Oak stand growth on California's hardwood rangelands

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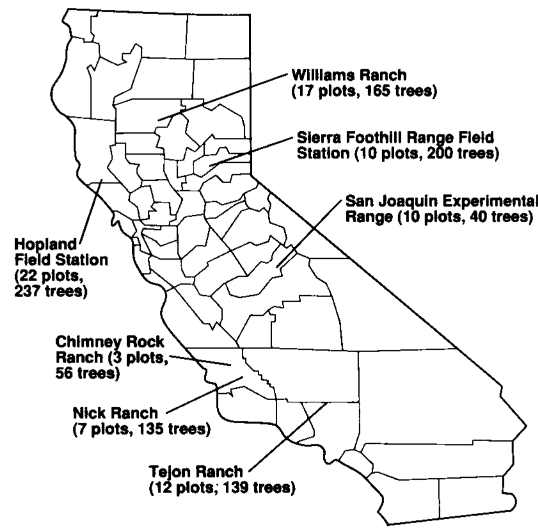
Estimating a stand's productivity is a preliminary step in devising management strategies for multiple uses of a site



The seven oak growth study locations represent varied geographic characteristics throughout the state's hardwood range area.

California has an estimated 7.1 million acres of hardwood rangeland, mainly composed of several oak species. These areas, predominantly privately owned, have been used primarily for livestock production, but the rising value of firewood in the mid-1970s made tree harvesting a profitable alternative use. Hardwood rangelands also provide critical habitat for many game and nongame wildlife species. Other public values include production of water supply and protection of water quality on watersheds, outdoor recreational opportunities, and intangible aesthetic features.

Subdivision of hardwood rangelands at a time of heightened environmental awareness has caused concern about the management of the oak trees on these areas. Questions have been raised about the long-term sustainability of oaks on these lands, because of the apparent poor regeneration of some species and uncertainty about the profitability of traditional range livestock operations. We therefore began a study to develop multiple-use management strategies that would improve profitability for landowners while protecting public values derived from privately owned hardwood range areas.

An important aspect of this study is a determination of oak tree growth and stand development at different levels of tree stocking. The oak canopy directly affects many interrelated resources, such as forage for livestock, wildlife habitat and income from recreational hunting, and income from firewood. Since we could find no statewide studies of tree growth on California's hardwood range, we developed a study plan to provide the data necessary to model tree growth relationships. The objective of the study reported here was to develop whole-stand basal-area-growth and volume growth relationships.

Methods

The seven representative study areas selected cover broad geographic characteristics througout California's hardwood range area. At each location, 3 to 22 plots of 0.1 acre each were randomly chosen in pure stands of blue oak (*Quercus douglasii*), as well as mixed stands of blue oak and interior live oak (*Q. wislizenii*) in the Sierra Nevada foothills, and blue oak and coast live oak (*Q. agrifolia*) in the coastal foothills. These study locations covered a wide range of stand density, species composition, and site quality. The 81 plots studied statewide were confined to sites that had a basal area of at least 50 percent blue oak, with the remainder of the mixed stands in either interior live oak or coast live oak.

At each plot, we collected data on tree species, individual tree diameter at breast height (DBH), basal area, individual tree total height, individual tree crown diameter, and individual tree radial growth over the preceding five and ten years. A total of 1,013 trees were measured.

The individual tree information was used for calculation of the following data for each plot: stand volume in cubic feet per acre; stand basal area in square feet per acre; percent stand crown cover; and periodic annual cubic foot and basal area growth over the previous five and ten years.

Results

Site index. Site index is a method of integrating the various elements of a site that contribute to tree growth, such as soil depth, fertility, slope, aspect, and rainfall, into one index number. Site index curves have usually been constructed by using the height of the dominant trees in a stand and their age as a proxy for site productivity. One interesting finding of this study is that this traditional method of assessing site quality in forest stands may not be useful on hardwood rangelands. During the field work, the difficulties of assessing age of the dominant trees became very apparent. Regular

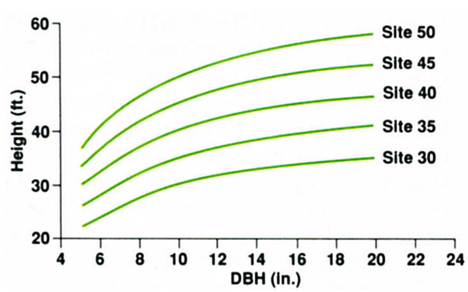


Fig. 1. Blue oak site index curves on hardwood rangelands for an index DBH (diameter at breast height) of 10 inches.

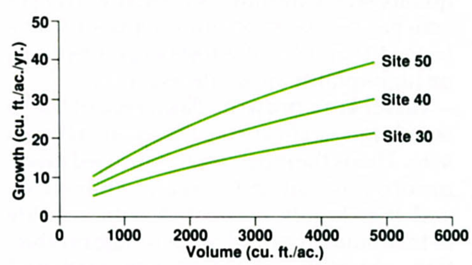


Fig. 2. Annual volume growth of stands of at least 50 percent blue oak for sites of low (site index 30), moderate (40), and high quality (50).

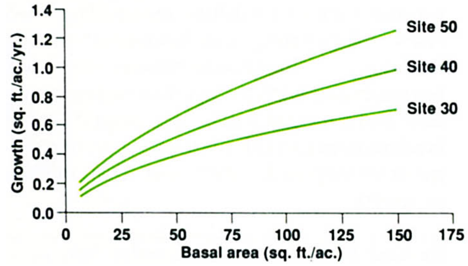


Fig. 3. Annual basal area growth of stands with at least 50 percent blue oak for sites of low, moderate, and high quality.

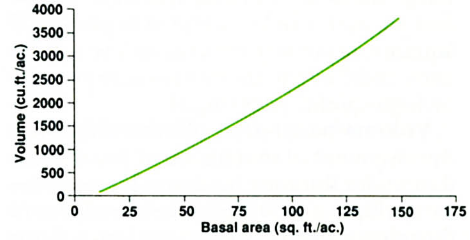
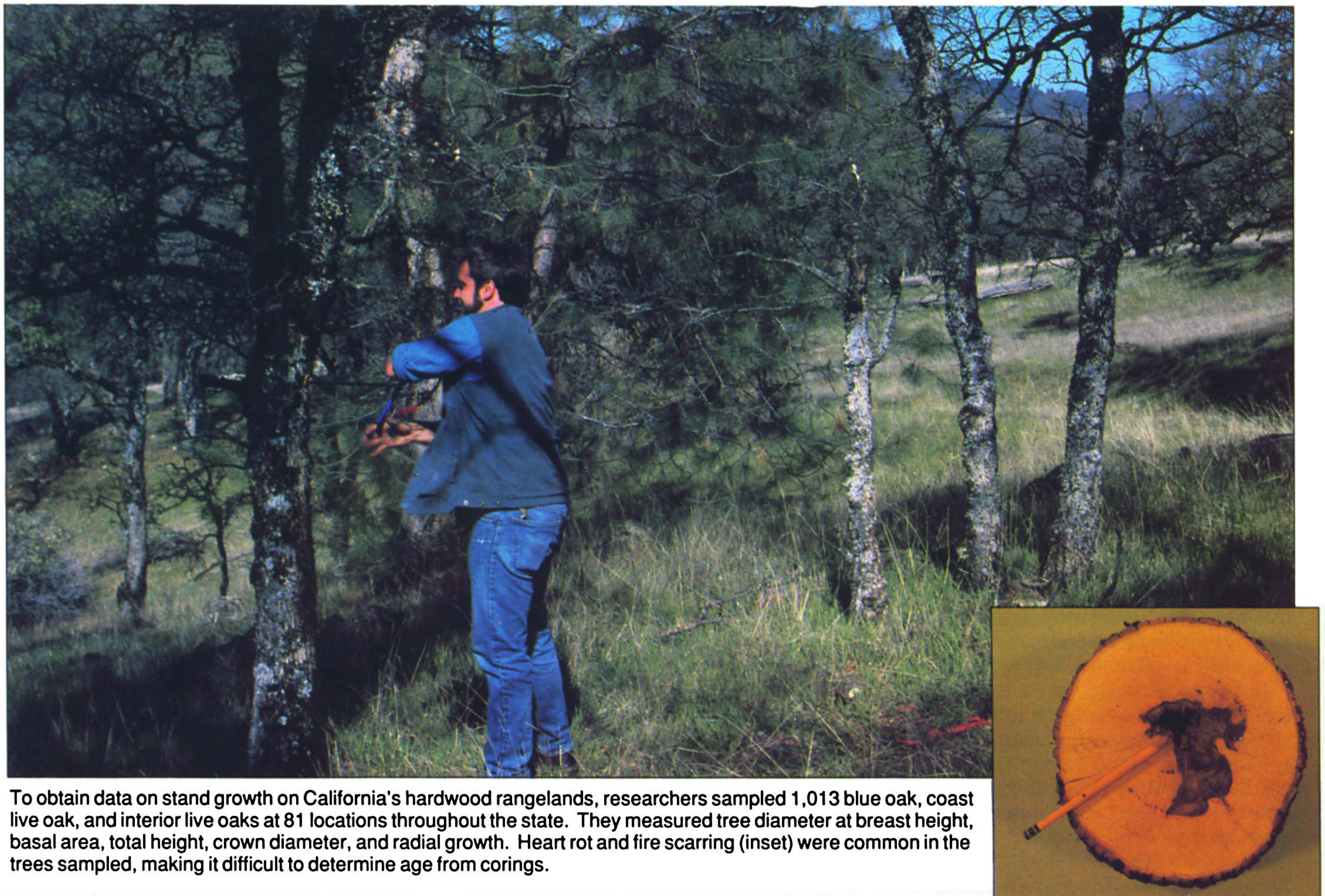


Fig. 4. Relationship between hardwood range basal area per acre and volume per acre for stands with at least 50 percent blue oak.



To obtain data on stand growth on California's hardwood rangelands, researchers sampled 1,013 blue oak, coast live oak, and interior live oaks at 81 locations throughout the state. They measured tree diameter at breast height, basal area, total height, crown diameter, and radial growth. Heart rot and fire scarring (inset) were common in the trees sampled, making it difficult to determine age from corings.

fire scars and the widespread occurrence of heart rot made finding total age from increment corings unlikely.

As an alternative approach, we used the relationship between tree height and diameter at breast height as a representation of site quality. This approach has been used in studies of uneven-aged forest stands in the eastern United States and for pinyon-juniper woodland stands in the Southwest. Site index under this concept is defined as the height attained by dominant trees at a standard DBH. The standard DBH used in this study was 10 inches. This means that the dominant trees in a stand with a site index of 40 feet would average 40 feet in height when the average DBH of these dominant trees was 10 inches. The taller the dominant trees for a given DBH, the higher the site index.

The site index equation was derived from statistical (regression) analysis of the relationship between tree height and diameter for the 204 dominant trees in the study sites. For example, a dominant tree with a 12 inch DBH and a total height of 42 feet would have a site index of 40 feet (fig. 1). The indexes for the 81 sample sites in this study ranged from a low of 24 feet to a high of 56 feet.

Cubic foot growth. Cubic foot stocking of the 81 stands in this study ranged from 66 cubic feet per acre (.8 cord) to 5,400 cubic feet per acre (64 cords). The average annual growth ranged from 2 cubic feet (.02 cord) to 51 cubic feet (.6 cord) per acre per year. Statistical analysis of cubic foot growth showed that both site index and total cubic foot volume were significant in predicting annual growth rate. These results are presented in figure 2 for hardwood range sites of low, medium and high productivity (site index 30, 40, and 50 feet, respectively). For example, a stand with a current volume of 2,000 cubic feet per acre can be expected to grow 12 cubic feet per acre per year on low-quality sites (site index 30), 18 cubic feet per acre per year on medium-quality sites (site index 40), and 23 cubic feet per acre per year on high-quality sites (site index 50).

Basal area growth. Basal area of the 81 stands ranged from 6 to 170 square feet per acre. This is the most commonly used measure of tree density in forest growth analysis, and it is highly correlated with wildlife habitat suitability and range forage production. As with volume growth, statistical analysis of basal area growth showed that both site index and total basal area per acre were significant in predicting annual growth rate. For example, a hardwood range stand with a basal area of 50 square feet per acre, can be expected to grow 0.37 square foot per acre per year on low-quality sites, and 0.65 square foot per acre per year on high-quality sites (fig. 3).

Volume/basal-area relationship. The development of management recommendations for thinning hardwood range areas for multiple uses will require knowledge of the relationship between cubic foot volume and basal area. Figure 4 shows the relationship derived from this study. Site index was not a significant variable in this case.

Conclusions

The four relationships presented for blue oak and mixed blue oak-live oak stands can be used to assess the productivity of hardwood rangelands with at least 50 percent of their basal area in blue oak. The height and diameter at breast height of the dominant trees in a stand and the stand basal area can be very quickly determined to assess the inherent productivity of a stand. Stand basal area and volume per acre can also be collected by timber cruising techniques routinely used in conifer forests. The relationships we have presented here can be used to estimate volume growth and basal area growth and to simulate the effects of thinning on stand growth and dynamics.

This work on oak growth on hardwood rangelands is a preliminary step to deriving multiple-use management strategies for landowners. Work on correlation of oak tree cover and stocking with forage production for livestock and wildlife, income from recreational hunting, and firewood value is under way. The growth relationships will be combined with these other resource values, and a model will be developed so that landowners can calculate oak tree management strategies for different sites on their property.

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