

# Uprooting and Trenching to Control Annosus Root Disease in a Developed Recreation Site: 12-Year Results

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**ABSTRACT:** Six annosus (*Heterobasidion annosum*) root disease centers in a proposed campground on the north shore of Big Bear Lake in southern California were treated in 1989. Trees, stumps, and roots were removed in six disease centers, and in two cases, soil trenching was used to stop the progress of the disease. A total of 154 trees and 26 stumps were removed; 300 linear feet of trenching was done around two disease centers. Of 101 trees sampled, 47% were infected with *H. annosum*. Sixteen percent of infected trees exhibited no visible crown symptoms. The pathogen was isolated from 50% of roots that showed resinosis and 14% of roots not exhibiting resinosis. Only the P biological species was present on living, infected Jeffrey pine and juniper roots. Twelve years after treatment, all six sites appear to be disease free with no aboveground symptoms of root infection. Tree mortality is continuing on untreated disease centers in this recreation area. *West. J. Appl. For.* 20(3):154-159.

**Key Words:** Root disease, *Heterobasidion annosum*.

Annosus root disease (ARD), caused by *Heterobasidion annosum*, is widespread and damaging in southern California recreation sites (Bega and Smith 1966). In addition to creating hazardous trees, the disease results in unwanted openings and depletion of desirable vegetative cover. ARD is a major limiting factor in establishing and maintaining conifers in many southern California recreation sites and, as a result, the recreational values of the sites are reduced. A 1978 survey (Wood 1978) in the proposed Big Bear Lake North Shore Recreation Area, San Bernardino National Forest, identified 43 annosus root disease centers. Annosus root disease similarly impacts other campgrounds in southern California. For example, about 40% of the 12-ac Barton Flats Campground, also on the San Bernardino National Forest, is infested with ARD and about six to eight pines are killed each year on this site (Allison, personal observations). Natural regeneration of conifers is nonexistent in the disease centers, and young trees on the margins continue to develop symptoms and die. Heavy impacts are also observed in recreation sites on the Cleveland and Los Padres National Forests. The ARD problem must be minimized in heavily

used recreation sites if a safe and satisfactory recreational experience is to be provided.

*Heterobasidion annosum* attacks a wide range of woody plants. Two host-specific biological species have been identified in California. The P biological species infects pines, incense-cedar, western juniper, and certain hardwood species. True firs, Douglas-fir, spruce, western redcedar, giant sequoia, and western hemlock are attacked by the S biological species.

Airborne spores produced in *H. annosum* basidiocarps land and germinate primarily on freshly-cut stump surfaces. The fungi then colonizes the stump wood and grows into the root system. Spread from the infected stump roots is via root contacts and root grafts with adjacent, susceptible conifers. This tree-to-tree progression results in an enlarging circle, or infection center, occupied by dead or dying trees (Orosina and Scharpf 1989). Infection centers may continue to enlarge until they reach barriers to expansion, such as large open areas devoid of susceptible root systems or areas dominated by nonsusceptible tree species.

*Heterobasidion annosum* may remain alive in infected roots or stumps for many years (Smith 1983). Susceptible conifers established within infection centers often die shortly after their roots contact roots of previously diseased trees. Because all conifers are susceptible to annosus root disease, attempts to revegetate ARD centers in recreation sites are now limited to conifers resistant to the existing

NOTE: John T. Kliejunas can be reached at (707) 562-8914; Fax: (707) 562-9054; jklijunas@fs.fed.us. The authors extend their appreciation to Ernie DelRio, former silviculturist on the San Bernardino National Forest, for study encouragement, support, and coordination. This article was written by U.S. Government employees and is therefore in the public domain.

biological species (P or S) of *H. annosum* on the site. Hardwoods or nonsusceptible brush species are also alternatives, but these are difficult to establish in the drier regions of California.

Under climatic conditions occurring in much of California, *H. annosum*-infested woody material may take up to 50 years to break down (Smith 1983). Within this time period, infection is possible in newly established susceptible conifer species, whether they are naturally or artificially regenerated. One direct control method for ARD is to remove infected stumps and roots. Because the pathogen is transmitted locally via root contacts with infected woody material, removal of such inoculum from the soil should allow for successful and timely establishment of susceptible conifers in these previously active infection centers. This theory forms the basis for stump-root extraction or "stumping" of sites prior to replanting with susceptible species. In other situations, stopping ARD progression by creating a buffer zone around an infection center may be feasible. To accomplish this, inoculum removal, removal of conifers at the margin of the infection centers, and trenching to break root contacts and to create a buffer strip between healthy and diseased trees are carried out. An attempt to halt spread of ARD by trenching to a depth of 6 to 7 ft, followed by soil fumigation, was unsuccessful in Eddy Arboretum, Institute of Forest Genetics, Placerville, California (Srago 1976), presumably because infection of roots beyond the trench had already occurred.

On the other hand, efficacy of removing infected roots during stand harvest to restore timber productivity has been demonstrated in commercial timber stands with *Phellinus weirii* and *Armillaria ostoyae* root disease. (Arnold 1981, Bloomberg and Reynolds 1988, Morrison et al. 1988, Thies 1984, 1987, Wallis 1976). Similar to *H. annosum*, these fungi are spread via root-to-root contacts. Bloomberg and Reynolds (1988) compared equipment for removing residual woody roots. They found that a large backhoe (180 horsepower) was most effective, and concluded that levels of inoculum were reduced below those likely to result in sufficient root contacts to produce infection in the newly regenerated stand. Pushing over infected trees, followed by removal of roots by machine and by hand, reduced mortality caused by *Armillaria ostoyae* in a ponderosa pine forest (Roth et al. 2000). Removal of red pine (*P. resinosa*) stumps infected with *H. annosum* has eradicated the disease on relatively small, infested sites in a Quebec plantation (Laflamme and Blais 1997).

The objective of this study was to determine the feasibility of establishing and maintaining vegetative cover in developed recreation sites by uprooting *H. annosum*-infested stumps and trees, and by trenching, to directly control annosus root disease.

## Methods

### Study Location and History

Big Bear Lake in southern California is a 3,000-ac reservoir created in 1884. Because public access to the lake was limited but desired, the Forest Service purchased 420 ac

along the north shore to provide recreation opportunities. Vegetation in the area consists of Jeffrey pine (*Pinus jeffreyi*) in the overstory, and Jeffrey pine, western juniper (*Juniperus occidentalis*), and single leaf pinyon (*Pinus monophylla*) in the understory. Curl leaf mountain mahogany (*Cercocarpus ledifolius*) is the only native hardwood in the immediate area.

In 1978, the San Bernardino National Forest proposed to develop the north shore area of the lake for recreation use by about 1,750 people per day. Maintaining the natural forest appearance was also a key objective. Proposed development included a campground (now named Serrano), amphitheater, day use area, and trails. Although no major logging activity historically had taken place within the area, numerous stumps and lack of snags throughout the site indicated that salvage of dead trees had been a continuous management practice for many years, probably dating back to the mid-1800s.

Because a stand examination conducted by the forest silviculturist in 1977 suggested that ARD was common in the area and causing damage, the Forest requested Forest Health Protection (FHP) to provide recommendations on how to maintain vegetative cover in and around the ARD centers. Forest Health Protection conducted a detailed survey in 1978 of sites proposed for development (Wood 1978). A total of 46 root disease centers, 43 caused by *H. annosum*, two caused by *Armillaria* sp., and one caused by *Leptographium wageneri*, were located over about 800 ac, mapped, referenced to control points used in surveying the campground, and marked on aerial photographs. Recommendations made by FHP for disease control included removal of trees exhibiting symptoms of root disease and removal of those that would probably die in the next 5 years, based on proximity to symptomatic trees. A total of 125 trees were banded by blue and white flagging and tagged at the base with numbered metal tags facing into the infection centers. It was suggested that removal of the trees could be delayed until just before or during construction to better determine the rate of decline due to *H. annosum*.

Final plans for development of the area, by then known as the Big Bear Lake North Shore Recreation Area, were completed in 1988.

### Site Descriptions

In May of 1988 the proposed development was re-surveyed by FHP and Forest personnel, and most of the root disease centers identified in 1978 were re-located. Six active annosus root disease centers appeared suitable for our study to determine the feasibility of direct ARD control (Figure 1). The six sites were chosen because they had relatively discrete, active infection centers with distinct margins between dying trees and healthy appearing trees in the surrounding forest. Site one was a small, active center, advancing at its southern margin into an adjacent, healthy Jeffrey pine stand. Sites two and five were active disease centers advancing east, south, and west into adjacent Jeffrey pine stands. Site three was an approximately 0.75 ac, very open, disease center actively advancing south into a stand of 10 to

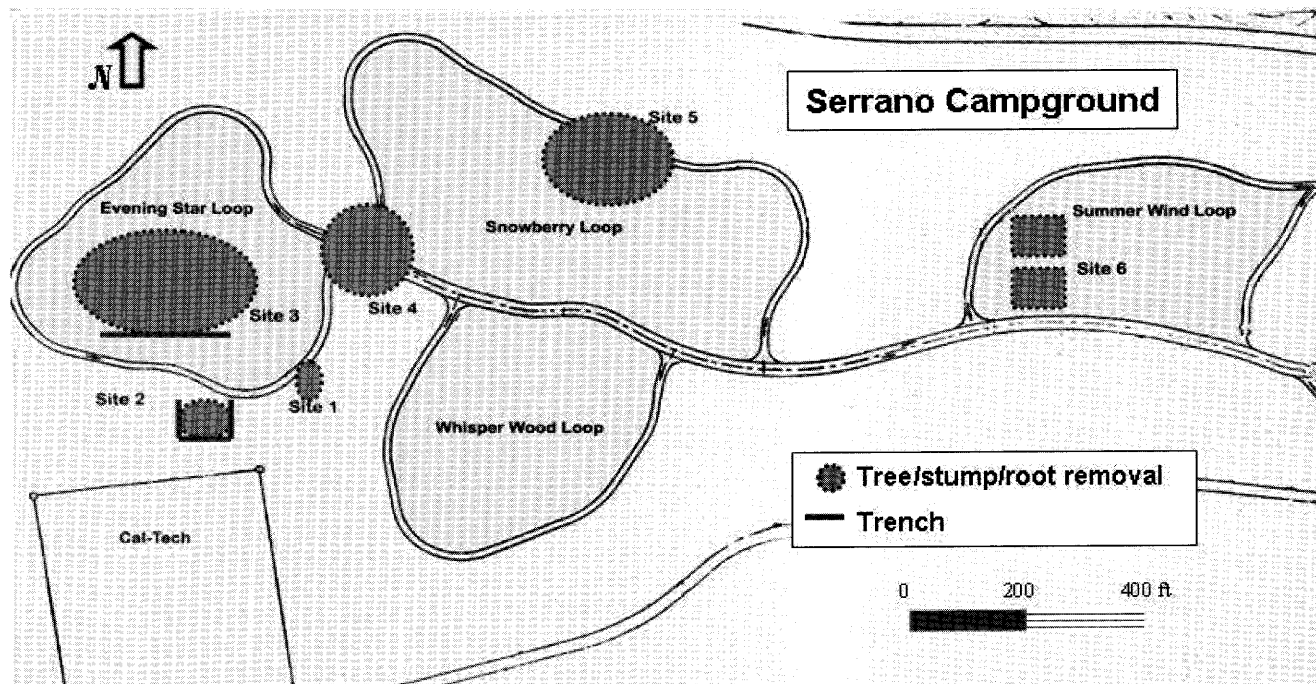


Figure 1. Location of annosus root disease centers at Serrano Campground, San Bernardino National Forest.

36 in. diameter at breast height (dbh) Jeffrey pine. Site four was an active disease center with numerous dead and dying western junipers present. Site six consisted of two root disease centers, one treated and one not, to demonstrate any differences in survival following planting of susceptible trees in the untreated center and in the center with inoculum removed.

### Treatments

Treatment of the sites began in July 1989. These included removal of living conifers and their root systems, and removal of conifer stumps and roots at all six sites; and trenching at margins of active disease at two sites (Figure 1). Inoculum removal was done in an attempt to cleanse the site while trenching was done to prevent root-to-root-spread of the pathogen into adjacent uninfested stands.

**Tree, Stump, and Root Removal.**—All conifers, stumps, and visible roots were removed with a backhoe within selected ARD centers (sites one through five). Site number six was split into two portions, one portion with a disease center that was treated by stump and woody inoculum removal, and one portion with a disease center that was not treated. The “centers” at the six sites were defined as discrete areas with symptomatic conifers. At sites one, two, four, five and six, only symptomatic living trees were removed at apparent margins of the centers. No attempt was made to create a buffer by removal of trees with no aboveground symptoms at the margins. At site number three, roots of trees at the southern margin of the disease center were examined and removed. If decay or resin soaking indicative of *H. annosum* infection were found, an additional tree into the healthy stand was removed. The three pieces of equipment used in this operation were a

rubber-tired model 755 backhoe, a model 977 loader, and a dump truck.

Smaller-diameter (about 4 in. or less dbh) Jeffrey pine and juniper were grasped by the bucket of the loader, lifted out, and removed (Figure 2). Trees 4 to 12 in. dbh were pushed over by the loader bucket or, alternatively, the bucket was lowered and the tree lifted out at the groundline and pushed over.

Two methods to remove trees larger than about 12 in. dbh were tested. Stems were either pushed over with the raised bucket (Figure 3), allowing the weight of the tree to dislodge the roots from the soil; or the stems were cut and the remaining stump and roots then lifted out. Pushing over



Figure 2. Smaller diameter Jeffrey pines were pulled out with the bucket of the loader.