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Managing California Black Oak for Tribal Ecocultural Restoration

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Many tribes in California and Oregon value California black oak (*Quercus kelloggii*) as a traditional source of food and other values. Over centuries or millennia, Native Americans learned that they could enhance production of desired resources by regularly igniting low-intensity surface fires in stands of black oak. Although black oak is likely to remain widespread in the future, a warming climate, increasingly dense forests, and altered fire regimes threaten the large, full-crowned mature trees that produce crops of high-quality acorns and provide cavities for many wildlife species. To examine the effects of different kinds of burns on tribal values including associated plants, fungi, and wildlife of special cultural significance, we reviewed and synthesized scientific studies of black oak in conjunction with interviews and workshops with tribal members who use the species and recall burning by their ancestors. We conducted two exploratory analyses to understand trends in large black oaks and potential tradeoffs regarding black oak restoration. Our findings identify opportunities for reintroducing low-intensity fire, in conjunction with thinning, to restore stands that are favorable for acorn gathering. We present examples of such projects and discuss how to overcome challenges in restoring the socioecological benefits of black oak ecosystems for tribes.

Keywords: ecosystem services, forest planning, cultural burning, traditional ecological knowledge, landscape restoration

California black oak (*Quercus kelloggii*, hereafter called simply "black oak") provides acorns, a traditional staple that remains a cherished food for tribes in California and Oregon. Black oak was the preferred species among many tribes with access to its acorns, and second only to its distant relative, the tanoak (*Notholithocarpus densiflorus*), for many others (Figure 1). Acorns have had an important role in cultural transmission and rituals, including dances, festivals, and ceremonies. Because of such significance, black oak qualifies as a "cultural keystone" species (Garibaldi and Turner 2004, Long et al. 2016).

Black oaks directly or indirectly support many animals that Native Americans valued for many reasons, including their utility in preparing food, regalia, baskets, and other goods. Examples include deer (*Odocoileus hemionus*); birds such acorn woodpecker (*Melanerpes formicivorus*), pileated woodpecker (*Dryocopus pileatus*), mountain quail (*Oreortyx pictus*), and band-tailed pigeon (*Patagioenas fasciata*) (Gleeson et al. 2012); and many predators that consumed acorn-eating birds and small mammals, including fisher (*Pekania pennanti*, an omnivorous mammal in the weasel family) and spotted owl (*Strix occidentalis*) (Long et al. 2016).

Native Americans actively managed oak stands for centuries or millennia, with families gathering and storing thousands of pounds of acorns (Anderson 2005). These oak stands occurred both within open oak woodlands and within conifer-dominated forests. Indigenous people had learned that igniting low-intensity fires regularly within oak stands not only facilitated acorn collection but also stimulated production of acorns, berries, and other foods, controlled populations of insects that consumed acorns, and did not damage to mature oaks (Jack 1916, Anderson 2006). Their practices maintained more open and heterogeneous stands with low fuel levels, which in turn stimulated understory diversity and increased resilience of the remaining trees to drought and fire (Underwood et al. 2003, Long et al. 2016).

Today, black oak remains widely distributed across California and into southern Oregon, with even a small population re-

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ported from Baja California, Mexico (Long et al. 2016). Oaks may fare better than many other kinds of trees under a hotter and drier future climate (McIntyre et al. 2015). Despite their adaptability, the species is vulnerable to localized extirpations after severe drought or wildfires in drier, more southerly areas, as well as to the introduced sudden oak death pathogen (*Phytophthora ramorum*) in the more humid, northwestern part of its range (Frankel and Palmieri 2014, Long et al. 2016). Moreover, tribal members are particularly concerned about the ecological services provided by mature black oaks, rather than the simple abundance of the species.

We synthesized findings from scientific studies of black oak and traditional ecological knowledge (TEK) from tribal members who have interest in gathering acorns and other values associated with the species. Our objective was to understand how treatments promote conditions desired by tribal members who value black oak and associated wildlife, plants, and fungi. In this article, we characterize desired conditions from the scale of individual acorns to large landscapes, examine concerns over current conditions, and present an approach for targeting restoration treatments. Finally, we provide examples of ongoing collaborations between national forests and tribes in restoring black oak systems.

Sidebar: Glossary of Technical Terminology

Cultural keystone—Species that significantly shape the cultural identity of a people, as reflected in diet, materials, medicine, and/or spiritual practice.

Cultural ecosystem services—"The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (Millennium Ecosystem Assessment 2005).

Epicormic branches—Shoots that arise from adventitious or dormant buds on the stem or branch of a woody plant, often after fire or increases in sunlight.

Heartrot—Rotting of the bole and large limbs of living trees by fungal pathogens.

Top-kill—Aboveground portion of plant is killed while the belowground portion survives and is able to sprout. Alternative postfire outcomes for black oaks include having no damage, resprouting from their crowns, or being entirely killed.

Traditional ecological knowledge (TEK)—"A cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes et al. 2000).

Threats to Tribal Values Associated with Black Oak

Although large black oaks have thick bark that protects them from low-intensity burns, intense fires often kill the aboveground stems. However, the trees typically resprout after such "top-kill" events. Researchers have described fire both as the "worst enemy" of black oak (McDonald 1969) and as a "blessing" by completely killing competing conifers that cannot resprout (McDonald and Tappeiner 2002). Mature black oaks are shade intolerant, so as conifers overtake them in the overstory, black oaks can become stunted due to reduced light, as well as more vulnerable to fire as ground and ladder fuels accumulate (Cocking et al. 2012b).

Most tribes in the Sierra Nevada depend on access to national forests to gather traditional resources because they have been dispossessed of their ancestral forestlands. Colonization and settlement by Europeans and Euro-Americans decimated both indigenous populations and lifeways, including long-standing relationships with forests, through a myriad of violent acts and policies recognized as genocide by descendants and academic researchers (Fenelon and Trafzer 2014, Norgaard 2014). Native Americans who survived that era and the continuing legacies of dispossession and cultural assimilation have embarked on a cultural resurgence, including strengthening their food sovereignty by renewing their relationships to traditional foods (Conti 2006, Turner and Turner 2007, Adamson 2011). However, many tribes have insufficient land bases to tend or restore culturally significant plant species and communities. Many tribal gatherers contend that because of limited access, lack of fire, and forest densification, they have limited opportunities for gathering high-quality black oak acorns, as well as understory plants and mushrooms that are important for maintaining traditional diets and practices (Anderson and Lake 2013).

TEK is cultivated through practice that builds and maintains relationships between people and place. The lack of sufficient opportunities to gather acorns and continue other traditions threatens not only material benefits but also important values including spiritual, religious, cultural heritage, social, sense of place, and educational values (Norgaard 2014), which collectively have been described as "cultural ecosystem services" (Daniel et al. 2012). The federal government is actively working toward fully integrating such ecosystem services into agency decisions (Schaefer et al. 2015). Tribal groups in particular have promoted the concept of "ecocultural restoration" that emphasizes the inextricable connections among ecological and cultural values held by indigenous peoples (Higgs 2005, Burger et al. 2008).

Management and Policy Implications

Wildfires and forest densification threaten the large California black oaks that produce acorns valued by tribes for food and social well-being. Tribal members identified desired conditions including large black oaks with full crowns and low branches that produce abundant acorns free from pests and a relatively open ground surface with diverse plant communities and edible fungi near the oak trees. Tribal knowledge of using frequent, low-intensity fires and other traditional tending and gathering practices can advance strategies for promoting these conditions. Active treatments that remove competing conifer trees, reduce fuels, and reintroduce low-intensity fire are needed to support tribal values associated with gathering acorns and other plant resources associated with black oak stands. Targeting stands with large black oaks in gently sloped areas close to roads would promote tribal access while reducing the likelihood of adversely affecting sensitive wildlife such as spotted owls and fishers. Forest management plans can build on recent efforts to work with tribes in developing monitoring, forest thinning, and fire management activities to promote black oaks.

Figure 1. Preferences for acorns from California black oak among tribal language groups. (From Long et al. 2016.)

Priority Areas for Black Oak Ecocultural Restoration

One strategy to strengthen relationships between tribal communities and their ancestral lands is to reinitiate tending and gathering within black oak stands on national forests to reinforce their physical, cultural, and spiritual connections. Native American archaeological sites in the southern Sierra Nevada landscape are strongly associated with black oak stands below average snowline (4,600 ft) (Hunt 2004), but acorns were also gathered and cached at higher elevations to facilitate summer gathering and trading forays for a variety of resources (Morgan 2008). Generating maps of potential priority sites for promoting abundant acorn crops is an important step to facilitate such efforts. Using geographic information systems (GIS) to map forest resources with participation of community members can

help to include TEK in forest planning, improve decisionmaking, reduce unintended consequences, and better manage conflicts (Daniel et al. 2012). Comparing depictions based on TEK and conventional ecological data sets within a GIS can reveal tensions and opportunities for alignment among land managers and members of indigenous communities (Robbins 2003).

Methods

Researchers from the US Department of Agriculture (USDA) Forest Service and the USDA Natural Resources Conservation Service (NRCS), the Chair of the North Fork Mono Tribe, and managers from the Sierra National Forest held meetings with members of several tribes located near North Fork, California, in 2013 and 2015 to discuss black oak restoration and management, including visits to active restoration sites. Several of the participants developed a report that integrated findings from those workshops, agency reports, and research publications (Long et al. 2016). We reviewed literature featured in syntheses on black oak (McDonald 1969, 1990), Native American forest management (Anderson 2005), socioecological restoration for forests of the Sierra Nevada and southern Cascade Range (Long et al. 2014), and the proceedings of a recent symposium on oak management in California (Standiford and Purcell 2015). Because tribal practitioners and managers described several dynamics based on traditional and local ecological knowledge, we searched for scientific literature relevant to those particular topics using Google Scholar. Two Native American students joined our effort; they conducted several semistructured interviews with some tribal members in the North Fork area who workshop participants suggested as being knowledgeable of black oak systems, and they attended public meetings held by the Sierra and Sequoia National Forests to address tribal issues in forest planning. Our research centered on Western Mono ancestral territory in the central Sierra Nevada, but we considered findings and consulted tribal practitioners from other regions, particularly parts of northern California. Although we did not have the resources to explore tribal traditional management practices across the full range of the species, we would expect those traditions to represent variations around the themes in central California.

Exploratory Analyses

We conducted two exploratory analyses to help evaluate need and opportunities for restoring black oak. First, we evaluated trends in black oak basal area using data collected following standardized methods in permanent field plots spaced at about 3-mile intervals across US forests by the Forest Inventory and Analysis (FIA) branch of the USDA Forest Service (Christensen et al. 2016). We used data from 420 plots across the range of black oak in California and Oregon that were located on national forests, sampled initially between 2000 and 2006 and remeasured between 2006 and 2014. We evaluated changes in black oak basal area between the two periods within several size classes and compared results from plots that were either affected or unaffected by fire. We calculated means and variances using double sampling for poststratification (Scott et al. 2005) and tested for differences based on the Z statistic.

Second, we generated a map of potentially desirable areas for gathering acorns using GIS software (ArcMap 10.1) to analyze data sets for vegetation (CALVEG) (USDA Forest Service 2004), slopes (using a 330-ft digital elevation model), and system roads on the Sierra National Forest (USDA Forest Service 2015). Based on our reviews and interviews, we considered several ecological criteria to identify potential priority stands. The first criterion was whether black oak was the dominant overstory tree ("Regional Dominance type 1") or a subdominant tree underneath a conifer overstory in a mixed forest ("Regional Dominance type 2"). The vegetation data set classified those types based on relative overstory cover in aerial imagery between 2000 and 2008. Second, we considered only stands with the quadratic mean dbh greater than 5 in., which McDonald (1990) had reported to be the minimum size for black oak to produce viable acorns. As metrics of accessibility by elders or other community members with physical limitations, we also considered two social criteria by selecting sites with slope less than 25% and within 492 ft (150 m) of a road maintained by the USDA Forest Service. The black oak stands that the Sierra National Forest and North Fork Mono Tribe have been treating have been within 150 ft of such roads, but we thought that the more generous buffer would still ensure accessibility and avoid excluding otherwise high-quality stands. We also applied a minimum size of 5 acres as a threshold, which approximates the smallest sites treated in the projects on the Sierra National Forest. We summed the area of those potentially high suitability sites for acorn gathering, and then we overlaid them onto maps of potential resting and denning habitat for fishers developed by the Conservation Biology Institute for a recent fisher conservation assessment (Spencer et al. 2015). That report notes that denning habitat is a subset of resting habitat that is concentrated at lower elevations, distinguished by trees that can form large cavities, and strongly associated with black oak. A comparable map for the spotted owl in the Sierra Nevada was not available.

Results and Discussion

Through synthesis of the meeting discussions, interviews, and literature, we identified conditions that influenced the suitability of acorn gathering areas, which in turn helped to interpret trends in black oaks and develop potential restoration strategies.

Conditions Desired by Gatherers

Native Americans describe the character of oak stands in a desirable condition at scales that range from the quality of individual acorns to the size and arrangement of patches within large forested landscapes (Figure 2). These qualities are important for outlining treatment strategies and focal areas for restoration.

Acorn Scale. At the finest scale, gatherers desire acorns that are not infested with filbert weevils (*Curculio* spp.) or filbert worms (*Cydia latiferreana*) (Anderson 2005). Useful indicators of acorn quality include the quantity of such good acorns per tree or unit area and the ratio of good to infested acorns. The traditional practices of knocking to remove acorns from the trees and burning fallen acorns and ground underneath oaks after the harvest have been regarded by practitioners and experts as an effective means to control these pests that overwinter in the soil (Anderson 2005). Research in many nut orchard systems has shown that retention of unharvested nuts in the trees and on the ground contributes to such problems (Siegel et al. 2008, Eilers and Klein 2009).

Tree Scale. Gatherers prefer large, mature trees with well-developed crowns that produce abundant crops of high-quality acorns (Figure 3). Gatherers desire low branches that can be reached with knocking sticks (up to 8–10 ft long) or climbed to help gather acorns (Anderson 2007). Practi-

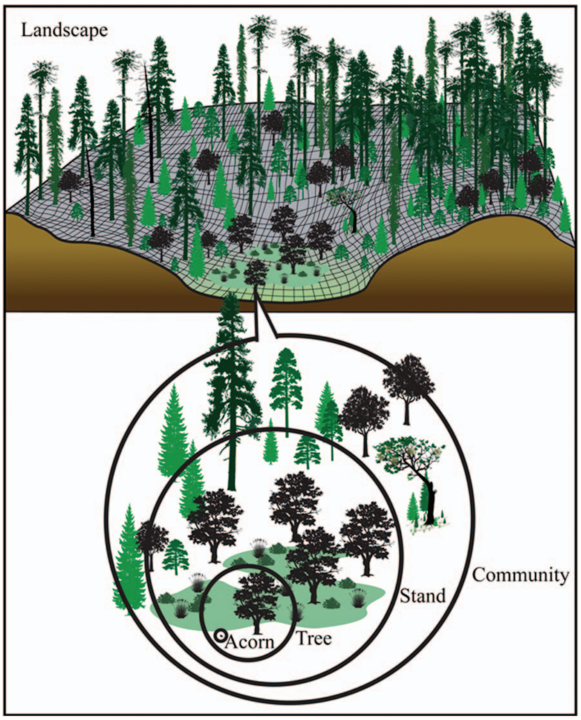

Figure 2. Various scales used to describe desired condition to guide restoration of black oak. (From Long et al. 2016.)

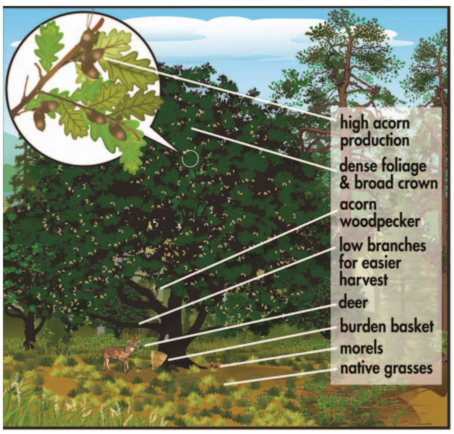

Figure 3. Idealized condition of trees and surrounding areas desired by tribal acorn gatherers. (From Long et al. 2016.)

tioners also explained that children climbed along the low branches of black oaks during games of tag. However, both conifer encroachment and relatively intense wildfires promote narrow and high crowns rather than the broad and low crowns desired by tribal members (Cocking et al. 2012b, Crotteau et al. 2015). A description of extensive black oak woodlands in the Central Sierra Nevada from the late 19th century noted that trees often had full crowns but with large branches beginning only 30–40 ft above the ground (Greene 1889). On the other hand, historical photos from vegetation surveys also show black oaks with large branches closer to the ground (Long et al. 2016). This difference in tree architecture may indicate where naturally ignited wildfires have shaped trees rather than burning and tending by Native Americans. Knocking and pruning by gatherers would also have reshaped the crown by trimming long branches and stimulating more acorn-bearing branches (Anderson 2007). Treatments that increase light to Oregon white oaks (*Quercus garryana*) by removing encroaching conifers stimulate crown regrowth as well as acorn production (Devine and Harrington 2006).

Tribal practitioners were not concerned by the presence of cavities in black oaks, which are formed through heartrot caused by oak canker rot fungi (*Inonotus andersoni* and *Inonotus dryophilus*) and sulfur fungus or chicken of the woods (*Laetiporus gilbertsonii*) (McDonald 1969, Swiecki and Bernhardt 2006); the latter fungus is also a traditional tribal food (Anderson and Lake 2013).

Stand Scale. Close proximity of conifer trees tends to degrade the acorn production, crown structure, and vigor of oaks (Holmes et al. 2008, Devine and Harrington 2013). Use of frequent fire can promote relatively open stand conditions, including small gaps around black oaks, by reducing conifers (Engber and Varner 2012, Cocking et al. 2014). It also favors production and accessibility of understory plants (Wayman and North 2007) and fungi such as morels (*Morchella* spp.) (Winder 2006), many of which are culturally important resources (Long et al. 2014, 2016).

Community Scale. When considering the suitability of large areas that include black oak stands for gathering, practitioners favor areas that afford a diversity of desired products, including berries, edible roots and tubers, mushrooms, basketry materials, and seeds (Figure 3).

Landscape Scale. The desire to harvest diverse resources increases the value of stands of black oak that are near meadows. To facilitate access and gathering, desired areas are relatively flat and are located near roads, many of which probably coincide with former trails used by Native Americans (Lake 2013).

Current Trends in Black Oaks and Associated Tribal Values

Tribal members noted that reductions in regular fires have diminished habitat quality for mature black oaks and associated production of acorn and other foods. Researchers studying changes in vegetation types from 1936 to 1996 in the Central Sierra Nevada found that the area where black oak was present as a subdominant under conifers declined by 25%, but its area expanded by a similar amount in areas classified as dominated by montane hardwoods (Thorne et al. 2008). They attributed the increase in oak-dominated area to removal of overstory conifers by logging and wildfires that promote oaks over many conifer species. That increase in area may have been facilitated by and may continue as the result of a warming climate marked by drought and wildfires (McIntyre et al. 2015).

However, such trends do not favor the increase in the large, mature oaks that provide large quantities of acorns and large cavities used by wildlife. Acorn production in black oaks and in many species of oaks in the eastern United States has been associated with age, diameter, basal area, and crown conditions (McDonald 1969, Garrison et al. 2002, McShea et al. 2007). In addition, production of acorns does not ensure usability, because tribal members avoid acorns with high levels of pests (Anderson 2005). McIntyre et al. (2015) reported that black oak in California maintained its basal area between the 1930s and early 2000s (average change was 5 ft^2/ac, credible interval −8 to

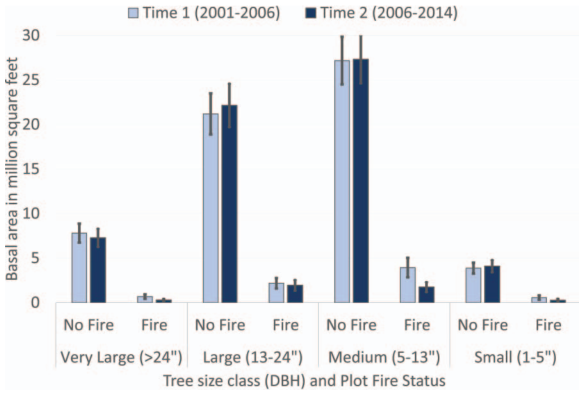

Figure 4. Recent changes in basal area in black oak sorted by size class and influence of fire, based on 420 FIA plots located on national forests.

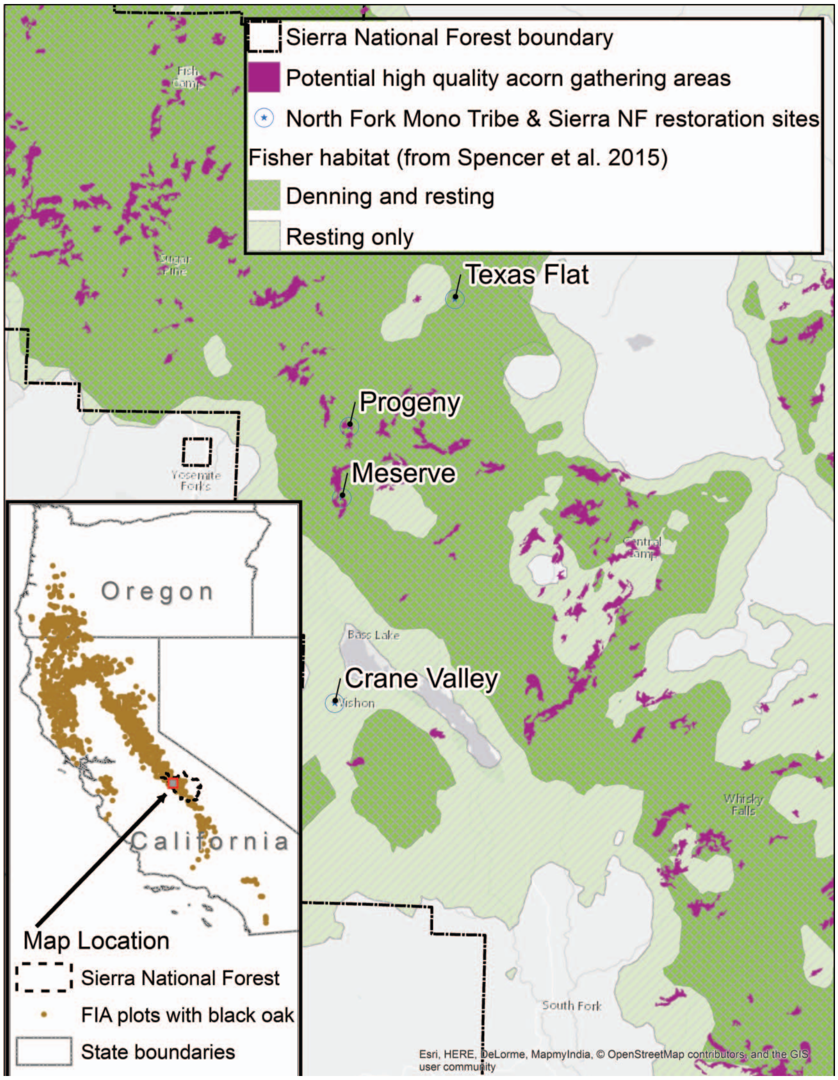

Figure 5. Potentially highly suitable areas for acorn gathering within part of the Sierra National Forest, overlaid with suitable fisher habitat, and location of four sites where the North Fork Mono Tribe has collaborated with the Forest Service on forest restoration.

15). They also found that trees larger than 24 in. dbh in general appear to have declined across California and especially in the Sierra Nevada (McIntyre et al. 2015). However, numerical changes in very large black oaks in particular are difficult to evaluate because of the low sample size in the 1930s data set (Thorne et al. 2007). Moreover, our analysis of the last two panels of resampled FIA data revealed a modest but significant decline in basal area from 24.6 ± 1.4 to 23.8 ± 1.4 (mean ± SE) ft^2/ac (change of −0.87 ± 0.39 ft^2/ac, $Z = 2.25$, $P = 0.012$) across the entire range of the species over the average remeasurement period of 7.2 years. Within size classes, most changes were modest and not statistically significant, although there were significant losses in trees greater than 24 in. and between 5 and 13 in. dbh within plots affected by fire (either wildfire or prescribed fire) (Figure 4). Intense fire often results in top-kill of even mature black oaks (Cocking et al. 2012b, 2014). Although resprouts have produced acorns within 11 years after being top-killed by wildfire (Crotteau et al. 2015), several decades may be needed for trees to return to heavy production (McDonald 1990). The formation of large, well-insulated cavities, in which fishers and spotted owls raise young (Long et al. 2014), also requires many decades for stems or branches to first grow large and then be hollowed out by heartrot (Long et al. 2016).

Identifying Potential Areas for Restoring Black Oak Acorn Production

Our GIS analysis identified 946 areas as potentially highly suitable for acorn gathering; these totaled 31,228 acres, or about 2.2% of the entire Sierra National Forest (Figure 5). Considering proximity to meadows would reduce that estimate even further. This finding is consistent with archaeological studies indicating that prime gathering sites were historically quite limited in extent (Hunt 2004). The North Fork Mono Tribe and Sierra National Forest had already been collaborating to restore four sites. Our analysis included the Meserve and Progeny sites where large oaks were prominent (Figure 6); the Crane Valley site had mostly small black oaks in the flatter areas, and the Texas Flat site involved only meadow restoration. This kind of analysis can help tribes, forest managers, and the public understand opportunities for restoration, especially when further customized based on more detailed forest inventories and knowledge of local forest managers, wildlife managers, and tribal members.

Strategies to Promote Desired Conditions

An active management strategy is important for promoting tribal values, because current trajectories in many mixed-conifer

Figure 6. Black oaks fringing the Progeny site on the Sierra National Forest, where the North Fork Mono Tribe and Forest Service staff have performed thinning and prescribed burns to restore desired conditions for oaks and the adjacent meadow.

forests are likely to lead to increased conifer encroachment or top-killing wildfires. Neither of those outcomes is likely to sustain large black oaks. In many stands, mechanical thinning or girdling, combined with treatments to reduce fuels, may be necessary before large black oaks are likely to withstand fire (Cocking et al. 2012b). However, fire is important because consumption of litter and production of smoke may help to control pests and pathogens, enhance gathering efficiency, and promote desired understory plants and fungi (Long et al. 2014, 2016). Consequently, reinvigoration of the black oak system depends on combining structural restoration with restoration of low-intensity fire to maintain sufficient canopy openings around black oaks. Such openings maintain the productivity of the mature oaks and desired understory species and provide areas where young replacement oaks can grow. Given the diversity of stands with black oak across the species' range, it will be important to customize treatment prescriptions to local conditions and local tribal values. Some researchers have expressed concern that opening stands too much would increase production of new branches along the stem (epicormic branching), which might at least temporarily divert energy from acorn production (McDonald and Ritchie 1994). However, such new growth provides the means to restore fuller crowns and lower branches (Devine and Harrington 2006) that acorn gatherers desire.

Challenges to Restoring Areas for Tribal Use

Tribal practitioners expressed concern about not only lack of access to favorable stands in national forests but also constraints on both burning and thinning treatments to restore more favorable conditions. Air-quality regulations have posed obstacles to expanding use of prescribed burning (Quinn-Davidson and Varner 2012), including cultural burning by tribes, despite the fact that tribes have emphasized the importance of both fire and smoke in sustaining the health of oaks and quality of acorns and other resources (Long et al. 2014). Tribes consider fire an essential tool in tending to gathering areas, and traditional use of fire is interwoven with society, culture, and education (Anderson 2006, Lake 2013).

Conservation measures have restricted forest treatments in areas occupied by fishers and spotted owls. Because those species are also associated with relatively dense and multilayered conifer stands, treatments to release black oaks from encroaching conifers may appear to conflict with their conservation. However, adopting a multiscale perspective on restoring forest landscapes can allay that concern by balancing conifer removal with conifer retention around oaks that appear suitable for nesting/denning or resting (Long et al. 2014).

Our analysis indicated that 79% of potentially high-quality areas for acorn gathering are located in habitat deemed suitable for fishers (Figure 5). Yet, those 24,733 acres represent only 5.9% of the total area identified as fisher resting or denning habitat (416,964 acres) on the Sierra National Forest. Moreover, fishers may prefer steeper slopes for denning, with studies in the southern Sierra Nevada reporting slopes greater than 17% in one analysis and a mean of 37% in another (Spencer et al. 2015). Furthermore, both fishers and spotted owls are likely to fare better in sites that are distant from roads and are on moister aspects that support high canopy cover and less frequent fire (Long et al. 2014). Those finer-scale associations further decrease the potential for treatment of priority gathering sites to pose a threat to these sensitive species. Furthermore, fishers appear tolerant of both thinning and burning up to 2.6% of a landscape per year, and they are likely to resume using treated areas within a few years of even more extensive fuel reduction treatments (Zielinski et al. 2013, Sweitzer et al. 2016). Our results suggest that managers could target many sites with burning and oak release treatments to enhance acorn production while avoiding areas that are particularly sensitive for spotted owls and fishers. In addition, increases in acorn production could enhance populations of prey for these species, including dusky-footed woodrats (*Neotoma fuscipes*) and western gray squirrels (*Sciurus griseus*) (Innes et al. 2007, Thompson et al. 2015). Monitoring outcomes for sensitive species and tribal acorn harvest would help to evaluate how landscape restoration can promote both objectives.

Creating Effective Partnerships to Promote Oak Restoration

Restoration of oaks for tribal use holds promise for establishing federal-tribal partnerships that build on TEK. The barriers to such partnerships are significant, including the potential for mistrust between the agency and local communities due to staff turnover, the appearance of slow progress, and historical resentments (Davenport et al. 2007). Tribes have highlighted a number of recommendations to promote more effective communications and collaboration, including early and frequent consultation and coordination at local levels (Vinyeta and Lynn 2015).

Examples of Current Oak Restoration Efforts Involving Tribes

• As discussed above, the North Fork Mono Tribe has been working with the Sierra National Forest to restore meadows at several sites that also have black oaks (shown in Figure 5). The Tribe has worked with staff on the Bass Lake Ranger District to apply a multistaged process for restoring oaks. The first stage involves removing small encroaching conifers, invasive plants, broken branches, and other fuels around oaks, and then conducting an initial burn to reduce fuels on the forest floor. The second stage requires cutting larger conifer trees to open the forest and release the oaks, followed by a second burn. The third stage involves pruning, trimming, and thinning the oaks, followed by another low-intensity burn. After those preparatory stages, the Tribe intends to use more routine burns to consume acorn pests, fumigate the oaks with smoke, and facilitate acorn gathering. The Tribe has also been actively engaged in planning treatments and monitoring for enhanced acorn production as part of the collaborative Dinkey Landscape Restoration Project on the Sierra National Forest. Finally, the Tribe has been working with researchers to study effects of treatments on acorn productivity and gathering efficiency.

• The Klamath National Forest has considered feedback from the Karuk Tribe

in promoting black oaks on ridge tops after wildfires. These oaks provide buffers to facilitate beneficial use of fire in addition to supporting tribal values.

• The Greenville Rancheria has collaborated with the Plumas National Forest and other partners to use prescribed burning to promote black oak and other valued species. Objectives for managing oak stands include maintaining an open understory for cultural activities and gathering pliable saplings for constructing cradleboards (Long et al. 2016), in addition to gathering acorns.

• A partnership in Oregon led by the Lomakatsi Restoration project, the Klamath Tribes, the US Fish and Wildlife Service, the NRCS, the Klamath Bird Observatory, and several other organizations in southern Oregon has promoted restoration of black oak and Oregon white oak (Cocking et al. 2012a).

The Future

Under the next generation of Land and Resource Management Plans for national forests, the use of prescribed fire and managed natural ignitions (also known as wildland fires managed for resource objectives) may expand to help address the backlog of forest restoration and constraints on mechanical treatments in many areas (North et al. 2015). Proactively managing black oak stands with high potential to meet tribal resource needs can reduce the likelihood that fires, whether wild or managed, jeopardize the services afforded by mature oaks.

Black oak restoration achieves multiple ecological goals, but it also affords opportunities to achieve social goals recognized under new federal forest planning rules, including engagement of tribes, minorities, low-income populations, and youth and consideration of ecological services and cultural benefits (Long et al. 2014). Inclusion of tribal communities in all phases of planning, implementation, and monitoring can create valuable opportunities to promote ecocultural restoration, especially for younger generations. Members of several tribes who participated in meetings on national forests in the Southern Sierra Nevada particularly highlighted the need to consider contemporary tribal community values in revised land and resource management plans, rather than focusing on archaeological values. Ron Reed, a member of the Karuk Tribe from Northern California, has explained the importance of having access to these vital resources: "You can give me all the acorns in the world, you can get me all the fish in the world, you can get me everything for me to be an Indian, but it will not be the same unless I'm going out and processing, going out and harvesting, gathering myself. I think that really needs to be put out in mainstream society, that it's not just a matter of what you eat. It's about the intricate values that are involved in harvesting these resources, how we manage for these resources and when" (Norgaard 2014, p. 81). Collaborative restoration of black oak stands or "orchards" to enhance acorn production can be an important strategy for promoting these important socioecological values for tribes across much of California and Oregon.

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