United States
Department of
Agriculture

Forest Service

Pacific Southwest
Forest and Range
Experiment Station

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Research Note
PSW–398

March 1988

Unusual Decline of Tanoak Sprouts

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McDonald, Philip M.; Vogler, Detlev R.; Mayhew, Dennis. 1988. *Unusual decline of tanoak sprouts*. Res. Note PSW-398. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 4 p.

Comparisons between abnormal and normal sprout clumps of tanoak (*Lithocarpus densiflorus* [Hook. & Arn.] Rehd.) in northern California indicated that sprouts in abnormal clumps had about five times the number of sprouts per clump, were three times as wide, and only one-fifth as tall. Stunted and chlorotic sprouts were examined for virus and disease organisms that might be used for biological control of this often weedy species. No pathogens or viruses that could account for the abnormal development were found in field or laboratory, but tests were not exhaustive. Decline could be from physiological events, unidentified pathogens or viruses, or lack of genetic exchange as a consequence of successive vegetative propagation.

Retrieval Terms: sprout development, disease, virus, tanoak, northern California

Root-crown sprouts of tanoak (*Lithocarpus densiflorus* [Hook. & Arn.] Rehd.) have high potential to dominate young conifers in plantations. Rapid expansion of sprouts aboveground and roots below makes planted ponderosa pine (*Pinus ponderosa* Dougl. ex Laws. var. *ponderosa*) and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) seedlings susceptible to shading and depletion of soil moisture and nutrients.[1] Lack of availability of herbicides on forest land in California and Oregon has caused foresters to consider other methods for controlling tanoak such as uprooting stumps, stump grinding, and preharvest burning. Unfortunately, these methods are untested on a large scale, and in general, are expensive. New methods for controlling tanoak are needed badly.

Abnormally developed and moribund sprout clumps of tanoak were noticed among healthy, well developed clumps in northern California (*fig. 1*). Possible reasons for this phenomenon were damage from diseases or viruses, or lack of adequate numbers of healthy tanoak shoots. The decline in sprout vigor could result from "increasing prevalence of fungi or obscure viruses in the root stocks."[2] The chance of a virus being the cause of decline was intriguing because of the possibility for developing a viral herbicide, much like the nucleopolyhedrosis virus being tested for suppression of the Douglas-fir tussock moth (*Orgyia pseudotsugata* McDunnough).

Little has been published on the pathogens associated with tanoak. This species has been reported as a susceptible host for Armillaria root rot caused by *Armillaria* species,[3] and for two species of powdery mildew (*Erysiphe trina* Harkn.) and (*Microsphaera alni* DC. ex Wint.).[4] Tobacco mosaic virus-like rods have been observed in tanoak leaves.[5] Subsequently, tobacco mosaic virus has been isolated from apparently normal tanoak foliage and symptoms of it induced in susceptible herbaceous plants with crude sap extracts.[6] A fungal vector for the virus was proposed.

Although the origin, development, and relationship of sprouts to the parent stump has not been investigated for tanoak, information[7-9] from other sprouting tree species probably applies. In general, sprouts develop from dormant buds located on the root crown or burl. Most buds are located beneath the bark, although some may be present on it. These buds connect with the primary xylem and move outward to the extent that the tree grows in radius each year. Some of the buds divide as they progress outward and thus the number of subsurface buds increases as the tree grows. Auxins, produced in terminal shoots, prevent the buds from developing. When the source of auxins is removed by cutting or fire, the dormant buds begin to grow. The young sprouts produce hormones in the growing leaves, and the leaves in turn act as a sink for material moving from the stump. New water conduction vessels and sieve tubes in the

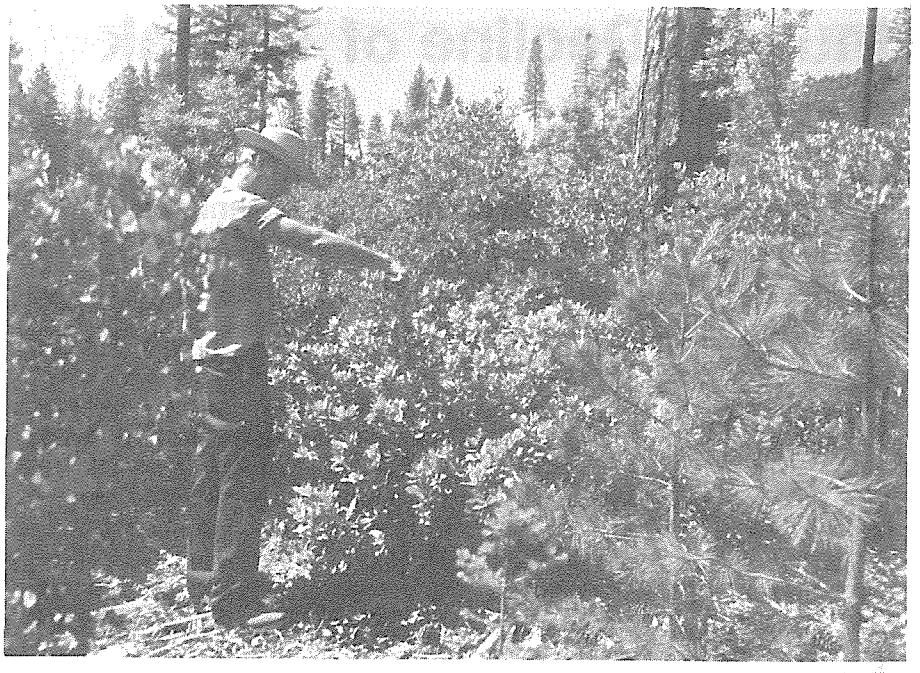

Figure 1—An abnormal tanoak clump on the Challenge Experimental Forest in northern California shows multiple stems and a flat top.

stump orient towards the growing sprouts. Consequently, each sprout is in direct vascular connection with the stump. Water and dissolved nutrients from the stump root system move into the sprout mostly through this direct connection and also by radial wood rays. Within a few weeks, the growing sprouts produce substances which inhibit development of the remaining buds. That part of the stump not physiologically connected with a sprout soon dies.

Tanoak is a vigorous sprouter. In northwestern California, 50 tanoak clumps were measured.[10] After 2 growing seasons the number of sprouts per clump averaged 27 with a range of 7 to 79. Average height was 1.3 m and crown diameter 1.4 m. In logged areas in southwest Oregon, tanoak sprouts numbered about 48 per clump at age 5 to 6.[11]

Information on the consequences of repeated vegetative propagation is scant. Although no cause was given, a general decline in vigor of hardwood coppice was noted in older European literature.[2] Continued decline was presumed. Further, experience indicated that coppice forests must be renewed from seed occasionally to restore the level of production. In Germany, however, oak coppices have been managed on short rotations for centuries without declining vigor.

This note reports a study of abnormal clumps of tanoak sprouts that develop from stumps following logging. Abnormal clumps were compared with control clumps and samples were examined for evidence of viruses or other possible pathogens. No virus, virus-like particles, or fungal isolates could account for the abnormal development. Possible reasons for the observed abnormalities are proposed.

STUDY AND SITE CHARACTERISTICS

The study site was located on the Challenge Experimental Forest in Yuba County, California. Because of moderate temperatures and plentiful rainfall, tanoak is abundant in this part of the Sierra Nevada. It often is found as single trees or in small groves. Occasionally, entire hillsides are occupied by the species.

The elevational range of tanoak on the Experimental Forest is between 760 and 976 m. Summers are hot and dry, and winters cool and moist. The average midsummer maximum temperature, based on 43 years of record, is 32°C; the midwinter minimum is -1°C. The growing season is about 200 days. Precipitation averages 1727 mm, with 94 percent falling between October and May. Soils are of clay loam-clay texture, are deep, moderately well drained, and quite fertile.

Stand age of tanoak, as determined by ring counts of freshly cut stumps in adjacent stands, ranged from 42 to 125 years in fall 1980 when the initial data were recorded. Nearly all trees originated by sprouting, and frequently two generations of sprouts were discernible. The study area was logged in spring 1972, and the slash piled by a bulldozer and burned in the fall. Before logging, the tanoak trees appeared to be healthy. All tanoaks were pushed over or sheared off by the bulldozer which eliminated about 50 percent of them. The remainder promptly sprouted. No herbicides or other toxic materials were applied in the area.

Stunted and chlorotic clumps of tanoak sprouts, although few and usually widely scattered in the Experimental Forest, were more prevalent in one area of about 40 ha located on a long continuous east-facing slope. This area was selected for the study.

METHODS

Reconnaissance indicated that about 30 clumps comprised the abnormal population in the study area. Among these clumps, nineteen were randomly chosen to represent the population. Each was measured for number of living and dead sprouts, average height, and crown width. In addition, the diameter of the parent stump or smaller stumps in the clump was measured. Age of the parent stump would have been desirable but was impossible to ascertain because of decay and logging damage. In several instances, the original stump had completely disappeared, leaving a depression surrounded by several smaller stumps. Data were gathered in 1980, and the clumps were reexamined in 1984.

Sampling for disease organisms in spring 1984 consisted of field examination of seven shrub clumps, including excavation of roots. Samples of stump wood, roots, and fungal fruiting bodies were gathered for further examination in the laboratory. This investigation involved microscopic examination of wood and fungal samples, and culturing for pathogens by placing wood samples in plastic bags with moist paper towels for one to three weeks.

In fall 1984, samples for virus testing were clipped from terminal ends of sprouts from six abnormal tanoak clumps, as well

as entire sprouts from two additional abnormal clumps. Samples from two healthy sprout clumps were collected as controls. Similar samples were gathered in spring 1985 when leaves were one-half to three-fourths expanded. Laboratory analyses were performed at the California State Department of Food and Agriculture, Division of Plant Industry, Analysis, and Identification unit in Sacramento.

Leaf dip preparations were made by touching freshly cut surfaces of leaves to droplets of 2 percent phosphotungstic acid, pH 6.8, on Formvar-carbon-coated copper grids and were examined with a Zeiss EM 9S-2 electron microscope. Leaf material also was embedded in Spurr's low viscosity epoxy embedding medium after fixation in 3 percent glutaraldehyde (buffered with 0.01 M Na-K phosphate buffer, pH 7.2) and postfixation with 2 percent OsO_4 for 1 hour. The embedded material was later sectioned, stained for 10 minutes in uranyl acetate (30 pct w/v in absolute methanol), and examined with the electron microscope.

RESULTS AND DISCUSSION

When compared to the control clumps, the abnormal sprout clumps were shorter and wider with unusually slow growth. Height of abnormal sprouts was similar and each clump tended to be remarkably flat topped. Number of sprouts per stump was many times that of normal development. Because leaf color was yellowish green to bright yellow, clumps were easily seen in dense brush. At no time were leaves observed to be chewed, mined, or otherwise affected by insects or animals. Amount of leaf pubescence was similar on normal and abnormal sprouts.

In 1980 or 8 years after logging, 14 of the 19 abnormal sprout clumps were from large single stumps and 5 were from clumps of stumps with 2 to 4 smaller stumps in the group. One of these groups had no living sprouts; all had recently died. Several of the sampled clumps had 10 to 20 dead sprouts, and one had 75 alive and 50 dead. Average height of the sprouts was 1.0 m; crown width was 1.9 m *(table 1)*. In contrast, normally developed sprouts were almost 4.8 m tall and 2.7 m wide.[12] The height-width ratio for normally developed clumps was 1.8:1; for abnormal clumps 0.5:1. Furthermore, in normal clumps one or more stems assume dominance by age eight and the shape of the crown is convex or even conical—not like the flat-topped crowns of the abnormal sprout clumps. Average number of living and dead sprouts per abnormal clump was 155, several times more than reported for younger normal clumps in the literature. The average diameter of parent stumps 10 to 15 cm above mean groundline in the study was 40.6 cm in a range of 30.5 to 61.0 cm. Because average diameter 10 to 15 cm above groundline of normal tanoak stumps on 12 growth plots (1195 trees total) was 26.9 cm, these were large trees relative to the age of stand and environment of the Experimental Forest.

Each sample clump was reexamined and remeasured in 1984. Average height of the sprouts had increased about 5 cm, average crown width had remained the same, and a few more sprouts had died in each clump. The one clump that had 50 dead now had about 75. Although crown width had not declined, future decreases are likely because adjacent vegetation is beginning to overtop the clumps.

Examination in field and laboratory revealed no fungal pathogens that could account for the abnormal condition of the sprouts. The only fungus isolated was *Stereum hirsutum* (Fr.) Fr., which causes a soft uniform white sap rot of hardwoods. The fungus was identified by typical wood decay and by fungal fruiting bodies attached to dead portions of the stumps. This organism is a saprophyte and colonizes only dead material. Examination in the laboratory indicated no cytological evidence for the presence of virus or virus-like particles, or mycoplasma-like organisms. These examinations, however, should be considered as superficial, and do not rule out the presence of pathogenic fungi or viruses other than the tobacco virus mosaic.

Another possible reason for the unusual decline of the tanoak sprouts is physiological. Even though the number of sprouts per clump is high, leaf area may not be high enough to sustain the large root system of the parent stump. Loss of fine roots and lack of new ones then might affect water and nutrient uptake, shoot elongation, and growth regulator relations. For *Quercus pedunculata* Ehrh. (now *Q. robur* L.) the condition for full preservation of life in the root system of the parent tree was a sufficient quantity of healthy shoots and, most important, their dispersal along the periphery of the stump.[13] Furthermore, "until the age of ten years the oak coppice growth lives almost exclusively off the root system of the parent tree." A photosynthetic threshold below which a healthy parent stump root system is not sustainable has been proposed for redwood (*Sequoia sempervirens* [D.Don] Endl.).[14]

Table 1—*Characteristics of abnormal tanoak sprout clumps after 8 years, Challenge Experimental Forest, Yuba County , California, 1980*

Parent stump diameter (*cm*)		Stump crown width (*m*)		Sprout height (*m*)		Sprouts per stump	
$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
40.6	8.9	1.9	0.4	1.0	0.2	155	44

A second physiological reason for the decline of the sprouts may be due to constriction of the sprout by the bark. After the buried bud breaks through the bark, the bark surrounds a relatively small area. Although the expanding sprout may have a thick, swollen-appearing attachment, the actual vascular connection between stump and sprout may be severely constricted. Such a constriction would be more likely on old, large diameter stumps having thick bark—a finding noticed in eastern *Quercus*.[15]

Because abnormal development took place only on sprout clumps arising from quite large (and presumably older) stumps, it could be a consequence of successive generations of sprouting. In the absence of genetic exchange, the vegetatively propagated sprout clumps may lack the ability to respond to a changing environment. Excessive sprout production may represent a distress response similar to a distress crop of seeds.

For solving the brush problems of southwestern Oregon, research on "biotic agents (insects, diseases) which might prove useful in controlling important brush species" was recommended.[16] Viruses also should be considered. That none were found in the current study does not mean that none exist. Little detailed research has been done on the pests of tanoak, and much is needed to explore their role in potential biological control of this and other hardwood species.

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