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A Dynamic Strategy for Conserving Southern Sierra Blue Oak Woodland

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Blue oak (*Quercus douglasii*) is a conspicuous and charismatic California endemic species. Blue oak woodlands host an array of native understory vegetation and provide important habitat for wildlife. This habitat also occupies a large quantity of valuable real estate, making it one of the more threatened California biomes. Historic threats such as habitat fragmentation, invasive species, altered waterways and ubiquitous pollution are compounded by climate change. In an effort to conserve remaining blue oak habitat, The Nature Conservancy is purchasing lands in sensitive areas and negotiating conservation easements with private land owners.

We provide The Nature Conservancy (TNC) with a dynamic strategy for conserving blue oak woodland in Tulare County, which is located in the southern portion of the blue oak range. This brief identifies areas of high ecological importance and provides a spatial and temporal analysis of climate change and development threats.

To provide a well-rounded strategy for protecting Tulare County blue oak woodland, we examine several components of blue oak woodland conservation, including the identification of quality habitat, a threat analysis, and strategies for multi-species management within protected areas.

1. Priority conservation areas

Conservation priority areas are core areas of habitat that contain the highest measurable habitat heterogeneity and biodiversity within Tulare County blue oak woodland. We recognize that TNC is interested in conserving both blue oaks and the blue oak woodland community. We therefore identify parts of Tulare County blue oak woodland that are likely to contain high quality habitat for woodland plant and animal species. In order to do this, we identify coarse-scale landscape features that represent habitat heterogeneity or act as indicators of high species biodiversity. Using a multi-criteria analysis, we rank watersheds within Tulare County blue oak woodland according to: (a) the amount of riparian habitat; (b) elevational range; (c) threatened and endangered plant species richness; (d) number of recorded vertebrate species; (e) degree of intactness. We identify six conservation priority areas based on the highest ranking watersheds or conglomeration of high-ranking watersheds. Our conservation priority areas comprise just under 20% of Tulare County blue oak woodland (358 km^2), 18.6% of which (66.5 km^2) is privately held. We believe this is a reasonable conservation goal.

2. Threat from development

Tulare County's population has been growing at an average rate of 2% per year, with new development occurring in the foothill region of the county. The majority of blue oak woodland currently falls under private ownership and was historically used primarily as land for grazing. The decline in profitability of cattle ranching in California along with rapidly increasing land prices is putting

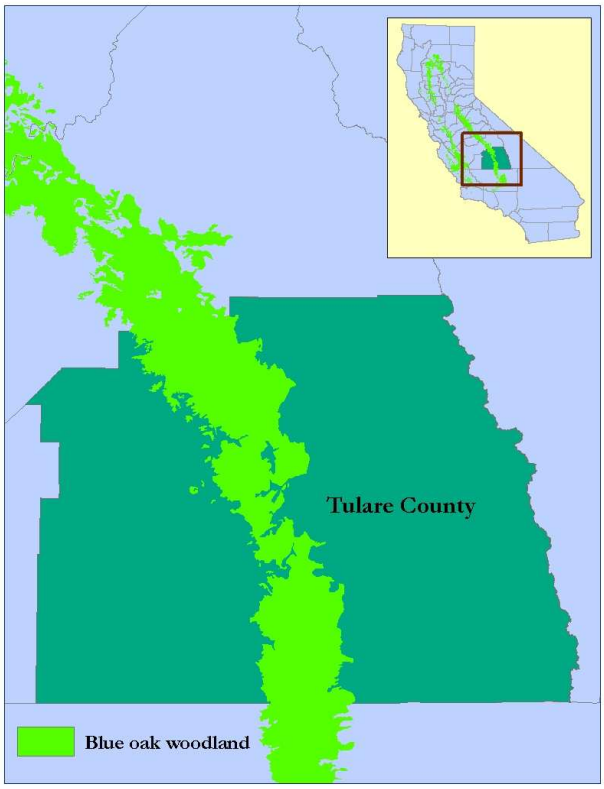

Figure 1: Blue oak woodland forms a vertical band across Tulare County within the foothill region of the southern Sierra.

unprecedented pressure on landowners to develop. Tulare County's foothills are still a relatively contiguous, unfragmented band of habitat, but commuters into the Valley's rapidly growing urban centers and retiring baby boomers looking for a rural lifestyle are beginning to develop the foothills. People bring with them homes, roads, pets, and invasive species, all of which present a threat to the native flora and fauna that live in blue oak woodland and to the oaks themselves. Studies have shown that oak woodland fragmentation affects tree regeneration rates, lowers biodiversity, and results in the extirpation of sensitive species. Efficient conservation will need to identify which patches of blue oak woodland are under the most immediate pressure from development.

We evaluate current development in Tulare County blue oak woodland. Presently less than 15% of Tulare County blue oak woodland is impacted by development. We provide development scenarios that depict a likely progression of development in the southern Sierra foothills and calculate the subsequent impact on the county's blue oak woodland. For example, we show that a complete build-out under Tulare County's current General Plan would directly impact 21% of the county's blue oak woodland; increased fragmentation by roads and rural residences would degrade an additional 57% of the blue oak woodland.

3. Climate change

Climate change will compound traditional threats such as habitat fragmentation, invasive species, altered waterways, and pollution that come with development. This synergy of threats has the potential to change natural blue oak woodland habitat in unprecedented ways. Driven largely by climatic requirements, blue oaks' current distribution covers a well-defined elevational band in the foothills encircling the Central Valley of California. Increases in temperature are expected to shift the distribution of suitable habitat for blue oaks northward and upslope, resulting in decreased range size. Existing research has found that the potential range of blue oaks is likely to shrink to 59% of the current range statewide over the next 100 years.

We evaluate the potential impacts of multiple climate change scenarios on blue oak woodland in Tulare County using both statistical modeling of suitable habitat and dynamic simulations of the blue oaks' response to a changing environment. Based on our model results, we develop a simple metric for assessing the likely persistence of blue oak woodland under climate change. Our models predict that climate change will reduce the range of suitable habitat for blue oaks in Tulare County by 25-95%. Because mature blue oaks are hardy and long-lived, the actual shifts in the distribution of the species will be lagged significantly compared to the shifts in habitat suitability. We identify which parts of the current range of Tulare County blue oaks are likely to disappear as suitable habitat, which parts are likely to persist, and which are likely to emerge as newly suitable habitat. We use these results in conjunction with development predictions to

evaluate the threat patterns within conservation priority areas.

4. Threat synergy

Conservation planning that aims for long-term blue oak persistence will have to protect blue oak woodland from the immediate threat of development, while planning for an eventual range shift due to climate change. We examine the relative effects of development and climate change on Tulare County blue oak woodland in 2080, which we believe to be a reasonable time horizon for conservation planning. We divide Tulare County blue oak woodland into 2500 m^2 pixels, then determine the relative quality of blue oak habitat under a 2080 climate and associated level of development threat for each pixel. This information may be used by TNC to identify areas for conservation priority.

Figures 2 and 3 provide an example of how we interpret the threat synergies of development and climate change. In 2080, about half of the current range of blue oak woodland will become unsuitable due to climate change. The suitable habitat that will remain is scattered through the range, and contraction to the upper-middle elevations of the current range occurs. Within suitable habitat, we evaluate the threat of development. If TNC were interested in conserving areas with high habitat quality and are highly threatened, then TNC should focus on priority areas B, C, and D.

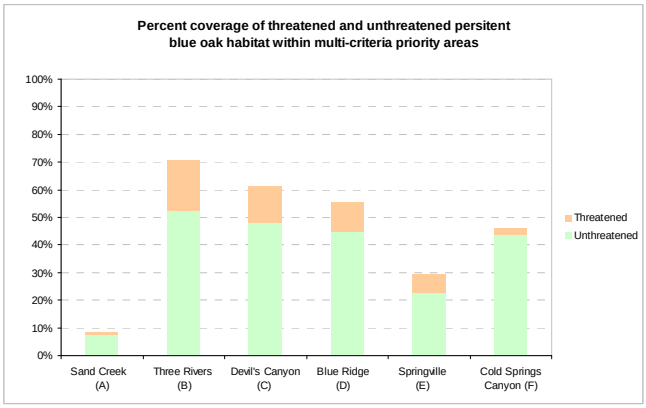

Figure 2: This graph shows the proportion of threatened and unthreatened persistent woodland within priority areas.

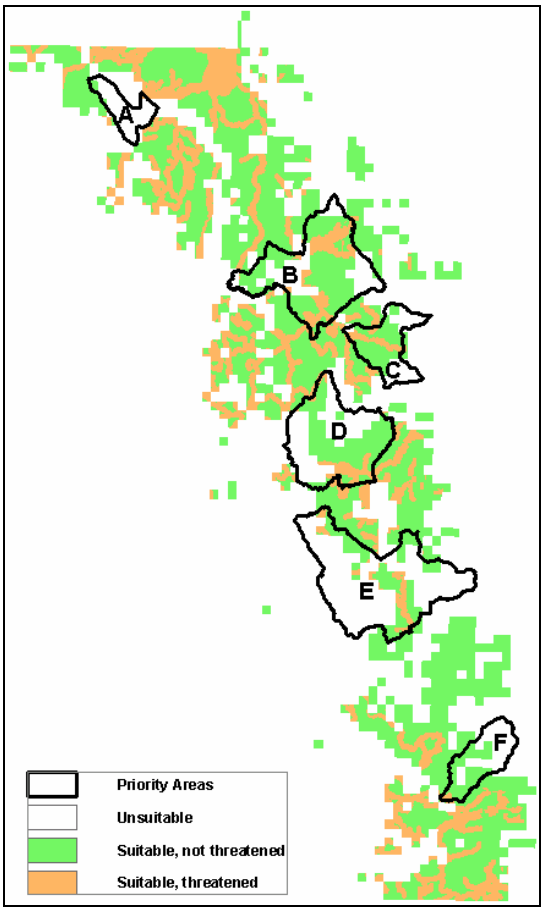

Figure 3: The distribution of threats within areas of likely persistence for blue oak woodland in the year 2080.

5. The blue oak community

We conducted our multi-criteria analysis and subsequent identification of conservation priority areas at the scale of Calwater planning watersheds, which average approximately 8500 acres. Conservation site selection, however, will likely be done at a smaller scale – possibly through the purchase or easement of private parcels. Fine-scale landscape features can be used to further identify and prioritize sites within conservation priority areas. Targeted wildlife species may require specific landscape features such as ponds, rocky outcrops, or mature trees. We provide a brief overview of blue oak woodland wildlife species and associated status on federal and state endangered species lists. We address the minimum size required to maintain viable populations of various woodland species. An

Recommendations

1. Work within conservation priority areas
2. Use threat-synergy in making conservation decisions within and between priority areas
3. Use bands of high persistence to connect reserves
4. Manage lands to optimize the chance of blue oak regeneration
5. Use species targets to determine site size, configuration, and connectivity.
6. Work with local institutions to maximize blue oak persistence outside of designated reserves

appropriate reserve size depends both on the species targeted and the management of land outside of protected reserves. We therefore provide a tiered approach to determining reserve size; we offer guidelines for the protection of wide-ranging woodland species down to areal requirements of smaller species within blue oak woodland. Mountain lions, for example, have home ranges of almost 10,000 acres and use a wide range of habitats, including blue oak woodland; reserves designed to accommodate this species will need to be large and interconnected to other foothill reserves and public parks.

6. Optimizing blue oak recruitment

Our models assume that blue oaks will persist indefinitely under current land use and climate conditions. There is evidence, however, that blue oaks are not regenerating over much of their range, including Tulare County. The reasons for lack of recruitment and seedling survivorship are varied, and include: grazing, invasive species, altered disturbance regimes, fragmentation, herbicides, and tilling. We review the debate over the "regeneration problem" and offer strategies for managing blue oak lands in order to optimize the chance of successful recruitment and survivorship.

We suggest the use of wire cage enclosures to protect emergent seedlings from grazing in areas where deer and cattle have access and root-cages where rodent damage is a problem. We recommend that grazing be kept to 10-20 acres per cow per year and pastures allowed to rest in the spring and summer. Mulching and weed control around emergent seedlings can reduce water and light competition. These techniques will likely increase blue oak regeneration in managed areas.

Conclusion

Blue oaks are an integral component of the California landscape. We offer a strategy for blue oak conservation in a dynamic landscape. We provide both methods and information for (a) prioritizing sites for limited-budget conservation, and (b) reconciling protecting lands from the immediate threat of development with planning for the long-term change caused by a warming climate. We suggest wildlife species that may be used for fine-grain conservation. Finally, we offer suggestions for the management of blue oak woodland in order to ensure that these magnificent trees are around for centuries to come.