes National Seashore.
- National Park Service. 2005. *Final Fire Management Plan Environmental Impact Statement: Point Reyes National Seashore and North District of Golden Gate National Recreation Area*. Point Reyes Station, CA: National Park Service, Point Reyes National Seashore.
- National Park Service. 2020. *Emergency Stabilization & Rehabilitation Plan, Woodward Fire, Point Reyes National Seashore*. Point Reyes Station, CA: National Park Service, Point Reyes National Seashore.
- National Weather Service. 2020a. Record event report. August 15. <https://mesonet.agron.iastate.edu/> (accessed September 8, 2020)
- National Weather Service. 2020b. Urgent fire weather message. August 15. <https://mesonet.agron.iastate.edu/> (accessed September 8, 2020)
- Odion, D. 2000. Seed banks of long-unburned stands of maritime chaparral: Composition, germination behavior, and survival with fire. *Madroño* 47(3): 195–203.

Rockweit, J.T., A.B. Franklin, and P.C. Carlson. 2017. Differential impacts of wildfire on the population dynamics of an old-forest species. *Ecology* 98: 1574–1582. <https://doi.org/10.1002/ecy.1805>

Steers, R.J., M. Curto, and V.L. Holland. 2008. Local scale vegetation mapping and ecotone analysis in the southern Coast Range, California. *Madroño* 55: 26–40. [https://doi.org/10.3120/0024-9637\(2008\)55\[26:LSVMAE\]2.0.CO;2](https://doi.org/10.3120/0024-9637(2008)55[26:LSVMAE]2.0.CO;2)

Stewart, O. 1951. Burning and natural vegetation in the United States. *Geographical Review* 41: 317–320. <https://doi.org/10.2307/211026>

Sugnet, P., and R. Martin. 1984. *Fire History and Post-Fire Stand Dynamics of the Inverness Bishop Pine at Point Reyes National Seashore*. Berkeley, CA, University of California, Berkeley.

Syphard, A.D., T.J. Brennan, and J.E. Keeley. 2014. The role of defensible space for residential structure protection during wildfire. *International Journal of Wildland Fire* 23(8): 1165–1175. <https://doi.org/10.1071/WF13158>

Van Dyke, E., and K. Holl. 2001. Maritime chaparral community transition in the absence of fire. *Madroño* 48(4): 221–229.

van Wageningen, J.W., and D.R. Cayan. 2008. Temporal and spatial distribution of lightning strikes in California in relation to large-scale weather patterns. *Fire Ecology* 4(1): 34–56. <https://doi.org/10.4996/fireecology.0401034>

Wrubel, E., and V.T. Parker. 2018. Local patterns of diversity in California northern coastal scrub. *Ecology and Evolution* 8(15): 7250–7260. <https://doi.org/10.1002/ece3.4104>



Citation for this article

O’Gallagher, Maritte J., Gregory A. Jones, Lorraine S. Parsons, Dave T. Press, Wende E. Rehlaender, Stephen Skartvedt, and Alison B. Forrestel. 2021. 2020 Woodward Fire case study: Examining the role of fire as an ecological process in a coastal California ecosystem. *Parks Stewardship Forum* 37(2): 331–340.

Parks Stewardship Forum explores innovative thinking and offers enduring perspectives on critical issues of place-based heritage management and stewardship. Interdisciplinary in nature, the journal gathers insights from all fields related to parks, protected areas, cultural sites, and other place-based forms of conservation. The scope of the journal is international. It is dedicated to the legacy of [George Meléndez Wright](#), a graduate of UC Berkeley and pioneer in conservation of national parks.

Parks Stewardship Forum is published online at <https://escholarship.org/uc/psf> through [eScholarship](#), an open-access publishing platform subsidized by the University of California and managed by the California Digital Library. Open-access publishing serves the missions of the IPPB and GWS to share, freely and broadly, research and knowledge produced by and for those who manage parks, protected areas, and cultural sites throughout the world. A version of *Parks Stewardship Forum* designed for online reading is also available at <https://parks.berkeley.edu/psf>.

Parks Stewardship Forum is distributed under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0).

The journal continues *The George Wright Forum*, published 1981–2018 by the George Wright Society.

PSF is designed by Laurie Frasier • lauriefrasier.com



On the cover of this issue

A montage of images from [One Tam](#), a collaborative partnership to manage the landscape of Mount Tamalpais in California, along with one from Alcatraz Island in Golden Gate National Recreation Area.

TOP: RAY LEE / RAY LEE PHOTOGRAPHY
SECOND ROW: LEE JESTER; VIVIEN KIM THORP / GOLDEN GATE PARKS CONSERVANCY;
PAUL MYERS / GOLDEN GATE PARKS CONSERVANCY
THIRD ROW: PAUL MYERS / GOLDEN GATE PARKS CONSERVANCY (BOTH PHOTOS)
BOTTOM: RYAN CURRAN WHITE / GOLDEN GATE PARKS CONSERVANCY
COVER LAYOUT: GARY E. DAVIS & DOROTHY A. DAVIS