BLUE OAKS AND PASTURE PRODUCTIVITY: IS THERE A RELATIONSHIP?

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For several decades ranchers and biologists have been concerned with the effect of blue oak (*Quercus douglasii*) on pasture growth. Controversy over the effect of blue oak on the growth of rangeland grasses in California has been fueled by contradictory reports. Several studies (Murphy and Crampton, Kay and Jansen) have found that the removal of blue oak from woodlands resulted in an increase in productivity in understory areas from twenty-five percent of that of open grassland before removal to two hundred percent after removal. This suggests that blue oak suppresses neighboring plant species. Holland, however, reported that grass growth under some blue oak canopies was over two times higher than that in open grassland just beyond the edges of the canopies, suggesting a stimulating effect of the oaks on their understory plants. At our study site, the Hastings Natural History Reservation in Monterey County, California, we compared apparent understory suppression and improvement by blue oaks in an oak woodland, oak savanna. In each of these two habitats six "negative" or low understory productivity trees were chosen that appeared to suppress understory growth, and six "positive" or high understory productivity trees were chosen that appeared to enhance understory growth. Each of the twenty-four trees was sampled for understory annual productivity, soil nutrients, fine roots in the upper twenty inches of soil, and oak predawn xylem pressure potential (XPP). Predawn XPP is a measure of water stress in plants, and low XPP indicates high water stress. Annual productivity and soil nutrients of open grassland (without oak cover), were sampled throughout the savanna and in open patches in the woodland. To determine the effect of oak roots on grass growth in the field, water-porous oak root exclosures made of low-fired clay were filled with soil from the site and placed under "positive" and "negative" oaks in the savanna. Seeds of ripgut brome (*Bromus diandrus*), the most common understory species, were planted in the exclosures and in controls in December 1986, and were harvested in April 1987 when the grasses began to turn brown.

Oak trees improve understory productivity by delivering nutrients to subcanopy soils; however, some trees described as negative trees appear to suppress understory productivity by means of large quantities of fine roots in shallow soils. Photograph by David Cavagnaro.

Soil Nutrients Below Oak Canopy

Soil under both "positive" and "negative" oaks had higher nutrients than did soil in the open grassland. These results corresponded with Holland and Morton, who reported a sharp decrease in soil nutrients beyond the edge of blue oak canopies, which was correlated with a decline in grass and forb productivity. Therefore, it is likely that improvement effects are produced by nutrient addition. This is supported by experiments conducted by others in which grassland productivity increased to more than double that of nearby open grassland after blue oak removal, and by observations that such positive effects remain for years after the trees have fallen.

The water stress of "negative" trees increased rapidly as the shallow soils dried during the rainless summer, whereas "positive" trees in the woodland and the savanna did not show significant decreases until July and August, respectively. This pattern also held true during second year of XPP measurements. Fine root biomass in the upper soil horizons was much higher under "negative" trees than under "positive" trees. These data, considered together, indicate that the "positive" and "negative" trees were utilizing different water sources and had differently structured root systems. The high XPPs and low root biomass in shallow soils is evidence that "positive" trees were not dependent on shallow soil moisture, and that they probably were rooted in the water table. Lewis and Burghy reported that blue oak trees in the Sierra Nevada foothills were able to take up labeled water placed in the water table over sixty-five feet below the soil surface. The rapid drop in XPPs and large shallow root biomass indicate that "negative" trees were dependent on water near the soil surface.

A Relationship Between Roots and Understory

These apparently different root morphologies were closely associated with the variation in understory productivities. Oaks with low understory productivities had high, fine root biomass in the shallow soil horizons also utilized by the understory species. Oaks with high understory productivities had low, fine root weights in the upper twenty inches of soil. The fundamental cause of these different root morphologies is not known, but several possibilities exist: genetic variation; tree age ("positive" trees sampled were larger than "negative" trees); a non-uniform deep substrate; or a change in lateral root production after death of the taproot or its failure to reach the water table. The latter two possibilities are supported by the observation that "positive" oaks appear to be more common in valleys and on lower slopes, whereas "negative" oaks appear to be more common on upper slopes. Many of the "positive" and "negative" trees we sampled, however, were within sixty-five to one hundred feet of each other and were intermixed along elevational gradients.

Maximum growth of ripgut brome plants at the end of the growing season under "negative" trees were significantly greater in oak root exclosures than they were in controls without exclosures. Under "positive" trees, however, the weights of ripgut brome in oak root exclosures and controls did not differ. Thus the exclusion of oak roots reduced the negative effect on ripgut brome by "negative" trees to large extent. These results indicate that much of this effect is probably due to interference mediated by oak roots.

In conclusion, both "positive" and "negative" trees appear to have the potential to improve understory productivity by delivering nutrients to subcanopy soils, but "negative" trees also appear to suppress understory productivity by means of large quantities of fine roots in shallow soils. The mechanism of this interference is not known. Climatic differences have been shown to correlate with regional differences in the effect of blue oak on its understory, but root morphology may ultimately determine where the cumulative effect of a blue oak tree falls on the continuum between facilitation and interference.

Throughout its range, blue oak has been extensively managed for both forage production and watershed improvement. Our finding that blue oak may vary in root morphology has implications for both forage management and watershed management.

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