

Status, Conservation, and Management of Oak Woodlands at Tejon Ranch, CA¹

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Abstract

Tejon Ranch, encompassing 109 000 ha, is the largest contiguous private property in California. In 2008, the Tejon Ranch Company and a coalition of five environmental organizations executed the Tejon Ranch Conservation and Land Use Agreement that placed 90 percent of the property into permanent conservation and created the Tejon Ranch Conservancy as its steward. Tejon Ranch supports extensive, diverse, and regionally significant oak woodlands. The Conservancy is characterizing the composition and structure of these woodlands to inform land management.

Deciduous oak woodlands at Tejon Ranch are well-stocked relative to deciduous oak woodlands previously surveyed by others in California, but like other California oak woodlands, Tejon Ranch also has a high proportion of low stocked areas. Annual grasses and forbs dominate valley and blue oak woodlands, while black oak woodlands have a higher shrub cover. Photo comparison of deciduous oak woodlands at Tejon Ranch indicates a decline in all three species between 1952 and 2009. The Conservancy proposes to assess ecological sites and vegetation states to inform management, increase oak recruitment with tree shelters, and assess grazing management to enhance understory biodiversity.

Key words: conservation, management, Tehachapi Mountains. Tejon Ranch

Introduction

Tejon Ranch (fig.1), at 109 000 ha, is the largest contiguous private property in California. The 2008 Tejon Ranch Conservation and Land Use Agreement (Agreement) between the Tejon Ranch Company, the property owner, and five environmental organizations (Audubon California, Endangered Habitats League, Natural Resources Defense Council, Planning and Conservation League, and Sierra Club) resulted in conservation of 97 000 ha of the Ranch, of which oak woodlands are a significant land cover type supporting numerous species of conservation interest. The Agreement created the Tejon Ranch Conservancy and charged it with developing and implementing a management plan for the conserved lands.

Over the past 200 years, human development and agriculture have eliminated extensive areas of oak woodlands. While 20 oak species still cover 4 million ha of the California landscape (Allen-Diaz and others 2007), they face a variety of threats. Perhaps the most well-studied threat is insufficient oak regeneration to maintain stable populations (Bolsinger 1988, Griffin 1976, Tyler and others 2008). Cattle grazing in oak rangelands is frequently cited as the cause of the regeneration problem (Allen-Diaz and others 2007).

Given the conservation significance of oak woodlands, understanding their ecology and identifying management approaches is a high priority of the Conservancy. This paper describes the conservation significance, structure and condition, and management priorities of oak woodlands at Tejon Ranch.

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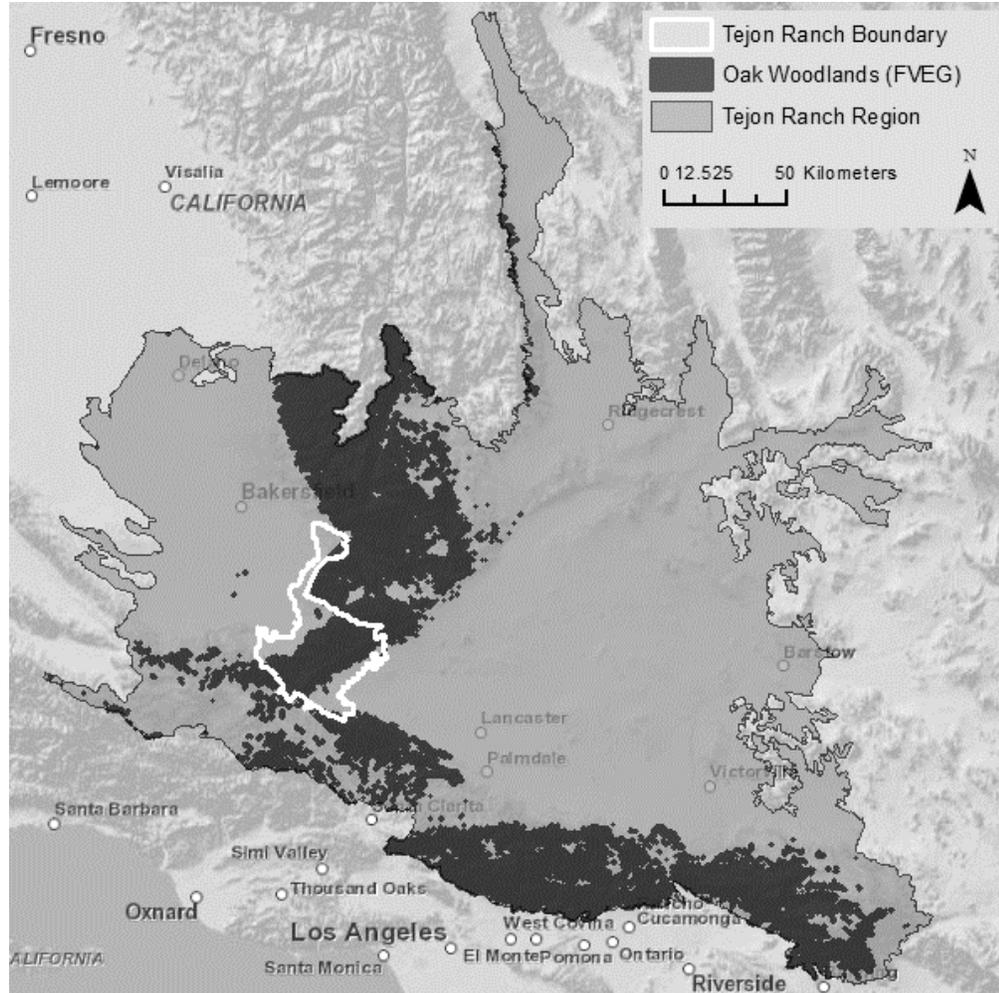


Figure 1—Location of Tejon Ranch, the region used in the conservation analysis, and the distribution of oak woodlands.

Methods

Study area

Straddling the Tehachapi Mountains of California, Tejon Ranch ranges in elevation from approximately 150 m to over 2070 m. Prominent ridges and associated valleys extend along the spine of the Tehachapis creating a complex landscape with highly variable elevations, aspects, and landforms. Tejon Ranch sits at the confluence of two floristic provinces (California Floristic Province and Great Basin Province) and four floristic regions (Great Central Valley, Sierra Nevada, Mojave Desert, and Southwestern California (Baldwin and others 2012).

Conservation analysis

To evaluate Tejon Ranch's contribution to oak woodland conservation, I quantified the conserved area of oak woodlands on the Ranch and in the surrounding region, defined by the Level IV ecological subsections (USEPA 2011) that intersect Tejon

Ranch and support oak woodlands, an area totaling 3 891 000 ha. I estimated the total area of Blue Oak-Foothill Pine, Blue Oak Woodland, Coastal Oak Woodland, Montane Hardwood, Montane Hardwood-Conifer, and Valley Oak Woodland from the FVEG land cover data set (CalFire 2006) within protected area using the California Protected Areas Database (GreenInfo Network 2013) and National Conservation Easement Database (NCED 2013). I follow Allen-Diaz and others (2007) by collectively referring to all oak savanna, woodland, and forest communities as “oak woodlands.”

Vegetation measurements

Vegetation characteristics were measured within 105 plots, each 20 x 30 m, in woodlands dominated by blue oak (*Quercus douglasii*), valley oak (*Q. lobata*), and black oak (*Q. kelloggii*) (Hoagland and others 2011). In each plot all trees, including seedlings and saplings, were counted, and diameter at breast height (1.37 m above ground; DBH) of trees and saplings was measured. Stocking rates (oak densities expressed as basal area of trees per land area) were derived by estimating basal area of all trees in each plot, assuming a circular cross-section with diameters based on DBH measurements. Composition and cover of understory vegetation functional groups were measured at 1-m intervals along three 30 m point-intercept transects in each plot. Vegetation functional groups included tree, shrub, grass, and forb; non-vegetative categories were bare ground, rock, leaf litter, wood, or cow pie. Refer to Hoagland and others (2011) for detail on plot selection and vegetation measurements. Statistical comparisons of oak woodland types at Tejon Ranch were made with ANOVA or t-tests with plots as the sample unit. The characteristics of Tejon Ranch oak woodlands were compared to results from statewide sample of Forest Inventory Analysis (FIA) plots reported by Bolsinger (1988) and statewide summaries from Allen-Diaz and others (2007).

Population growth rates

To quantify the mortality and recruitment of blue, valley, and black oaks on Tejon Ranch, 1952 aerial photos of Kern and Los Angeles counties were compared with 2009 USDA National Agriculture Imagery Program (NAIP). From these photos, three blue oak, three black oak, and eight valley oak photo stands were surveyed in each year, and the locations of all oaks were marked. Trees present in the 1952 photo that were not present in the 2009 photo were interpreted as mortality, and trees present in the 2009 photo that were not present in the 1952 photo were interpreted as recruitment. These results were used to calculate annual population growth rates over the 57-year period spanned by the photos. Refer to Hoagland and others (2011) for details on this analysis.

Results

Conservation analysis

Within the 3 891 000 ha regional extent around Tejon Ranch (fig. 1), there are 228 000 ha of oak woodlands, and approximately 110 000 ha (48 percent) of these woodlands are within protected areas. The conserved lands at Tejon Ranch protect an additional 18 000 ha, increasing the protected area of oak woodlands in the region by 16 percent. Including the conserved lands at Tejon Ranch, over 70 percent of black

oak woodlands (Montane Hardwood + Montane Hardwood-Conifer), 42 percent of valley oak woodlands, and 27 percent of blue oak woodlands (Blue Oak Woodland + Blue Oak-Foothill Pine) in the region are within protected areas.

Vegetation characteristics

Tejon Ranch supports 11 oak taxa, including two recognized hybrids (table 1). The most extensive oak communities are blue oak, valley oak, black oak, canyon live oak (*Q. chrysolepis*), interior live oak (*Q. wislizeni* var. *wislizeni*), and Brewer oak (*Q. garryana* var. *breweri*) woodlands.

Table 1—Oak taxa recorded at Tejon Ranch

Scientific name	Common name
<i>Quercus berberidifolia</i>	Scrub oak
<i>Quercus chrysolepis</i>	Canyon live oak
<i>Quercus douglasii</i>	Blue oak
<i>Quercus garryana</i> var. <i>breweri</i>	Brewer oak
<i>Quercus john-tuckeri</i>	John Tucker oak
<i>Quercus kelloggii</i>	Black oak
<i>Quercus lobata</i>	Valley oak
<i>Quercus wislizeni</i> var. <i>wislizeni</i>	Interior live oak
<i>Quercus wislizeni</i> var. <i>frutescens</i>	Interior live oak (shrub form)
<i>Quercus Xalvordiana</i>	Alvord oak
<i>Quercus Xmorehus</i>	Oracle oak

Average stocking rates of blue (7.2 m²/ha) and valley (13 m²/ha) oaks at Tejon Ranch are within the ranges reported for California as a whole by Allen-Diaz and others (2007), while the average stocking rate of black oaks on Tejon (32 m²/ha) is higher than they reported statewide (11 to 22 m²/ha). Blue, valley, and black oak plots at Tejon Ranch more frequently support higher basal area of oaks than did a sample of statewide FIA plots (Bolsinger 1988, fig. 2). Twenty percent of valley oak plots and nearly 70 percent of black oak plots at Tejon Ranch had basal areas greater than 100 ft²/acre (units reported by Bolsinger 1988), while no valley oak plots and less than 30 percent of the black oak plots exceeded 100 ft²/acre of basal area in the statewide FIA data. However, nearly 50 percent of valley oak plots at Tejon Ranch support basal areas less than 25 ft²/acre, while there were no statewide FIA plots in this lowest category. Blue oaks at Tejon Ranch show a similar pattern to statewide FIA data, with about 75 percent of plots supporting less than 50 ft²/acre.

Considering just woodlands at Tejon Ranch, the composition of understory vegetation is similar in valley and blue oak woodlands, which differs significantly from black oak woodlands (Hoagland and others 2011). Mean relative cover of herbaceous functional groups (that is, the sum of annual grass and forb cover) exceed 75 percent in blue oak and valley oak woodlands, which is significantly higher ($p < 0.001$) than the herbaceous cover of black oak woodland understories (mean cover <40 percent). Black oak woodlands have a significantly greater cover of understory shrubs than do blue or valley oak woodlands (25.6 percent vs. <2 percent, $p << 0.001$). Black oak woodlands support a significantly higher cover of tree species in the understory layer ($p < 0.05$) and downed wood ($p << 0.001$) than do blue or valley oak woodlands.

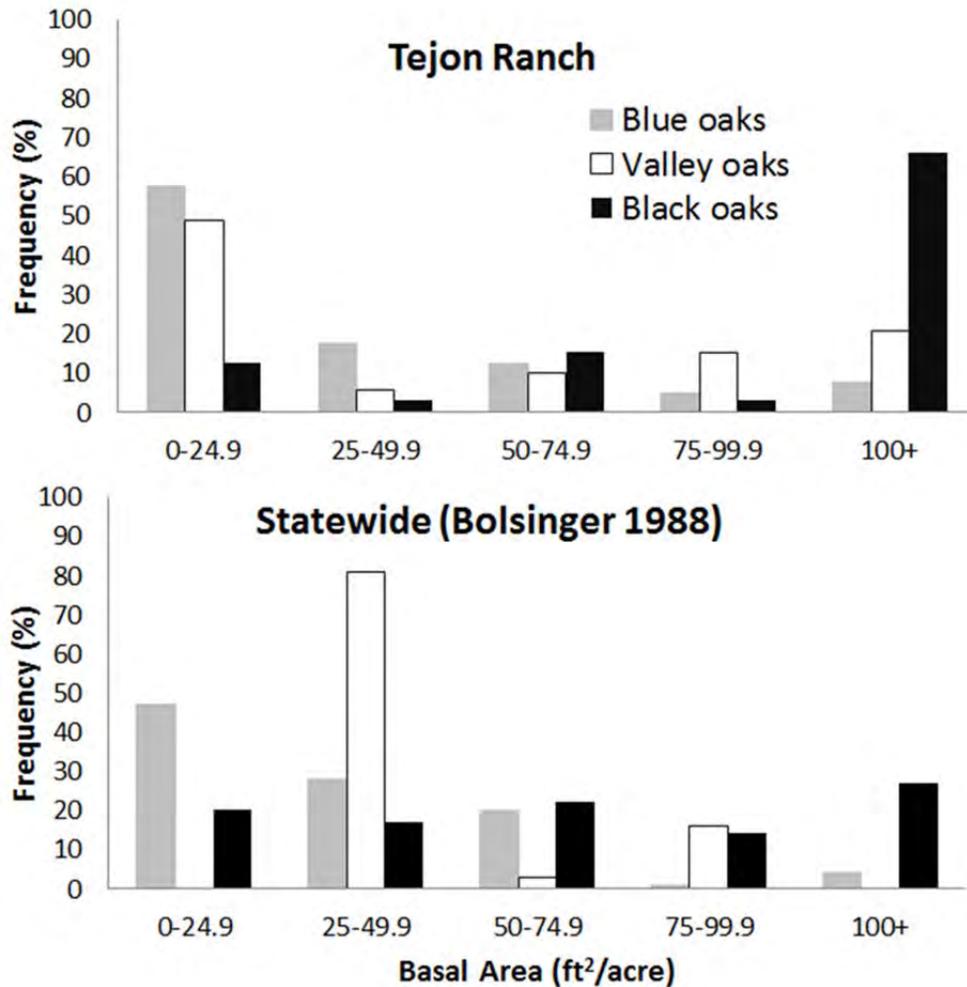


Figure 2—Stocking rates of blue, valley, and black oak woodlands at Tejon Ranch compared to statewide FIA plots (Bolsinger 1988).

The DBH range of blue and valley oaks is comparable between Tejon Ranch and statewide data reported by Allen-Diaz and others (2007). The largest blue oak measured at Tejon Ranch has a DBH of 82 cm and the largest valley oak 240 cm (fig. 3), while Allen-Diaz and others (2007) reported blue oaks grew to 600 cm DBH statewide (largest >180 cm) and valley oaks to 120 cm (largest >240 cm). The largest black oaks at Tejon Ranch (>150 cm, fig. 3) exceed the largest individuals they reported statewide (up to 120 cm). The size structures of the three deciduous oak populations at Tejon Ranch are different (fig. 3), with valley and black oaks having a higher proportion of larger individuals in their populations than blue oaks. Over 13 percent of black oaks and nearly 27 percent of valley oaks at Tejon Ranch exceed 100 cm DBH. However, there are few very small individuals in any of the Tejon populations. Approximately 6 percent of the blue oaks measure less than 10 cm DBH, and no valley or black oaks measure less than 10 cm DBH.

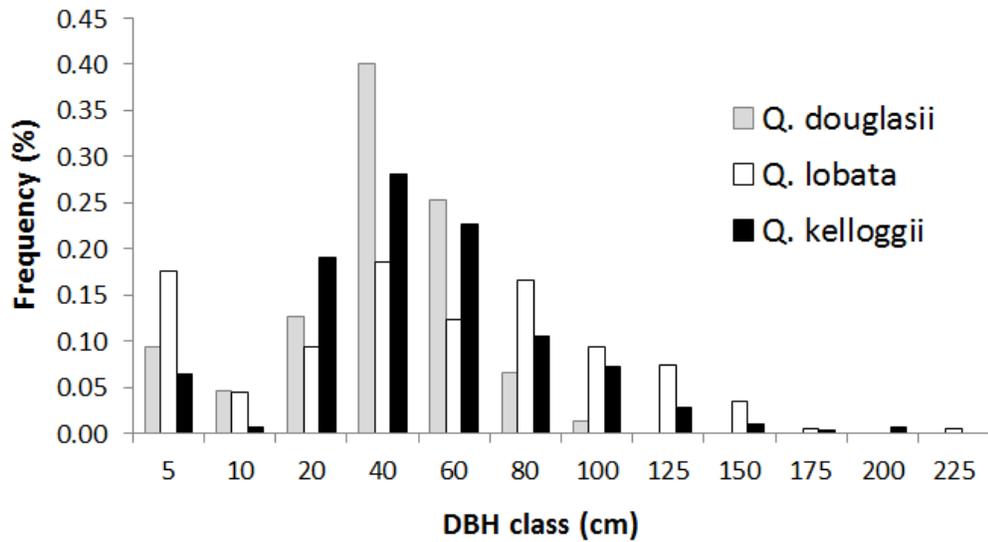


Figure 3—Diameter at breast height (DBH) of blue (*Q. douglasii*), valley (*Q. lobata*), and black (*Q. kelloggii*) oaks at Tejon Ranch.

At Tejon Ranch, valley oak saplings are more abundant than either black oak or blue oaks (Hoagland and others 2011). Within 55 plots containing valley oaks, 44 saplings were recorded within 11 plots. However, within 35 and 26 plots supporting black oaks and blue oaks, respectively, 17 black oak saplings were present in six plots, and 12 blue oak saplings were present in four plots. The densities of black oak and valley oak seedlings are similar, with 185 and 186 seedlings found in 26 and 27 valley oak and black oak plots, respectively. Only five blue oak seedlings were found in two plots.

Population growth rate

Population recruitment, mortality, and growth rates at Tejon Ranch are comparable among the three oak species (Hoagland and others 2001). While the valley oak recruitment rate is higher than either blue or black oaks, recruitment rates for all species are an order of magnitude less than mortality rates. Blue oaks have the highest mortality and lowest recruitment rates. Thus, population growth rates for all species are slightly less than 1.0, indicating declining populations. Blue oaks exhibit the lowest population growth rate of the three species, and Hoagland and others (2011) calculated that at an estimated annual population growth rate of 0.998, blue oaks could suffer a 9.3 percent population decline over the next 50 years.

Discussion

Conservation

The conserved lands at Tejon Ranch support over 18 000 ha of oak woodlands or 8 percent of the 228 000 ha of oak woodlands in the Tejon Ranch region (fig. 1). The Tejon Ranch Conservation and Land Use Agreement increased conservation of oak woodlands in the region by 16 percent to 128 000 ha. In particular, the conserved

lands at Tejon Ranch contribute significantly to protection of blue oak and valley oak woodlands at the southern ends of their ranges. Oak woodlands conserved on Tejon Ranch are diverse, comprised of 11 taxa or one-third of the oak taxa in California.

Structure and condition

Landowners, policymakers, and the public are concerned about inadequate oak regeneration (Allen-Diaz and others 2007), although Tyler and others (2008) suggest there may not be an oak regeneration problem. Cattle grazing in oak rangelands is often identified as the source of poor oak recruitment; however, Davis and others (2011) showed that native grazers (for example, deer) and seed predators (for example, rodents) also control oak population growth. Sheep and cattle have grazed oak rangelands at Tejon Ranch since the 1840s. Over 50 percent of the oak rangelands at Tejon Ranch, primarily blue and valley oak woodlands, are in low-stocked conditions (<50 ft²/acre basal area). In contrast, less than 20 percent of higher elevation black oak woodlands, which are less important rangelands at Tejon Ranch, are in low-stocked conditions. However, relative to Bolsinger's (1988) reported stocking rates of oak woodlands across California, much of the valley and black oak woodlands at Tejon Ranch are better stocked than other parts of California (fig. 2). One-third of valley oak woodlands at Tejon exceed 75 ft²/acre compared to only 16 percent of valley oak woodlands statewide, and while over 40 percent of black oak woodlands exceeded 75 ft²/acre statewide, nearly 70 percent of black oak woodlands at Tejon Ranch exceed 75 ft²/acre. Valley and black oak woodlands at Tejon Ranch support large individuals (fig. 3).

Seedlings of all species were observed in oak plots at Tejon Ranch, although blue oak seedlings were rare the year data were collected. Blue, valley, and black oak saplings comprised 7.7 percent, 21.2 percent, and 5.8 percent, respectively of the individuals of each species that were counted at Tejon Ranch. However the estimated growth rates of blue, valley, and black oak populations at Tejon Ranch are slightly less than 1.0, suggesting these species are declining over time (Hoagland and others 2011).

At Tejon Ranch, the understories of blue and valley oak woodlands are dominated by nonnative annual grasses and annual forbs with little shrub cover, while black oak woodlands have a significantly higher cover of shrub species (Hoagland and others 2011). The composition and structure of the oak woodlands at Tejon Ranch prior to European settlement are unknown. Bauer (1930) described Tehachapi Mountain foothill woodlands as having an open structure, but growing in dense stands in more favorable sites. He characterized the oak woodlands as having "layered societies," possibly suggesting well-developed canopy, shrub, and herbaceous layers. However, Bauer (1930) also noted that human land uses had facilitated nonnative plant invasions and altered fire regimes that changed the structure and composition of woodlands.

Management

Conservation at the privately owned Tejon Ranch is via conservation easements (Tejon Ranch Conservancy 2013). Under these easements, the Tejon Ranch Company retains the right to graze livestock in conserved lands, but grazing is subject to management measures developed by the Conservancy to enhance conservation values. The Conservancy used the oak woodland ecology and condition

information reported here and elsewhere to develop adaptive management strategies for conserved lands at Tejon Ranch.

The Conservancy's current priority is to increase our understanding of oak woodland structure and function. As discussed by Allen-Diaz and others (2007), a residual dry-matter (RDM) model (George and others 1985) has been used for management of oak rangeland understory species composition and productivity, but there is little research to support extension of this model to biodiversity management. The Conservancy hypothesizes that human land use practices in this region over the past 170 years have reduced the native biodiversity of oak woodland understory communities. We are assessing whether the Ecological Sites framework (Bestlemeyer and Brown 2010) we are using to develop grasslands management strategies can be applied to oak woodlands. We propose to explore how woodland understories may respond to managed grazing regimes.

Oak populations appear to be in decline at Tejon Ranch; however, given the long life span of adult oaks and the current demography and population growth rates at Tejon Ranch, enhancing oak regeneration is not urgent. Davis and others (2011) found that excluding livestock and deer browsing and rodent seedling predation improved oak recruitment. As resources are available, we can enhance recruitment of oaks and other woodland tree species by using tree shelters to protect seedlings and saplings from grazers and browsers (McCreary and others 2011). Climate change research suggests that areas of Tejon Ranch will provide suitable climate envelopes for oaks into the next century (Hoagland and others 2011, Sork and others 2010) and that these stable climate refugia are logical areas for enhancing recruitment.

As with many other parts of California, Tejon Ranch supports a significant population of wild pigs (*Sus scropha*) that root and forage extensively in oak woodlands. The Conservancy hypothesizes that wild pigs alter oak woodland understory composition, elevate oak seedling mortality, and compete with other wildlife for acorns. The Conservancy has initiated research and planning for the management of wild pigs at Tejon Ranch to enhance the condition and native biodiversity of oak woodlands.

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