



# County of Santa Cruz

0091

## OFFICE OF THE AGRICULTURAL COMMISSIONER

**DAVID W. MOELLER**  
AGRICULTURAL COMMISSIONER  
SEALER OF WEIGHTS AND MEASURES  
DIRECTOR, MOSQUITO AND VECTOR CONTROL

December 2, 1999

Agenda Date: December 14, 1999

### BOARD OF SUPERVISORS

County of Santa Cruz  
701 Ocean Street  
Santa Cruz, CA 95060

### Report of the Scientific Task Force on Oak Decline

Dear Members of the Board:

At your September 28, 1999 meeting, your Board directed the Agricultural Commissioner and the County Fire Chief to assemble a Scientific Task Force to examine the decline and die off of oak trees in the County and to report back to your Board on December 14, 1999, with recommendations on how the County and affected property owners could respond to this problem.

The Task Force was established on October 7, 1999, and met on October 20 and November 15. The Task Force addressed issues including the extent and cause of the die off, the risk to live oaks, various control methods including the use of pesticides for bark beetle control, public education, and current and proposed grant-funded research on oak decline and disease. The Task Force's findings, a summary of their work in progress, and recommendations for your Board's consideration are described in the attached report. The Agricultural Commissioner and the County Fire Chief and their respective staff members support the recommendations of the Task Force.

It is therefore RECOMMENDED that your Board:

1. Accept the *Report of the Scientific Task Force on Oak Decline* and direct the Agricultural Commissioner and County Fire Chief to carry out the recommendations of the Task Force.

Respectfully submitted,

David W. Moeller, Agricultural Commissioner  
for  
Steve Wet-t, County Fire Chief  
Members of the Scientific Task Force

Approved:



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SUSAN A. MAURIELLO  
COUNTY ADMINISTRATIVE OFFICER

Attachment

cc: County Fire Chief Steve Wert  
Scientific Task Force Members

**REPORT OF SCIENTIFIC TASK FORCE ON OAK DECLINE, December 14, 1999**

Primary authors: James Nee, Agricultural Commissioners Office

Geoff Holmes, CA Dept. of Forestry & Fire Protection

**EXECUTIVE SUMMARY**

- 1. Tanoak trees are dying in large numbers in Santa Cruz County. California live oak trees are also dying, but in lesser numbers.**
- 2. The primary cause of the tanoak die off is unknown at this time. Implicated possible causes are beetles, fungi, and weather, which may be operating separately or in combination.**
- 3. It is known that the Western oak bark beetle and ambrosia beetle feed on and reproduce in dead and dying tanoaks. Also the pathogenic fungus *Hypoxylon thouarsianum* has been found in dead and dying tanoaks.**
- 4. There have been confirmed reports of a number of California live oak trees dying in parts of Scotts Valley and in the Santa Cruz Mountains.**
- 5. We expect the intensity of the die off to decline over the winter due to seasonably cooler temperatures and, if beetles are a cause of the deaths, the life cycle of these insects. We cannot predict the extent of a possible resurgence.**
- 6. The first reported tanoak die off in California was in Marin County in 1995. It is now occurring in the counties of, Mendocino, Sonoma, Marin, and more recently in Santa Clara, Santa Cruz, and Monterey counties. There is an unconfirmed report of tanoaks dying in unusual numbers in Santa Barbara County.**
- 7. The extent of the tanoak die off in Santa Cruz County appears now to be limited to trees northwest of Old San Jose Road and possibly up to the San Mateo County line. However, this conclusion needs to be confirmed.**
- 8. Landowners can help to control the spread of bark beetles by (a) cutting down dead oak trees, sawing them to fireplace length, stacking, and covering them tightly with thick plastic, (b) avoiding the movement of oak logs to new sites within the county and outside, (c) providing proper cultural care to live oaks, and (d) the very limited application of pesticides.**
- 9. Preliminary research shows that spraying California live oak trees with a pesticide to control bark beetles may have some merit. Such treatment should be reserved for ornamental or specimen trees within active zones of the infestation. It is not practical, feasible, or even desirable to encourage the widespread use of pesticides.**
- 10. The presence of dead tanoaks and California live oaks in the forest has not significantly**

increased the risk of fire, however, this may change if the die off continues.

**11. Scientific research will help to reveal the breadth and possible causes of the problem. Two proposed scientific studies are designed to do this and may reveal whether county live oaks are in jeopardy.**

## INTRODUCTION

On September 28, 1999, the Santa Cruz County Board of Supervisors directed the County Agricultural Commissioner and the County Fire Chief to form a Scientific Task Force to examine and report on the extraordinary mortality of oak trees occurring in the county. The Board acted in response to the concerns of many County residents. The Board directed the task force to report to them by December 14th on what the county can or should do to respond to the oak decline and to describe environmentally sound measures which property owners can use to deal with the decline. The task force was established on October 7th and met October 20 and November 15. Members of the task force are listed at the end of the report. The group herewith submits this report on the oak decline to the Board for their review and acceptance.

## EXTENT AND CAUSE OF DIE OFF

In Santa Cruz County the **tanoak** (*Lithocarpus densiflorus*) die off first came to wide public attention this spring. There are reports that the problem was present here to a minor extent in 1997 and 1998. Tanoaks in several parts of the northern California coast have been dying over several years. An unusual number of dead tanoaks have been seen in Del Norte County at Redwood National Park; at scattered sites in Mendocino County; in Sonoma County; in Marin County at Mt. Tamalpais State Park, Golden Gate NRA, and Muir Woods National Monument; in Santa Clara County along Highway 17; and in the Big Sur area of Monterey County. At some of these sites California live oaks (*Quercus agrifolia*) are also dying at an accelerated rate. In Santa Cruz County there are confirmed reports of a substantial number of oak deaths in Scotts Valley and the Santa Cruz Mountains. The cause of mortality is unknown but there are several suspects.

The pathogenic fungus *Hypoxyton thouarsianum* has recently been found by plant pathologist Dr. Ted Swiecki in tissue of dead tanoaks collected in Marin County. He reports this fungus has long been seen in association with cankers on declining and recently killed California live oaks (see Reference 2H).

During the autumn of 1999 pathologists from the California Department of Forestry and Fire Protection (CDF) and the California Department of Food & Agriculture evaluated plant tissue collected from several tanoaks in Scotts Valley. They found no pathogen which could, by itself, cause such a precipitous tanoak decline as is apparently occurring in our county.

Oak bark beetles and ambrosia beetles are no doubt associated with the tanoak decline, but, based on present information, they are not the primary cause. Regarding California live oaks, we suspect the large population of beetles emerging from tanoaks presents a threat to stressed live oaks. However, we lack sufficient scientific proof to primarily blame bark beetles and ambrosia

beetles for live oak deaths in the county.

The oak mortality could also be the result of a combination of environmental and biological factors making them especially susceptible to pathogens and insects. These factors could include (1) stress on oaks from the drought of 1984-94, the wet winters of 1995, 1996, and 1998, and the dry 1997 (see Reference 2D), (2) an especially high oak bark beetle population in 1999, (3) the advanced age of central coast oak trees, (4) the natural shading out of **tanoaks** by the taller redwoods in the coastal forest and, (5) other environmental conditions.

As Dr. Swiecki has said, "If **tanoak** decline is similar to most other forest declines, it is unlikely that a single culprit will surface. It is likely that **tanoak** decline results **from** a complex of interacting factors, including the current status of **tanoak** stands, environmental conditions, and an array of native pathogens and insects." (see Reference 2H)

### **ARE COUNTY LIVE OAKS AT RISK?**

There is insufficient information for us to determine if a significant number of California live oaks in the county are at risk. We have a strong suspicion that the dead and dying **tanoaks** may have spawned a dramatic increase in the number of beetles that spill over onto and overwhelm the California live oaks. When an especially abundant population of bark and ambrosia beetles intensively attacks live oaks they can kill those trees, but we are not certain the present very high number of beetles is responsible for the deaths of our oaks.

Where the **tanoaks** and live oaks grow adjacent to each other there is a clear danger of beetles from an infected **tanoak** attacking a nearby live oak.

### **CONTROL OF OAK MORTALITY**

It is impractical to try to control the mortality of **tanoak** and California live oak in native forests, even if we knew the cause of their decline. The trees are too numerous, scattered, and remote to accomplish more than token control. However, one step that landowners can take to reduce the spread of **wood** boring beetles is to remove as many dead oak trees as possible. Trees should be cut down sawed to fireplace length, stacked, and tightly covered with thick clear plastic to confine and kill emerging beetles. Fresh cut oak stumps should also be sealed with clear plastic. Small tree branches should be chipped and spread on the ground. If it is impractical to seal and chip the wood, the sawed logs should be cut to very short lengths to enhance drying. (see Reference 2E)

The movement of oak logs around the county and out of the county may aid the spread of the beetles. Homeowners and campground users should be discouraged from transporting oak firewood to new sites. Commercial firewood cutters and retailers operating in the county should securely cover oak firewood when transporting it to customers so as to **minimize** the escape of beetles along the travel route.

In landscaped areas several things can be done to help protect California live oaks. Landowners

should apply Integrated Pest Management, i.e., use several control techniques but start with the least environmentally intrusive technique. First, remove dead trees as described above. Second, landowners should provide optimum growing conditions for their trees. Creating these conditions will help to control insects such as the oak moth caterpillar and identified diseases and reduce stress to the trees. There are many publications available to landowners that can help enhance oak growing conditions (see References 2B and 2C). Also a licensed arborist can give important advice on proper watering, mulching, aeration, fertilization, pruning, etc. of oaks. Lastly, it may be necessary to apply a pesticide to control the beetles. However, pesticides should **not be** the landowners' first means of control. A permethrin insecticide could be applied to the surface of oak tree trunks up to about 10 ft. above the ground. The pesticides Astro and Dagnet, made by the FMC Corporation, are 36.6 percent permethrin and labeled in California for bark beetle control. The company has recommended that the products be applied by a licensed pest control operator, not by a homeowner. Other less concentrated permethrin products may be available from garden supply stores. Advice on those products can be sought from the retailer or the County's Master Gardener program (phone 763-8007). If a pesticide application must be done, it should be done in the spring and again in the fall before bark beetles emerge to invade new trees. Research proposed for next year will help to determine the proper timing of applications.

**The Task Force wants to emphasize** that we do not know with certainty that the application of permethrin will protect oaks **from** whatever is killing them. However, we understand that it will exclude oak bark beetles and ambrosia beetles from the trees for several months.

## **PUBLIC EDUCATION**

Task Force member Steve Tiosvold and his associate **Pavel** Svihra have written a brief landowners guide to help protect **California** live oaks. (see Reference 2I)

## **RESEARCH GRANT REQUESTS**

Specific information on the oak die off and how to control it will be developed as the research described below progresses.

In late November Task Force member Rick Standiford received a \$46,000 grant for the Integrated Hardwood Range Management Program (IHRMP) at the University of California, Berkeley, to:

- (1) Collect basic information on the mechanism causing the oak mortality
- (2) Develop, test, and ground-truth a suitable reconnaissance method for surveying patches of diseased oaks and for determining the extent of the mortality
- (3) Develop oak management recommendations
- (4) Determine the long-term IHRMP response to this mortality, e.g., needs for education and research.
- (5) Produce a final project report by July 1, 2000

Task Force member Steve Tiosvold is a member of the research project team. Also, Dr. U Win, a GIS consultant who is assisting with the county's Santa Margarita Water Basin study, will be cooperating with Dr. Standiford on part of the oak research. Dr. Standiford said that studying the oak decline in Santa Cruz County will be a high priority and he would like to use our Scientific

Task Force as a review forum for his final report.

U.S. Forest Service plant pathologist Susan Frankel of **Vallejo**, in conjunction with other agencies, has submitted a grant request to her USDA Forest Service Washington, D.C., Office for **\$50,000** to:

- (1) Determine the extent and severity of the **tanoak** and live oak decline in coastal California
- (2) Observe all aspects of the decline and evaluate the associated environmental factors
- (3) Determine the extent of mortality in other oak species at stands adjacent to dead or dying **tanoaks**

If Ms. Frankel's grant is approved, she and Dr. Standiford have agreed to work together so their study products will not overlap.

Task Force member Fred McPherson is seeking \$2,000 from undefined sources to support tabulation, mapping, analysis, and presentation of oak mortality data which would be gathered in the field by trained volunteers of the Santa Cruz Chapter of the California Native Plant Society. The report would be used to help ground-truth aerial imagery produced by the above two research projects.

Task Force member Steve Tjosvold and his associate Pavel Svihra are seeking a grant to determine the efficacy and longevity of the permethrin insecticides Astro and Dragnet in protecting California live oaks from bark beetle attack. Study sites will be in the Santa Cruz Mountains and **Marin** County.

## **CALIFORNIA FOREST PEST COUNCIL**

As a result of efforts by Task Force member Jack Marshall, the influential California Forest Pest Council, at their November 18th annual meeting, resolved to support **identifying** primary California live oak and **tanoak** mortality agents and possible environmental factors that may cause the decline. They also supported development of a management plan for this threatened resource. They further resolved to:

- “1. Encourage the Director of the USDA Forest Service's Pacific Southwest Forest and Range Experiment Station to dedicate funding and personnel to appropriate oak and **tanoak** projects,
- 2. Encourage the Regional Forester of USDA Forest Service's Pacific [Southwest] Region to seek [USDA] State and Private Forestry funding to be encumbered for, or dedicated to, appropriate oak and **tanoak** projects,
- 3. Encourage State and Federal legislators to seek respective State and Federal appropriations for the purpose of funding above suggested research and management guideline development,
- 4. Encourage the University of California to fully fund the current oak and **tanoak** research request from its Integrated Hardwood Range Management Program, and
- 5. Encourage the University of California to request that the newly **filled** extension plant pathologist position at UC Berkeley help evaluate the current, and spreading, oak and **tanoak**

mortality problem.”

## RECOMMENDATIONS

We request the Board of Supervisors to support these recommendations:

1. The Agricultural Commissioner's Office, the Office of the County Fire Chief, and the county's U.C. Agricultural Extension Service prepare and present a public information program concerning the **dieoff** to local service clubs, professional nurserymen, **arborists**, and other appropriate groups in the county.
2. The Task Force **not** be dissolved before December 31, 2000, to enable the group to quickly respond to a possible resurgence of **tanoak** mortality, to reconvene in the summer of 2000 to determine whether progress in research would enable identification of the cause and control of the oak decline, and to provide a forum for researchers studying oak decline to have their reports peer reviewed,
3. In April 2000, the Agricultural Commissioner's Office and the Office of the County Fire Chief prepare a status report for the Board of Supervisors on the oak decline.
4. The Board of Supervisors support state and federal agency funding for research on oak decline.
5. The Board of Supervisors, in cooperation with county firewood retailers, the owners of the Santa Cruz KOA Campground, and the Santa Cruz District Office of the California Department of Parks & Recreation, strongly discourage the transportation of oak firewood to new sites within and out of the county.
6. The Board of Supervisors, in cooperation with U.C. Cooperative Extension, encourage property owners to treat infested trees where feasible as follows: cut dead trees to logs of fireplace length, stack, and cover them tightly with clear 6 ml. plastic, and seal the stump with clear plastic; all of this to confine bark beetles when they emerge **from** the wood).
7. The Board of Supervisors, in cooperation with U.C. Cooperative Extension, encourage property owners to provide proper cultural care to live oaks so as to increase their ability to withstand stress.
8. The Office of the County Fire Chief, in cooperation with the California Department of Forestry & Fire Protection, promote the use of a **website** to establish and maintain information about the decline of tan oaks in the county.

## TASK FORCE MEMBERS

### OFFICIAL MEMBERS

Steven Wert; forester, ranger unit **chief**; Chair of Task Force & County Fire Chief-Felton  
 Geoffrey Holmes, forester, Calif. Dept. of Forestry & Fire Protection (CDF)-Felton  
 James Nee, agric. inspector, Santa Cruz Co. Agric. Commissioner's Office-Watsonville  
 Steven Tjosvold, environmental horticulture advisor, U.C. Cooperative Extension-  
 Watsonville  
 Richard Standiford, hardwood specialist, Univ. of Calif., U.C. Cooperative Extension -  
 Berkeley  
 Fred McPherson, ecologist, UCSC and Calif. Native Plant Sot.-Boulder Creek



## EXOFFICIO MEMBERS

Donald Owen, entomologist, CDF-Redding  
 David Adams, forest pathologist, CDF-Sacramento  
 Jack Marshall, forest pathologist, CDF, Pitch Canker Task Force-Will&s  
 Walter Mark, pathologist, Cal Poly's Swanton-Pacific Ranch-Davenport  
 Raymond Sherrod, City Arborist-Santa Cruz,  
 Laura Kuhn, Community Development Director-City of **Scotts Valley**,  
 Steven Singer, biologist, Santa Cruz Mtns. Bioregional Council-Santa Cruz  
 Karl Kolb, Chair of Rio Del Mar Community Tree Committee-Aptos  
 Erin Nachbar, FMC Corp.-Encinitas, CA  
 Steven Staub, private forester, Pitch Canker Task Force-Felton  
 Deborah **Hilliard**, botanist, Calif. Dept. Fish & Game-Morro Bay  
 Steven **Bakkan**, forester, Calif. Dept. Parks & Rec. (CDP&R)-Sacramento  
 George Gray, ecologist, CDP&R-Santa Cruz  
 Donald Cox, private arborist, Soquel

## REFERENCES

## 1. Research:

(A) Rick **Standiford**, *Evaluate Insect/Disease Complex Causing Mortality in **Tanoak** and Coast Live Oak*, Request for Temporary Funds, Integrated Hardwood Range Management Program, University of California, Berkeley. Note: Study received funding in November 1999.

(B) Susan Frankel, *Pre-suppression Survey for **Tanoak** Decline on Federal, State, and Private Land in Coastal California*, Proposed by USDA Forest Service, Pacific Southwest Region-Vallejo; with support from the National Park Service, CDF, and the **Marin** Municipal Water District.

## 2. Publications

(A) County Scientific Task Force on *Oak Decline*, *Minutes of Task Force meeting dated October 20*.

(B) Cox, Donald. 1999. *Oak Tree Health Preservation*. Report available from Don Cox, licensed arborist in Santa Cruz County via email: don@treelove.com. September 1999.

(C) Johnson, Sharon. Undated (probably late 1980s). *Living Among the Oaks: A Management Guide for Landowners*. Available from Univ. Of Calif. Cooperative Extension, Natural Resources Program, 163 Mulford Hall, Berkeley 94720.

(D) **NOM**. 1999. *Palmer Drought Diversity Index, California-Div. 4, years 1895-1 999 monthly averages*. Available via Internet at <http://www.ncdc.noaa.gov/cgi-bin/ginterface>. Nov. 30, 1999.

(E) Sanborn, Sherburn. 199 1. *Controlling Bark Beetles in Wood Residue and Firewood*. Tree Notes, No. 3, December 1991. CDF, Sacramento

(F) Svihra, Pavel. 1999. *Sudden Death of **Tanoak**, Lithocarpus densiflorus*. Univ. Of Calif. Cooperative Extension in **Marin** County, Pest Alert #1, June 1999.

(G) - - 1999. *Western Oak Bark Beetles and Ambrosia Beetles Associated with Dying*

*Live Oaks*. Univ. Of Calif. Cooperative Extension in **Marin** County, Pest Alert #3A, October 1999.

(H) Swiecki, Tedmund. 1999. *Observations on Tunoak (Lithocarpus densiflorus) Dieback and Mortality in Marin County, California*. Research report from Phytosphere Research, Vacaville, available on the internet at <http://phytosphere.com/tanoak.html>

(I) Tjosvold, Steve and Pavel Svihra. 1999. *Beetles Kill Stately California Live Oaks: A Synopsis of the Problem and Practical Guide for Landowners*. Univ. Of Calif. Cooperative Extension in Santa Cruz County, Watsonville. November 24, 1999. In press.

1A  
draft proposal by  
Rick Standiford - submitted to  
Rec'd U.S. for funding  
by D. Moeller ~ Oct. 20, 1999

**Request for Temporary Funds  
Integrated Hardwood Range Management Program**

**A. Name of Project: *Evaluate Insect/Disease Complex Causing Mortality in Tanoak and Coast Live Oak***

**B. Purpose and Goal:**

Beginning in 1995, evidence of mortality in **tanoaks** (*Lithocarpus densiflorus*) in **Marin** and **Sonoma** Counties appeared. The source of the sudden death of **tanoaks** was not known and has not been identified to date. The symptoms are that trees experience foliar discoloration, and eventual death. Subsequent resprouts wither and die. Secondary attack by insects occurs in these dead and dying **tanoaks**. Both the western oak bark beetle and oak ambrosia beetle have built up to very high population levels in these dead and dying **tanoaks**.

In 1998, the first reports of widespread mortality of coast live oak (*Quercus agrifolia*) appeared in **Marin** County. Complete mortality of all live oaks in a stand appeared. These were in close association with **tanoaks** that had experienced sudden death. All trees were heavily infested with both species of beetle.

During 1999, **tanoak** sudden death and associated coast live oak mortality was reported in **Santa Cruz**, **Santa Clara**, **Marin**, and **Sonoma** Counties. A group of UC farm advisors, specialists, private arborists, and landowners evaluated an area in **Scotts Valley**. On a 140 acre parcel, all **tanoaks** surrounding a large coast live oak stand were dead. Both beetles had attacked all live oaks, and approximately 1/3 of the trees had already died. A similar trend has been reported in both **Sonoma** and **Marin** Counties. The incidence of this pattern of **tanoak** sudden death and coast live oak mortality seems to be increasing. Bay Area newspapers and television stations have carried major stories on this issue.

The purpose of this request is to determine the seriousness of this apparently new source of oak mortality, and to develop an appropriate action plan. This request for temporary funds is due to the fact that this is an emerging issue that may be an emergency affecting all coastal oak **woodlands**, as well as **tanoaks** stands on North Coast forests.

The specific goals of this project are:

- Develop the basic information on the mechanism causing this mortality (pathogen/insect interaction)
- Determine the extent of this pattern
- Develop management recommendations
- Determine long-term **IHRMP** response (education, research needs)

**C. Action Plan:**

Goal 1: Mortality Mechanism -- To date, there has been no specific evaluation of the pathology of **tanoak** sudden death. The request for funds will be to support field sample collection and laboratory evaluation by Professor Emeritus Bob Raabe. Farm Advisors **Pavel Svirha** and **Steve Tjosvold** will work with Professor Raabe to identify field locations for

collection of samples. Laboratory analysis will be carried out to identify the specific pathogen(s), if any, associated with the **tanoak** sudden death. Collections will also be made to determine if pathogens are associated with the coast live oak mortality, and if there is a direct link with the **tanoak** sudden death. The possibility of disease vectoring with the two beetles will be investigated. The specific cause of the mortality is the necessary first step to evaluate the risk to coast live oak and **tanoak** stands.

**Goal 2: Extent of Mortality** -- There has been an apparent increase in the spatial distribution of the **tanoak** and coast live oak mortality based on reports from consulting **arborists** and foresters and public service requests **from** homeowners. This goal will develop a procedure for detection and monitoring using aerial photography, **Landsat 7**, and other remote sensing datasets. Preliminary estimates will be made of the current extent of this mortality, and serve as a benchmark for outbreaks and possible spread. Spatial statistics will be applied to current stands with evidence of mortality to determine site and vegetation characteristics of these areas. This information will be used to map out areas of risk for **future** mortality.

**Goal 3: Management Recommendations** -- The monitoring information (goal 2), coupled with the specific mortality mechanism (goal 1), **will** be used to assess the economic and environmental impact, and to propose future policy and management recommendations. Recommendations will be suggested based on current knowledge about beetle and specific pathogen biology. Procedures for field testing these will be developed and tested with cooperating landowners. Material will be distributed to professional and landowner audiences.

**Goal 4: IHRMP Response** -- The results of this effort will be incorporated into **IHRMP** and Oak Woodland Conservation Workgroup planning. 'The design of educational outreach procedures, and follow-up research needs will be coordinated as part of Workgroup and program planning.

#### **D. Budget**

##### Goal 1:

Casual Labor:	\$6,000
Laboratory Procedures (S&E)	\$4,000
Travel	\$3,000
Total:	\$13,000

##### Goal 2:

Graduate student researcher	<b>\$9,300</b>
Cost of Aerial Photos (S&E)	\$20,000
Travel	\$2,000
Total:	\$3 1,300

##### Goals 3 :

Travel (farm advisors, cooperators)	\$2,500
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## Goal 4:

Funds already requested through Oak Conservation Workgroup for publication duplication

Meeting of Workgroup will focus on long-term response

## TOTAL:

Casual Labor:	\$15,300
Laboratory Procedures:	\$24,000
Travel	\$7,500
Total:	\$46,800

1B

0104

### Fiscal Year 2000 NFS Prevention/Suppression Project Proposal Summary Sheet

Region/Area: 5 Project Number: \_\_\_\_\_ Regional Priority: \_\_\_\_\_

Pest(s): -Unknown\_\_\_\_\_

Proposed Treatment: Pre-suppression survey\_\_\_\_\_

Treatment Location: -Federal, state and private lands in coastal CA \_\_\_\_\_

Primary Project Objective: (check only one)

\_\_\_\_\_ protect critical threatened/endangered species habitat

eradicate new exotic insect/disease infestation(s)

\_\_\_\_\_ protect developed sites/high value trees

- X - protect adjacent private land

\_\_\_\_\_ protect native vegetation (forests and trees)

\_\_\_\_\_ other (please specify) \_\_\_\_\_

Proposed project is urgent: \_\_\_\_\_ yes X no  
(urgent = treatment must be carried out within one years in order to be effective).

Proposed project is in:

critical wildlife habitat

X urban/wildland interface

\_\_\_\_\_ general forest area

\_\_\_\_\_ other (please specify) \_\_\_\_\_

Proposed project funding:

FY 2000 FHP funds requested: \_\_\_\_\_ \$50,000 \_

FHP carryover funds proposed for use: \_\_\_\_\_

• Other funds \_\_\_\_\_

Total project funding: \_\_\_\_\_ \$50,000 \_

**Other pertinent information:** This pre-suppression survey will collect data to determine if **tanoak** decline needs to be added to FHP's risk map. In 1999, native **tanoak**, *Lithocarpus densiflorus*, died in large numbers from the Six Rivers National Forest, south to Santa Barbara, which covers the entire extent of **tanoak** in coastal CA. **Tanoak** decline was first reported in 1996, since then, neighboring native oaks have died from beetle attack driven by skyrocketing beetle populations breeding on the dead and dying **tanoak**. **Tanoak** and native oaks are dying on private lands in urban areas and at the **wildland** interface raising concerns over tree loss and increasing fire hazard for property owners, cities and counties. This project will determine the incidence and severity of **tanoak** decline and provide scientific methods concerning a phenomenon that the local media is fueling alarm over by reporting rumors.

OPTIONAL FORM 99 (7-90)

#### FAX TRANSMITTAL

# of pages 4

To	JIM NEE	From	Susan Frankel
Dept./Agency	831 763 8080	Phone #	707-562-8917
Fax #		Fax #	

0105

<b>USDA - Forest Service</b> <b>FOREST PEST MANAGEMENT PROJECT PROPOSAL</b> (Ref: FSM 3400, Report FS-3400-E)					
<b>0 PART I - REQUESTING OFFICE USE ONLY</b> <span style="float: right;">x</span>					
1. Region/Area <b>5</b>	2. State <b>CA</b>	3. Fiscal Year <b>2000</b>	4. Casual Agent <b>unknown</b>	5. Group <b>BB &amp; OD</b>	6. Landownership ( <i>x appropriate box</i> ) <input type="checkbox"/> National Forest <input checked="" type="checkbox"/> Other Federal
7. Type of Project ( <i>x appropriate box</i> ) <input type="checkbox"/> Prevention <input checked="" type="checkbox"/> Suppression		8. Status of Project ( <i>x appropriate box</i> ) <input checked="" type="checkbox"/> New Project <input type="checkbox"/> Continuing Project		9. Host Protected <b>tanoak and native oaks</b>	
10. Prevention/Suppression Method <b>Pre-suppression survey</b>		11. Pesticide <b>n/a</b>		12. Application Rate <b>n/a</b>	
13.			First Year Targets and Costs		Funds Needed in Subsequent Years
Program Activities (a)			Units of Work (b)	Unit Cost (c)	Total Planned Cost (d)
(1) Pretreatment Survey (Acres)			1 million ac	\$.05 per ac	\$50,000
(2) Treatment (Acres)					
(3) Volume Treated (MBF)					
(4) Volume Removed (MBF)					
(5) Volume Protected (MBF)					
(6) Post-Treatment Evaluation (Acres)					
(7) Environmental Monitoring (Acres)					
(6) Other (identify)					
(9) Subtotal					
(10) Indirect and service charges (Field) Percent of Subtotal ( %)					
(11) Total Field Costs					\$50,000
14 Proposed By (Signature) <b>/s/ Susan J. Frankel</b>			15. Title <b>Plant Pathologist, PSW Region, Vallejo</b>		16. Date <b>10/26/99</b>
<b>0 PART II - REGION OR AREA USE ONLY</b> <span style="float: right;">x</span>					
17. Region/Area Indirect and Service Charges Percent of Total Field Costs ( %)					
18. Total Project Costs					
19. Approved By (Signature)			20. Title		21. Project Number
22. Date					
<b>0 PART III - WASHINGTON OFFICE USE ONLY</b> <span style="float: right;">x</span>					
23. Project Action ( <i>x appropriate box</i> ) <input type="checkbox"/> Approved <input type="checkbox"/> Disapproved			24. Total Funds Allocated		
25. Approved/Disapproved By (Signature)			26. Title		27. Date
28. Remarks					

0106

## **Pre-suppression Survey for Tanoak Decline on Federal, State and Private Land in Coastal CA**

**Proposed by:** USDA Forest Service, Pacific Southwest Region  
California Department of Forestry and Fire Protection  
**Marin** Municipal Water District  
Golden Gate National Recreation Area, Muir Woods National Monument

### **Project Description**

This partnership between Federal, state and private **land** managers is proposing a pre-suppression survey to determine the extent and impact of **tanoak** (*Lithocarpus densiflorus*) decline in coastal CA.

### **Background**

Tanoak decline was first reported in 1996 in **Marin** Cc. (but may have started earlier and gone unreported). In 1999, there are observations of **tanoak** decline reported throughout the coastal population of **tanoak** including: the Six Rivers National Forest, Redwood National Park, Muir Woods National Monument, Mt Tamalpais State Park, south to private lands in Santa Cruz Co. All ages and sizes of **tanoak** trees are affected from seedlings to mature trees. The symptoms appear as a branch **dieback**, which eventually girdles the tree and causes a rapid death of the leaves. The trees often resprout but the sprouts die-out as well. After the trees die, ambrosia beetles and other insects colonize them. Circumstantial evidence indicates the insects can then move into neighboring native oaks and kill them. The causal agent or agents and environmental conditions associated with **tanoak** decline are unknown.

### **Site Description and Location**

The native coastal population range of **tanoak** that extends from North of Santa Barbara to the Oregon border.

### **Project Objectives**

Determine the extent and severity of **tanoak** decline in coastal CA. Observe **tanoak** decline in depth and evaluate associated environmental factors. Determine extent of mortality in adjacent native oak species.

### **Funding**

To complete this project we are asking for \$50,000 to be used for aerial, roadside, and ground survey of the extent and impact of **tanoak** decline from the Oregon Border south to Santa Barbara. The survey will note extent of damage, describe the array of symptoms, note if adjacent native oak species are affected and determine if there is any pattern of distribution or correlation with environmental factors.



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**Production function for R5 - Tanoak decline pre-suppression survey**

**Cost** = \$50,000 for pre-suppression survey. To calculate project benefits also added \$100,000 in treatment costs that would be applied in future years.

**Benefits** - Prevent death of native tanoak (*Lithocarpus densiflorus*) and native oaks (*Quercus* spp.) and loss of merchantable wood for flooring and other special uses.

**Unquantified benefits** - Avert costs for dead tree removal and reforestation in urban areas and private lands. Decrease the risk of fire in Marin Co., Santa Cruz Co. and other urban interface areas. Sustain animal and plant populations that depend on tanoak and oak for habitat. Maintain aesthetics and ecological integrity in high-use recreation areas. Prevent soil erosion and maintain groundwater supplies in watersheds.

**Objective of project** - Determine incidence and severity of tanoak decline and associated native oak mortality in CA.

**Assumptions**

Determining the locations of dead and dying tanoaks and native oaks and the extent of damage is the first step in a management plan for this forest decline. The project will provide information that will be used to prevent further mortality. This project and a follow-up treatment (cost = \$100,000) will prevent the loss of 500,000 BF of merchantable tanoak.

**Background data**

There is over 2.1 billion cu ft of tanoak in California and 6.12 billion BF of merchantable wood (1). Mendocino Redwood Co. opened a tanoak mill in 1999 and other tanoak mills are in operation in CA.

Common grade tanoak flooring is selling for \$4.57 per sq. ft. (2).

**Calculations**

Value of lost tanoak in California w/o project

$$500,000 \text{ BF} \times \$4.57 = \$2,285,000$$

Value of tanoak saved - cost of project (Cost of project = survey + treatment)

$$\$2,285,000 - (\$50,000 + \$100,000) = \$2,135,000$$

$$\text{B/C Ratio} \quad \$2,135,000 / \$150,000 = 14.2$$

**References**

1. **Bolsinger, Charles L.** 1998. The hardwoods of California's timberlands, woodlands, and savannas. Resource Bulletin PNW-RB-148. Pacific Northwest Forest Research Station. Forest Service, USDA. Portland, OR.

2) 1999. Pricelist. Ecotimbers. www.ecotimbers.com - wood dealers in Berkeley, CA.

**TASK FORCE FOR OAK PROBLEM**  
**October 20, 1999**

Meeting began at <sup>2</sup>4:05 p.m.

This Task Force is being formed as requested by the Santa Cruz County Board of Supervisors. County Fire Chief Steve Wert has been asked to chair this Task Force.

Those in attendance were: Steve Wert, Wally Mark, Laura Kuhn, George Gray, Fred McPherson, Steve Singer, Jim Nee, Steve Tjosvold, Bill Ruskin, Jack Marshall, Deborah Hillyard, Don Cox, Ray Sherrod, and Steve Staub.

Some facts discussed were: Bark Beetles seem to take over an already diseased tree. The Bark Beetle population has drastically grown because of this infestation. There is no correlation of human activity and no statewide infestation apparent. Some infestations are present without the Tan Oak.

Steve Wert stressed there are three major points of knowledge required. Those needs are to identify the cause, identify the effect of that cause, and the mitigation to control it.

It was agreed to focus first on cause. Jack Marshall stated there has already been a sampling of Tan Oaks for fungus and bacteria. Steve Staub and Wally Mark spoke regarding the need for standardized specimens to track this disease. Also noted was the fact that the contributing factor for the disease could be gone before the tree has died. Live Oak Trees seem unaffected.

Steve Tjosvold stated there is a grant proposal in process at the University of California at Santa Cruz for the survey on the cause of infestation. Also, a Forest Pathologist is being hired by UCSC.

<sup>someone</sup>  
~~Jack Marshall~~ suggested an aerial survey be done. He also stated the need for a designated zone of infestation and a zone of mitigation.

The Forest Pest Action Council may be a source of information on this infestation. It was also noted there might already be photographs available. Discussion was made regarding use of websites. Laura Kuhn stated a digital format is required for website use. Deborah Hillyard will be gathering information on existing websites that may be used by this Task Force.

Steve Wert asked Jack Marshall to be on Task Force. Steve Tjosvold will gather educational information for the public and will put together a packet of information. He will also be looking for models of guidelines that have already been successfully used.

A resolution was made to form a group to validate this research. An official report will be sent to the Board of Supervisors.

The next meeting will be November 15<sup>th</sup> at 2:00 in the CDF Headquarters Conference Room.



2B  
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## OAK TREE HEALTH PRESERVATION

In order to address concerns about beetle/borer infestations and sudden death of Tanbark Oak and Coast Live Oak, we offer the following recommendations.

### ***Evaluate conditions and correct any existing stress factors that can be changed***

Physiologically stressed trees are more susceptible to pests and disease and may be the first to be attacked by oak bark beetles and ambrosia beetles. A professional arborist evaluation may be needed to determine the condition of the tree(s) and to prescribe a course of action. Evaluation should include:

#### **1. Watering** (not too much or too little)

Oaks cannot tolerate frequent watering (daily or several times a week), especially directly on the trunk and root collar. **If your oaks are within range of your lawn and shrub sprinklers, sooner or later they will be killed.**

**To avoid drought stress**, oaks sometimes need a **summer watering program that is infrequent** (every two to six weeks apart) **and deep** (six to twelve inches water penetration depth). Not all oaks need this summer watering. This should be prescribed by an arborist on a case-by-case, tree-by-tree basis. But it is important to consider, because like pine bark beetles, the oak beetles are not as attracted to vigorous trees with adequate water and sap flow.

#### **2. Soil grade** (avoid major changes in grade)

Oaks cannot tolerate soil, mulch or other material piled above the root collar on the trunk wood. Mulch is beneficial, but piled against the trunk it can be a problem. (See # 3 below.) This will restrict aeration to sensitive conductive tissues and/or create conditions for wood-rot fungus infection at the base of the tree. **Trunk wood is meant to be above ground and roots should be below ground. Keep it that way, or if it is not, correct the conditions immediately and repeat inspections annually.** If the tree trunk looks like it goes straight into the ground without any root flare showing, almost certainly the soil grade at the base has been raised. Carefully (without injuring bark) pull away the soil or mulch at the base until you see the top of the flare of the main support roots. Maintain this corrected grade level out at least two to four feet from the base of the tree. (If the hole that results from this procedure creates a hazard, it can be filled with coarse gravel or rock.)

#### **3. Other conditions** (undergrowth, ground covers, mulch and fertilization)

Native oaks should not have shrubs and ground covers (especially lawns) with high water requirements growing within the root zone of the tree(s). Drought tolerant plants are ok, if not under frequent irrigation. [The root zone is usually defined as the area inside the dripline (outer perimeter of the foliage canopy). The actual root zone of a tree may extend much further out than the dripline.] Clear ivy and other dense growth away from trunk.



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Let the fallen oak leaves build up a natural layer of beneficial mulch. If the natural mulch has already been removed, correct this important growing condition by adding a two to four inch layer of mulch throughout the root zone (compost, leaf mold or wood chips, but don't use shredded bark). Don't pile mulch against the trunk.

Supplemental fertilization is not normally needed by native oaks growing in natural conditions. However, plant nutrition should be considered in a comprehensive evaluation. Signs of nutrient deficiency include chlorosis (yellowing of foliage) sparse and/or stunted growth. Before deciding to fertilize, rule out other factors that **can cause** similar symptoms (i.e., water deficiency and impaired function of roots and conductive tissue from disease, pests or mechanical damage).

#### **4. Construction, bark wounds and root damage**

Avoid construction activity, root cutting, excavation, trenches, grade changes (cuts or fills), compaction, paving or dumping of chemical materials or paints anywhere within the root zone of your trees.

Previous construction injury, wounds and root damage may have reduced the health of certain trees. Even though the foliage looks reasonably good now, vigor and resistance to beetle attack may be diminished. This type of pre-existing injury should be considered in a comprehensive tree health evaluation **and** plan of action.

#### **5. Pest and disease control**

Control insect pests, especially defoliators such as oak moth caterpillar. These add physiological stress for the tree. Correct conditions that predispose the tree to fungus infections (see #1 and #2 above). Contract with a certified arborist, horticultural consultant or licensed pest control advisor to evaluate and make recommendations on pest and disease control, and how to improve growing conditions.

#### **6. Pruning** (beetles may be attracted by fresh pruning cuts)

Correct pruning is very important. Many untrained tree workers do not understand principles of modern arboriculture, how a tree responds to pruning, how to make proper cuts, and how insect pests can be attracted by the results of poor pruning practices.

Except for removal of dead, dying and damaged branches, pruning of oaks should be avoided during the growing season and especially when beetle emergence is expected (March and October). Prune oaks for aesthetics, health and structural safety during winter months. If exceptions need to be made for emergencies, then the number and size of cuts should be kept to a minimum. Brush and wood should be properly processed immediately (see next page). Never remove more than 25% of the foliage of a tree in a one year period.

Responsible arborists have long used this pruning timing method with trees such as pines and elms; to avoid unnecessary exposure to the beetles that infest those trees or spread disease. Now we have to include oaks in our range of caution,



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**[If** pruning is essential, an immediate **commercial follow-up drench-spray of the lower trunk and scaffold limbs with Astro** may prevent beetle attack (active ingredient - permethrin 36.8% **Not pyre thrin**). ~~Astro is available only to licensed pesticide applicators.~~ Use of this pesticide should be conservative. While not highly toxic to humans, **it is extremely toxic to bees, fish and aquatic invertebrates.**] Astro label is available from Target Specialties, San Jose. *and W F S, Watsonville*

## Dealing with beetle infested trees

**If a Tanbark Oak or Live Oak tree is already heavily infested, dead or dying, it should be removed and properly disposed of as soon as possible.**

- Chip (grind) the smaller branches and haul away. Split the wood for firewood.
- Cover the wood and stump with heavy clear plastic (6 mil preferred) for six to eight months. The plastic should completely cover the wood pile and be tucked or weighted down, and tightly sealed around the perimeter. This process is to trap and kill the new emerging brood of beetles, so they can't fly to other trees in the vicinity. After that period the wood may be uncovered and dried for the fireplace.
- Grind the stump if possible. Beetles breed and emerge from the above ground stump wood.
- Preventive spraying with Astro has not been proven as totally effective, but may be used in certain situations if you want to do everything possible to save an important tree or trees. See *above' note forprecautions.* This spray does not kill beetles already in the tree. It has a residual effect (up to several weeks) on the surface of the wood, and is used to discourage beetles from going to other parts of the same tree or to nearby trees when they emerge.
- **If** a tree shows initial stages of beetle attack (black tar-like exudation or small holes with very fine sawdust present) or if nearby trees are heavily infested, drench the areas with the insecticide that are showing these signs, as well as the lower trunk and larger limb wood. (This is not a foliage spray, only the bark is sprayed.) Cracks and crevices in the bark should be drenched thoroughly.

Prepared September 1999 by:

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Research and content contributions:

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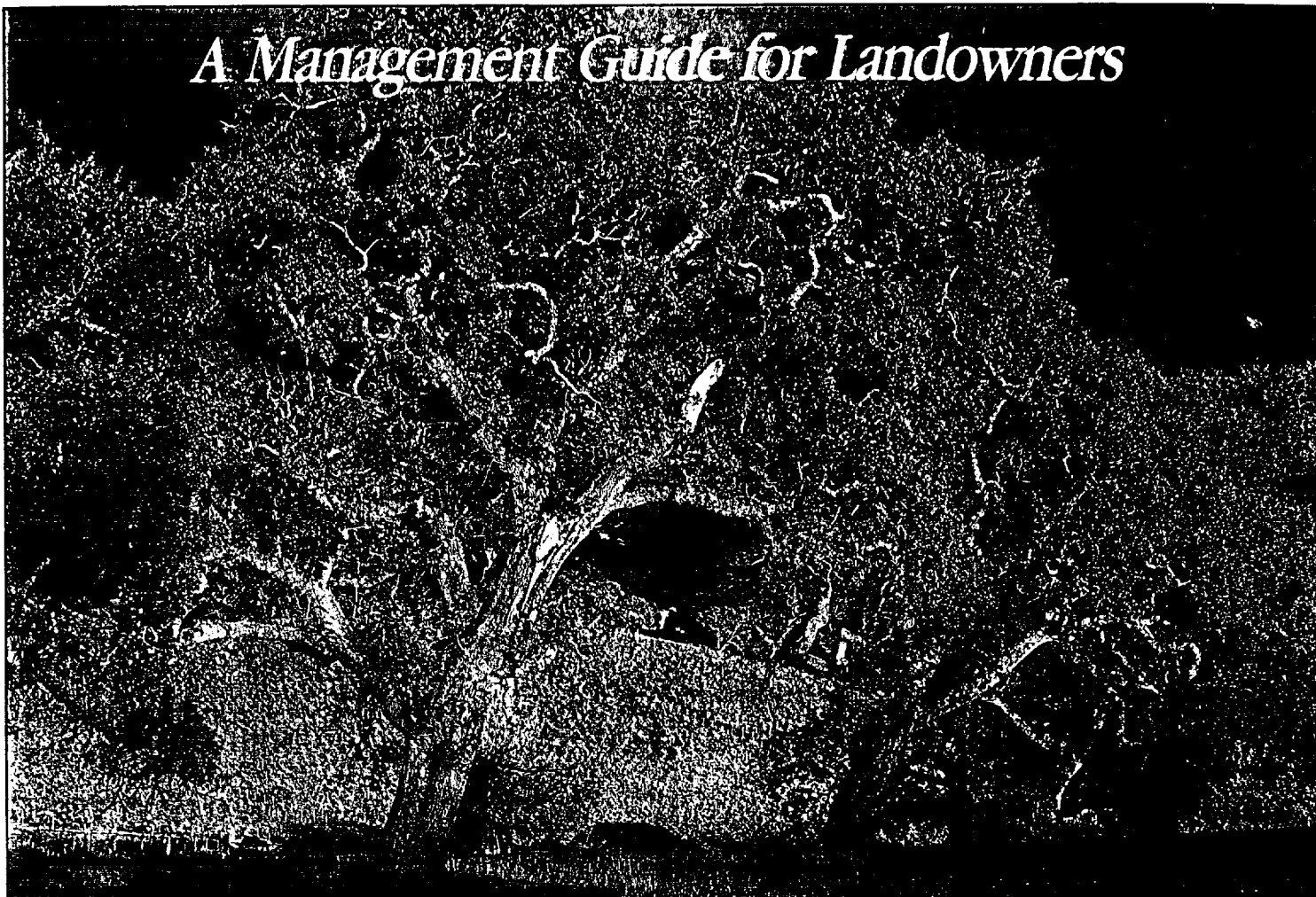
Calif. Dept. of Forestry, Davis, CA

**Barrie D. Coate** – Consulting Arborist

Los Gatos, CA

# LIVING AMONG THE OAKS<sup>2C</sup><sub>072</sub>

## *A Management Guide for Landowners*



LARRY ULRICH

What is more characteristic of the California landscape than the oak? Round-crowned oaks dapple the rolling hills, solitary monarchs shade our rural roads, and valley giants stretch skyward in banners of leaves and lichen. Both past and present-day travelers have stopped in awe of our native oaks, and countless photographs and memories are framed by their spreading, weather-worn branches. The oak is particularly emblematic of the inland regions of California, where scattered oaks, rolling pasture, and distant cattle are the common elements of an infinitely variable landscape.

In this region—often called the hardwood range by land managers—the vistas of oaks, pasture, and cattle bestow a tranquility that sometimes belies the fourth element—people. Like the earliest Californians, humans today come to the oaks for food, shelter, and beauty. As we appreciate the beauty of oak landscapes, we fatten our flocks on their bounty, and seek homesites in their shadows. But intensifying land use in the hardwood range has brought soil erosion, reduced forage production, poor regeneration among some species of oaks, and dwindling resources, due to development. Today the hardwood range clearly shows signs of the last hundred years of human habitation.

All Californians can assist in the protection and enhancement of native oak resources, but none are in a better position to do so than landowners in the hardwood range. These individuals shape the future by their decisions, which cumulatively direct the management and land use of more than seven million acres of California's oaks and pasture.

This brochure is designed for you—the landowner. It brings together a variety of current information about living and making a living among the oaks. The University of California Cooperative Extension hopes that you will find this information useful as you manage your land and make decisions that shape the future of your oaks.

### **OAKS GIVE US:**

- **Shade & Shelter**
- **Increased Property Values**
- **Beautiful Carefree Landscapes**
- **Food & Fuel**

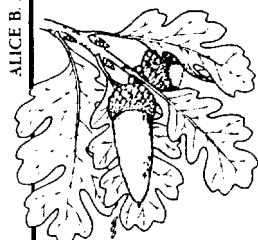
### **Needs and Conflicts**

In designing and building homes, workspaces, storage areas, gardens, orchards, and places for animals, your decisions are shaped by your over-all objectives for your land. Managing land as a residential site, for animal production, for wild or park-like qualities, all may require different actions. As you choose management objectives for your land and evaluate its suitability, also consider the oaks on those sites and whether your objectives are compatible with the basic needs of the trees. Careful planning and design can often provide benefits for both people and oaks.

Past development among the oaks has revealed specific areas of conflict. Various construction practices seriously injure oaks or inadvertently kill them, increasing fire hazards and creating liability and management problems. Gardening practices such as amending the soil, planting lawns, or irrigating under established oaks will kill them. Domestic animals and wildlife, as well as insect and fungus pests, also take their toll. In combination these elements can present formidable obstacles to the survival of mature oak trees. Harmful effects can be minimized, however, by thoughtful management practices.

# Oaks of the Hardwood Range

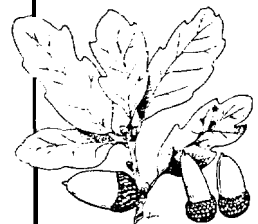
California has 15 species of oak in the genus *Quercus*, 8 of which grow to tree size. Of these, only 5 are conspicuous members of the hardwood range plant community:



## Valley oak, (*Q. lobata*).

This tall, spreading deciduous oak was once an important member of the Central Valley's riparian

forests. From Shasta County to Los Angeles County, it is still a conspicuous oak in the hardwood range, especially in valley bottoms and on deep alluvial soils.



## Blue oak, (*Q. douglasii*).

This deciduous oak is the dominant oak of the hardwood range from Shasta County to Kern

County. Where it shares its range with the Valley oak, blue oak occupies the more shallow soils, steeper slopes, and upland sites.



## Coast live oak (*Q. agrifolia*)

is an evergreen oak found from southern Mendocino County southward into northern Baja

California, primarily west of the coast ranges. In the southern portions of its range, it replaces the valley oak in the hardwood range, and in valley and alluvial sites, it often attains a tall spreading appearance.

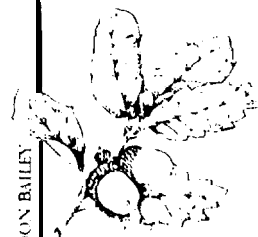


## Interior Live Oak (*Quercus wislizenii*).

This evergreen oak is widely distributed in California from Siskiyou County south into Baja California.

It is abundant in the

Sierra Nevada foothills and in the coast ranges occupies the higher, drier, or more inland sites than the coast live oak. Interior live oak is generally found in more heavily wooded sites than the blue oak, and in chaparral habitats or other dry locations it often develops a shrubby form.



## Engelmann or mesa oak (*Q. engelmannii*).

This semi-deciduous oak has a limited distribution in less than 2 per-

cent of the state—primarily in western San Diego County. There, the mesa oak replaces the blue oak in the hardwood range.

# LIVING AMONG THE

## Building Around Oaks: The Hazard Zone—Where the Roots Are

Young, native oaks are tolerant of environmental changes and will usually adapt to landscaping practices. But as oaks mature, their environmental tolerances become set and changes can weaken or kill them. A mature oak, for example, is well adapted to California's naturally dry summer weather. If the environment of an adult tree is changed by the introduction of summer watering—for gardens, lawns, or improved pasture—fungi will proliferate on its roots and begin to kill it. Unfortunately, there may be few visible signs of a fungus attack before it is too late (See "Oaks in the Home Garden"). On the other hand, a young tree on well-drained soils, raised under a regime of summer watering, maintains some resistance to threatening fungi even into adulthood.

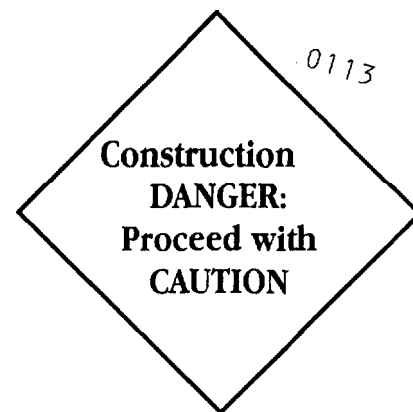
The most vulnerable parts of a mature tree are the root crown (at the base of the trunk) and the entire root zone. Oak roots are relatively shallow and extend from the root crown outward, reaching some distance beyond the tree's drip line (the outermost edge of a tree's foliage). For management purposes, think of a tree's root zone as being one third larger than the drip line area. Ideally there should be no disturbance within this zone. This means no grading, digging, trenching, covering the ground with asphalt or concrete, or landscaping with plants that require summer watering (see "Oaks in the Home Garden"). Even excessive foot traffic, operating heavy equipment, and parking vehicles (particularly heavy ones) should be avoided.

Think of the root zone as the tree's "home"—the minimum ground required for its survival. The best way to live with a mature oak is to leave it and the area beneath its canopy alone. Establish a mini-park, if possible, for birds and other wildlife, and keep it dry. If modifications are unavoidable, strive to keep the root zone area in as natural a condition as possible, and keep ground disturbance as far away from a tree's trunk as possible.

## Threats To The Root Zone

A mature oak is accustomed to a certain balance of moisture, air, soil temperature, and nutrients. A change in these factors can severely alter conditions for the tree. The most common human activities that alter a tree's root environment are:

**Changes in grade.** This includes any changes in the ground level under the tree, either by mounding up soil or excavating it. Excavating soil can destroy the roots and expose them to damage by surface activities. Mounding up soil reduces the oxygen supply to the root zone, which can suffocate a tree. Depending on climate and soil moisture, additions of soil can also encourage root rot



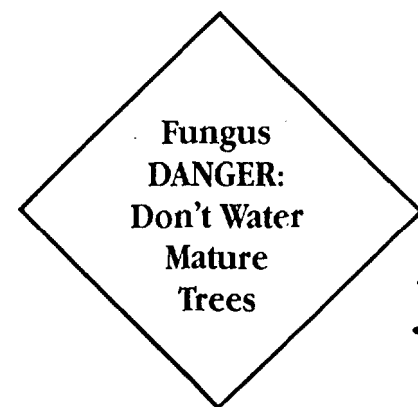
**Changes in drainage.** Changes in the drainage around an oak can put water into the root zone during the season when soil temperatures are high and oaks need to be dry. Saturated soils inhibit the exchange of oxygen in the root zone and encourage the proliferation of soil-borne diseases.

**Soil compaction.** Heavy traffic or the operation of heavy equipment can cause soil compaction, that is, the spaces between the soil particles become compressed. Since a tree "breathes" through the exchange of gasses that occurs within these spaces, compaction will lessen gas exchange, suffocating the tree.

**Paving.** Paving presents many of the same hazards as soil compaction, and compaction itself often occurs in preparation for and during paving. When the ground is covered with a nonporous material such as asphalt or concrete, the free passage of moisture, air, and other gases within the root zone is impeded. There are porous materials, however, that are more compatible with the oak environment and make excellent ground coverings. Porous brick with sand joints, for example, or gravel, bark, wood, mulches, and many other similar such materials provide an attractive ground covering that permits the free passage of water and air.

Regardless of the permeability of the ground covering, nothing should be placed within a six-foot radius of a tree's trunk—the minimum area that should always be left undisturbed and uncovered.

**Fills.** In general, do not fill within the drip zone of a tree because fills tend to compact the soil and hence reduce permeability



They also promote water entrapment in the root zone, encouraging root and crown rots. Use retaining walls outside of the drip line to protect the natural grade under the tree.

If there is no alternative to filling within the dripline, techniques are available to minimize impact on the tree. Consult an arborist specializing in oaks, or some of the publications listed in "Additional Resources".



**Trenching.** Trenching is a commonly overlooked cause of tree mortality. When utility trenches are dug into the root zone, major portions of a tree's roots may be cut or severely damaged. When a large proportion of the roots are damaged, trees die. Trenching in the root zone should be avoided whenever possible.

Perhaps the best alternative to trenching is to place utilities in a conduit which is bored through the soil. This eliminates the need for trenching, and the small size of the conduit minimizes root damage.

If utility conduits are unavailable, try to have all utilities placed in a single trench, as multiple trenching by different companies is a common culprit in tree deaths. Convincing utilities to use a single trench may require vigilant lobbying with the various companies, since it is often difficult to coordinate their timing needs and trenching specifications. Persistence pays off, however, and coordination can be accomplished!

After any trenching in the root zone, the tree should be carefully pruned to remove canopy material proportional to the roots lost or damaged. An arborist can best advise on the needs of this pruning.

**Disturbance beyond the root zone.** Beyond the root zone, mature oaks are usually less affected by landform and drainage changes, soil compaction, paving, fills, and trenching activities. But the indirect effects must still be considered. Watch out for fill materials that could pond water around a tree. Consider the effects of nearby pools on local soil moisture, and watch for bank or hillside cuts that could drain moisture that a tree is used to receiving. Any activity that changes the environment of a mature tree, even indirectly, could threaten its well being.

## Native Plants for Oak Gardens

These are just a few California native plants that can be used in landscaping oak gardens. Once established—usually after a year—they require little care, one monthly watering, and offer beautiful foliage, showy blossoms, and, sometimes, pleasant fragrances.

### Shrubs Partial Shade

**Carpenteria californica**, Carpenteria  
**Ceanothus** species: Wild lilacs  
*C. griseus*, *C. thyrsiflorus*, *C. maritimus*, plus cultivars: *C. Joyce Coulter*, *C. Ray Hartman*.  
*Cercis occidentalis*, Western redbud  
*Cercocarpus betuloides* var. *blanchae*, Mountain-mahogany  
*Eriogonum arborescens*, Santa Cruz Island wild buckwheat  
*Ganya elliptica*, Silk-tassel bush  
*Heteromeles arbutifolia*, Toyon  
**Mahonia** species, Barberries and Mahonias: *M. amplexens*, *M. dictyota*, *M. fremontii*, *M. Haematocarpus*, *M. bigginsiae*, *M. pinnata*  
*Prunus ilicifolia*, Holly-leaf cherry  
*Rhamnus californica*, Coffeeberry  
**Ribes** species, Gooseberries: *R. aureum* var. *gracillimum*, *R. malvaecum*, *R. speciosum*, *R. sanguinum*, *R. viburnifolium*  
*Rosa californica*, California wild rose  
*Rosa californica*, "Plena" double California rose.  
*Salvia clevelandii*, San Diego wild sage  
*Salvia leucophylla*, Coastal white sage

### Shrubs Full Sun

**Fremontodendron californicum mexicanum** and cultivars, Fremontia, Flannel bush, "California glory" "Pacific sunset"  
*Galvesia speciosa*, Island snapdragon  
*Lupinus albifrons*, Silver bush lupine  
*Lupinus chamosis*, Chamisso bush lupin  
*Mimulus aurantiacus*, Bush monkey-flower  
*Mimulus pumiceus*, Red monkeyflower  
**Penstemon clevelandii**, Cleveland's penstemon and other species  
*Romneya coulteri*, Matilija poppy

### Ground Covers

**Baccharis pilularis** subsp. *pilularis*, Dwarf coyote bush  
**Ceanothus griseus** var. *horizontalis*, Carmel creeper  
**Ceanothus maritimus**, Hoover ceanothus  
**Ribes viburnifolium**, Catalina currant

### Evergreen Herbaceous Plants

**Dryopteris arguta**, Wood fern  
**Eriogonum umbellatum** var. *polyanthum*, Buckwheat  
**Heuchera maxima**, Giant alum root  
**Iris douglasiana** and hybrids  
**Viguiera deltoidea** var. *parishii*,

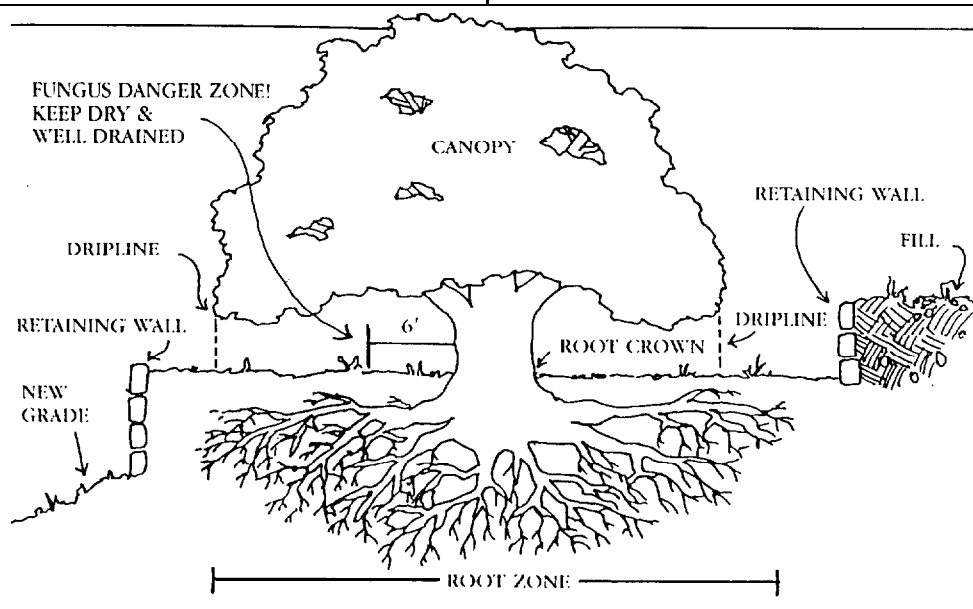
### Deciduous or Annual Herbaceous Plants

**Clarkia** species, Clarkias  
**Collinsia** species, Chinese houses  
**Dodecatheon clevelandii**, Shooting stars  
**Eschscholzia** species, Poppies  
**Montia perfoliata**, miners lettuce  
**Nemophila menziesii**, Baby blue eyes  
**Oenothera** species, Evening Primroses  
**Sisyrinchium bellum**, Blue-eyed-grass  
**Viola pedunculata**, Yellow pansy  
**Zauschneria californica**, California wild fuchsia

### Bulbs

**Brodiaea** species and related genera: *Dichelostemma pulchellum*  
*Tritileia laxa*  
**Calochortus** species, Mariposa lilies  
**Chlorogalum pomeridianum**, Soap plant  
**Lilium pardalinum**, Leopard lily  
**Trillium chloropetalum**, Common trillium

For more information about these and other California native plants compatible with oak gardens, contact local arboreturns, botanical gardens, and the California Native Plant Society (see "Additional Resources").





# OAKS IN THE HOME GARDEN

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Oaks can prosper in close proximity to human habitation if care is taken to preserve the basic elements of the natural oak environment. Garden settings include many of the building hazards discussed above, but there are several more considerations. If the needs and limitations of mature oaks are not part of gardening design and procedures, well-meaning people can make serious mistakes.

## Care and Feeding of Mature Oaks

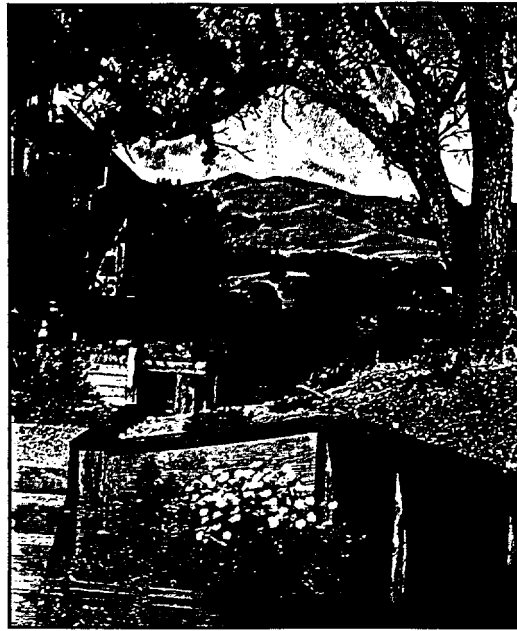
In approaching the design and care of your oak garden, periodically evaluate the health of your oaks. The information in "Oak Health Check" (see right) should help you with this. If problems are evident, consult the references at the end of this brochure or an arborist specializing in oaks. If your oaks pass their health check, they will not need a lot of attention from you as long as care is taken to preserve the basic elements of their environment. The following information can guide your care of mature, healthy oaks.

**Pruning.** Mature oaks do not require pruning except to remove dead, weakened, diseased, or dangerous branches. Sometimes a light thinning, called "daylighting", of 10 to 20 percent of the leaf area from branches three to six inches in diameter can benefit a tree by opening its canopy to deeper light penetration. This also reduces wind resistance and the weight of branches. Avoid excessive pruning, however, as it stimulates vigorous sprouting that is highly vulnerable to damage from mildew.

Light pruning can be done at any time of the year. Heavy pruning, however, should be made during the dormant period (winter) on deciduous oaks and during July and August on evergreen trees. The most important factor in pruning is to make all cuts correctly. Avoid leaving branch stubs and do not paint cuts. For more advice consult an arborist or recent publications on pruning techniques.

**Watering.** Mature oaks in wildland settings are adapted to dry, summer conditions. Summer irrigation will doom the adult tree (see "Diseases") and is to be avoided, especially near the base of the tree. Do not water even ornamentals planted under oaks. If they need watering they do not belong there (see "Oaks in the Home Garden"). If the winter season is unusually dry, a supplemental watering in the early spring, can complement natural rainfall. Water deeply in the outer two-thirds of the root zone. A similar watering can be repeated once or twice during especially dry summers.

**Feeding.** A healthy, mature oak under natural conditions does not require supplemental feeding. But when the oak exhibits disease or stress, or when growth is poor and its natural fertilizer supply (the leaf drop and organic litter that decomposes under the canopy) is removed, supplemental feeding can be beneficial. Young oaks can be fertilized to encourage rapid growth.



*Compatible building around oaks protects a tree's root zone.*

Nitrogen is the primary fertilizer of value to oaks. It can either be spread on the ground in the outer two-thirds of the root zone, or it can be applied through holes dug into the ground, 18 inches apart, along the tree's drip line. Fertilizers should be applied at a rate of two to four pounds of actual nitrogen per thousand square feet of surface area. Consult the label on the fertilizer container to determine the nitrogen content and calculate an application rate. A fertilizer that is 50 percent nitrogen, for example, would require an application of four to eight pounds per thousand square feet.

Either nitrate or organic fertilizers can be used on oaks. Organic fertilizers are preferable as they remain available to the tree longer than nitrate fertilizers, and should be applied in winter so nitrogen will be available in the root zone during spring. Nitrate fertilizers should be applied in late spring, after the first flush of growth is complete. Do not over-fertilize, as it stimulates excessive new growth that is subject to mildew.

An iron deficiency, indicated by yellow leaves with thin dark-green veins, can develop in oaks on poorly drained, alkaline, or clay soils. This situation is difficult to correct, but acidifying the soil with sulfur, worked into the surface at a rate of 10-20 pounds per thousand square feet, may slowly improve conditions. Iron chelates (organic complexes of iron) are also helpful, but are expensive.

## Compatible Gardening Beneath Oaks

Since mature oaks will not tolerate summer watering, care must be taken to select landscaping components that are in harmony with the established oak environment. Thick ground coverings of lawn, ferns, ivy, or any other vegetation requiring watering are inappropriate under oaks, not only because of

their water requirements and fungus problems, but also because the thick root mats of such ground covers inhibit the exchange of air and moisture that a mature tree requires.

Many attractive native plants are well suited to the natural oak environment and, when incorporated into oak landscapes, will provide beautiful, low maintenance, irrigation-free gardens. The California Native Plant Society can provide excellent information on landscaping with native plants (see "Additional Resources"). In addition, the University of California has developed some strains of drought-tolerant, shade-tolerant grasses that could be used under an oak in the outer portions of its drip-line area.

In all cases of planting under oaks, the zone within six feet of the trunk should be disturbed as little as possible. If care is taken to keep the base of the tree dry, some native plants, as well as mulches or porous ground coverings such as gravel, brick with sand joints, and wooden decking (built on concrete piers rather than on poured foundations), can be used even in this sensitive area.



*Colorful galls, caused by gall wasps, are common on twigs, branches, and leaves.*

## Fire Safety Considerations

The threat of wildfire exists throughout all oak-inhabited regions of California. Oaks are fairly resilient when burned and will usually resprout at the base of the tree, where branches join the trunk, or in the forks of branches.

Oaks can also be readily incorporated into the fire-resistant landscaping needed around homes and buildings. Local fire fighting agencies require clearance zones around buildings (usually 30 feet) where brush must be removed and dry, highly flammable vegetation must be reduced. Since oaks cannot tolerate lawn coverings or summer watering, porous ground coverings can be used under mature oaks to retard the growth of flammable weeds (see "Threats to the Root Zone—Paving"). Organic debris should be cleared and branches should be pruned and kept from touching the ground or hanging over buildings. This reduces the dangers of ground fires spreading into tree canopies or onto roofs.

Dependable water sources, such as water

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impoundments, swimming pools or water tanks (located away from mature oaks), greatly improve fire-fighting resources on any piece of land. For guidance always consult the clearance regulations of local fire-fighting agencies.

## Diseases and Infestations

Oaks in natural conditions are relatively free from disease. But when compromised by soil compaction, changes in soil moisture, or other disturbances, trees become weakened and have difficulty fending off their natural enemies. Often by the time the symptoms appear the tree is in crisis, and remedies may be too late. An arborist or Cooperative Extension Advisor should be called when the following symptoms are noticed:

—Loss of tree vigor, twig die-back and wilting, abnormally yellowish leaves, and wounds on the bark that ooze rusty-looking fluid. These symptoms accompany crown rot (*Phytophthora* and *Pythium* spp.).

—Die-back of branches, emergence of clumps of honey-colored mushrooms at or near the base of the tree in the late summer or fall; often accompanied by a white fan-like fungus growth between the bark and sapwood and black shoestring-like rhizomorphs in the soil. These symptoms accompany the oak root fungus, *Armillaria melea*.

*Armillaria melea* is usually present on the roots of all oaks, even when the fungus is not visible. Under natural conditions it is held in check by summer drought. Once a serious infestation develops on the roots of a tree, however, the fungus can persist in the soil organic material and can later infect other trees—even after death and removal of the host tree. Fruit trees and ornamentals planted on the site, particularly those that are irrigated during the summer, may be subject to infestations.

—Another, less common fungus infestation, called "heart rot," occurs when one or several fungi attack the inactive heartwood of an oak. This does not usually impair the

tree's vigor but can weaken it structurally. Weakened branches will break off, and a weakened trunk may not be able to support the crown during a wind storm. Regular examination of the tree and judicious pruning and bracing where needed can prolong the life of an afflicted oak.

**Mistletoe.** This parasitic shrub grows in the branches of many oaks and can cause structural weaknesses that make a tree more vulnerable to branch breakage. Small infestations can be controlled by cutting out the mistletoe, and cutting back the oak's bark around the spot where the mistletoe stem entered the oak branch. Major infestations are difficult to control, however, and a Cooperative Extension Advisor or an arborist specializing in oaks should be consulted.

**Spanish Moss.** Spanish moss is actually a lichen, rather than a moss, and since it is not parasitic it generally offers little threat to oaks. Growth may be slightly reduced due to shading of many leaves in a tree heavily laden with Spanish moss. But the situation is not life-threatening and is easily alleviated by judicious pruning.

**Insect pests.** Innumerable insects find their livelihoods in the branches and leaves of the oaks, usually without much consequence to the healthy tree. The oak gall, for example, is a harmless swelling of branchlets in reaction to enzymes released where a wasp lays its eggs. These galls can be so abundant, colorful, and multi-formed that they resemble dangling Christmas ornaments.

There are some insect infestation however, like pit scales (appearing as pinhead-size scales on the bark of twigs and branchlets), oak moth, and other leaf-eating infestations, that can cause serious damage to oaks. Whenever a severe insect attack causes substantial leaf loss, changes in leaf color, twig die-back, sooty foliage and branches, or other significant changes in appearance, intervention may be required. University of California Cooperative Extension has several publications on diagnosis and treatment of insect infestations (see "Additional Resources"). Farm Advisors and arborists can also provide needed information.

**Animal pests.** In most cases animals pose little problem to the mature oak. Browsing or grazing animals may inhibit natural regeneration but rarely threaten the mature tree. There have been cases, however, where populations of ground squirrels or other ground-dwelling rodents have caused serious damage to oaks. Take measures to control these populations if oak vigor is diminished or if there is extensive excavation by animals in the root zone.

**Other Diseases.** The health and vigor of oaks can also be compromised by a number of other afflictions that are not discussed here. Since 1980, for example, die-back and decline, particularly among coast live oak (*Quercus agrifolia*), has been observed in wide-spread areas of California. Several fungi may be involved in this condition and treatments are still experimental. Whenever you notice serious, unexplained decline in your oaks, contact an arborist or a Cooperative Extension

# Oak Health Check 0116

## Check for tree growth:

- Tree size is not a good indicator of growth. Oaks on steep, less watered sites may be **smaller** but still healthy.
- Twig growth for the season can vary from 3 to 24 inches or more in length. If twig growth is less each year, the tree may be declining.
- Look for growth cracks on a tree's trunk. Cracks appear as widening fissures on existing bark. Tissue in the cracks should be bright green or pink when scratched. Loose bark indicates dead tissue and a diseased condition.

## Check for pests and stress:

- Watch for disease or insect infestations indicated by leaf loss, changes in leaf color, twig die-back, sooty foliage and branches, or other significant changes in appearance.
- Watch for unusual leaf drop during the early summer, particularly among the older leaves. This can be an indication of drought stress, nutrient deficiencies or other root zone problems.
- Watch for twig and branch die-back from the ends of branches. This can be an indication of disease, root loss and/or other root zone problems.
- Watch for emergence of clumps of honey-colored mushrooms at or near the base of a tree in the fall and early winter. These are often accompanied by a white fan-like fungal growth between the bark and sapwood. These symptoms accompany the oak root fungus, *Armillaria melea*.
- Watch for mistletoe, a parasitic, broad-leaved shrub that grows in the branches of many oaks.
- Watch for other changes of tree appearance that may indicate declining health.

## Check for structural weakness:

- Watch for developing structural weaknesses caused by mistletoe, heavy foliage or poor branch structure. Tight, V-shaped branch crotches, long horizontal limbs, extensive decay in branches, and cracks developing in crotches are all indications of weak branch structure. Have tree pruned or support branches to prevent further breakage.

## Check for poor drainage:

- Standing water should not be evident within a tree's root zone.
- Building, landscaping, or other activities near oaks should not increase water in the root zone during the summer.

## Check the root crown condition by digging carefully at the base of the tree:

- A characteristic root flare should be obvious. If not, the trunk has been buried and soil should be excavated to the original grade.
- Bright pink, green or dark red bark tissue is healthy. Dark yellow or brown tissue underneath the bark indicates disease.
- Large decay pockets at the root crown or in the buttress roots may indicate a dangerous condition.

Consult a U.C. Cooperative Extension Advisor, an arborist specializing in oaks, or "Additional Resources" for guidance in dealing with problems you may find.

Coast live oak laden with Spanish moss.



DANIEL D'AGOSTINI

AVID CAVALIERO

Historically, livestock grazing and wildlife production have been the dominant land use throughout the hardwood range. We can thank the livestock industry for the open, pastoral character of much of California's countryside. But it is also in portions of this region that regeneration for several oak species has been poor, especially during the last 100 years. Cattle are the oft-named culprits, and although it is true that cattle do take their toll on the oaks by consuming acorns, seedlings, and saplings, oaks often do not regenerate even when the cattle are taken off the land. Obviously, the oak regeneration problem is more complex.

It has been suggested that grazing for the last hundred years has caused a combination



DAVID CAVAGNARO

of ecological reactions that are inhibiting natural oak regeneration. Such factors as changes in the species composition of the grassland, greater ground squirrel populations, insect and soil fauna changes, and alterations in populations of acorn and seedling eaters may all complicate oak regeneration. Whatever the causes, careful management is needed—of both land and oaks—if these trees are to continue their traditional and ecological role on the hardwood range.

In managing land, animals, plants, and other property resources, there are many things landowners can do to encourage healthy, vigorous oak populations. Some basic management considerations are discussed in the following section. But, in making management decisions that affect oaks, your greatest guidance will probably come from your own observations. Oaks and ecological settings vary tremendously from place to place, as does the relevance of management concepts. So before making decisions, study what actually takes place on your land. Experiment if you want to—you may discover techniques that could also be useful to other landowners.

## Grazing Animals and Oaks

**Minimizing direct impact on existing trees.** Watch your trees for signs of animal damage. Take care that the number of animals congregating under trees does not cause excessive soil compaction, expose the root crown at the base of the trunk, or expose surface roots. Also watch for excessive chewing on the tree trunk. Animals can kill a tree

by girdling if they chew around the tree, through the bark, and into living wood. These types of problems are of particular concern in paddocks or pastures where animals are concentrated.

Measures such as reducing numbers of stock, alternating pastures in use, installing exclosures, screens, or other protective devices to keep animals away from sensitive or damaged areas, can alleviate problems. If damage is severe, you may want to consult an arborist for remedial treatments.

**Pasture management.** In managing your pastures, always remember the general prohibition against summer watering of oaks. If your pastures are improved by summer irrigation, adjust irrigation devices to apply water outside of the root zone only. Adjusting watering schedules to infrequent but long periods of irrigation will also reduce stress on oaks. Always try to keep the base of the tree dry (see "Oaks in the Home Garden"). Observe the location of watering devices and other water sources to make sure that the area beneath an oak's canopy does not become wet from leaky water lines, valves, holding tanks, or from animals splashing in troughs.

## Experiments to Encourage Natural Oak Regeneration

This is currently an area of considerable experimentation and few results—in part because it takes a long time to obtain results from trees that live many years. But if you have the interest and flexibility in your management needs, you might experiment to encourage greater natural oak regeneration on your land. Do not count on high success rates, however, since other, unknown factors may be limiting the oaks.

**Promising sites.** Areas particularly favorable to natural regeneration include north-facing slopes, regions with an annual precipitation greater than ten inches, deep soils, alluvial sites, swales, or other places with subsurface water. The absence of large numbers of seedling, sapling, or acorn eaters, like ground squirrels, deer, or feral pigs will also improve seedling survival.

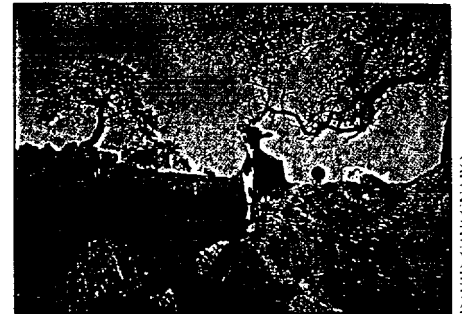
Because seedling mortality is usually high, regeneration possibilities are best in areas that can remain free from grazing animals for a number of years, and where several mature trees provide acorns. Small groves or clusters of trees could provide such sites. Sites offering some natural protection, such as rocky or shrubby areas that naturally exclude or impede the movements of deer or livestock may also be favorable.

**Techniques.** A number of techniques can be employed to encourage natural regeneration.

1) Create fenced areas, called exclosures, that protect seedlings from animals. Exclosures can be small enough to protect single

seedlings or large enough to accommodate entire groves. They are designed to exclude specific animals. For example, some of the smaller exclosures can keep out birds and ground-burrowing animals. You can design appropriate exclosures yourself, look at examples on this page, or refer to the references in this brochure for ideas.

2) Experiment with seasons of grazing, as well as duration and numbers of animals in areas where seedlings or saplings are present. These may be in areas where you have employed exclosures or in areas where regeneration is occurring naturally. Cattle may avoid oak leaves when other forage is abundant. Oak seedlings and saplings can also resprout after being grazed.



DAVID CAVAGNARO

## Helping Nature—Propagation and Planting

Propagation and planting are rewarding ways to speed up nature's processes, beautify your home site, or even enhance the woodland on more remote parts of your property. Your investment for propagation activities can vary according to the time and money you want to spend. Both simple and elaborate efforts have proved successful. Site factors such as soil moisture, predators, weather, and luck are important in propagation success, and these are often hard to evaluate.

**Seed and seedling sources.** Regardless of whether you are planting acorns you collect or seedlings raised elsewhere (by native plant nurseries, youth groups, or service clubs, for example), an effort should be made to use local seeds for all wildland planting. Scientists believe that local ecotypes, or strains of species, have evolved in response to local conditions and are therefore best adapted for survival.

**Collecting acorns.** Most acorns ripen from late October to early November, with seeds on the lower branches ripening first. Use tools, such as long-handled loppers, or sticks to knock them down. Fully mature acorns will dislodge easier than green ones, but birds, deer, and insects will quickly take their toll if acorns are not collected soon after ripening. The biggest acorns are usually best. Test by soaking them in a pail of water, keeping only sinkers. Acorns that float often have been damaged by insects or have not matured properly. But if acorns were collected off the

ground where they may have dried out, **soak** them longer—up to 24 hours—before discarding floaters.

**Storing acorns.** Acorns may be stored up to six months without significant loss in viability if they are kept cool and not allowed to dry out. Place them in peat or saw dust within polyethylene bags, in an environment with temperatures around 40 degrees Fahrenheit, such as in a refrigerator. Polyethylene bags with a wall thickness of four to ten mils are ideal for storing acorns since they are permeable to carbon dioxide and oxygen but impermeable to moisture—two factors that help maintain acorn viability.

**Preparation for planting.** Float the acorns again, and select the sinkers.

**Planting directly in the field.** Direct planting of acorns eliminates the root disturbance that occurs with transplanting and allows maximum root development. Methods for planting vary tremendously, so feel free to experiment. Additional information on planting can be found in other Cooperative Extension publications (see "Additional Resources").

Select a site with good drainage. Plant in the late fall or early winter when acorns will be well-watered by the rains. Dig a hole ten inches in diameter and four to five inches deep. Break apart hard or compacted soil with a shovel. Place one gram of nitrogen fertilizer in the bottom of the hole and **replace** the soil, tamping it down and leaving a one to three inch depression at the top. Remove acorn caps and place six to ten acorns, tips down or sideways, in the hole. Cover with remaining material and tamp down. Use some protective device (see illustration) to exclude both above and below-ground predators. Keep the soil covered with mulch and weed when

necessary. Thin seedlings to two or three at the end of the first season and one by the third year.

If the site is on a steep slope, cut into the hillside to create a pocket for the seed. Plant the acorns on the lip of the pocket with the cut sloping slightly downward and deeper into the hillside (see illustration of exclosures). This acts to reduce erosion and collect moisture for the seedling. It also keeps the seedling out of the seasonally-saturated soil at the back of the cut.

If acorns are planted after heavy rains when soils are moist, watering is not needed. Otherwise, water thoroughly after planting. Periodic watering during the first several sum-

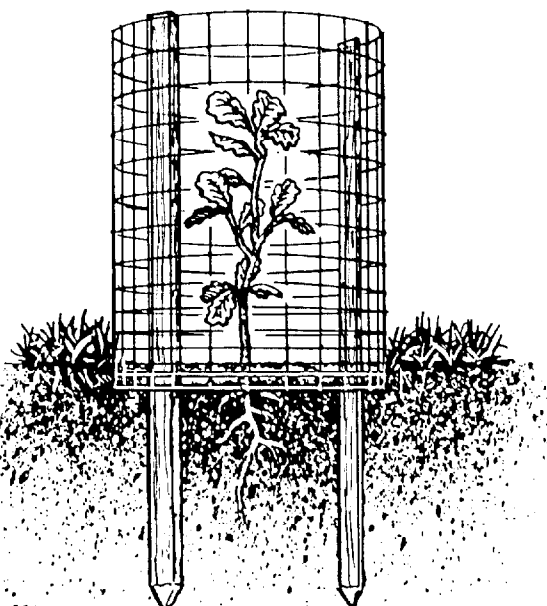
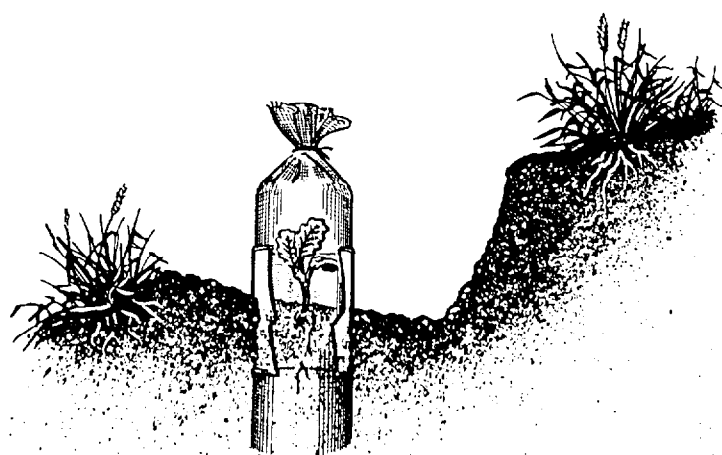
**Planting into cans.** Plant acorns in loose potting soil in one-gallon cans or deeper containers (because the tap root grows quickly, depth of containers, not width, is important). Containers should have holes in the bottom to allow for drainage. Place acorns on their sides at a depth of one half to one times the width of the acorn. Keep the soil moist but aerated.

**Transplanting.** If possible, seedlings should be transplanted as soon as the first leaves open and become firm, before extensive root development occurs. Young trees in containers should be transplanted in the late winter or early spring, after the ground has begun to warm and before the leaves of deciduous trees begin to emerge. The hole should be twice as wide and deep as the can. Thoroughly wet the root ball in the can. Carefully remove the root ball. If roots have begun to curve around the inside of the container, prune them to allow placement in the hole without bending or folding. Prune a corresponding amount of foliage after transplanting. Gently set the root ball in the hole with the root crown at the level of the soil surface. Fill the hole with soil, firmly tamp and soak.

**Watering transplanted oaks.** Watering, weeding, and mulching is important until the seedling is well established. If transplanting is done during the fall or winter, normal rains should be adequate until the dry season. For the first season, thoroughly soak seedlings so that water deeply penetrates the soil every two weeks or whenever the top two inches of soil is dry. Taper off as trees become established—many plantings are successful with only several supplemental waterings during the first season. If the transplant is to live in an irrigated environment make sure the area around the root crown is adequately drained.

**HOOF &  
TOOTH THREAT  
Avoid Root Zone  
Trampling &  
Chewing By  
Livestock**

mers will increase seedling survival. Good sites may only need watering two or three times the first year, but dry conditions in poor or sandy soils may require watering as often as once a week. Always soak the soil thoroughly to stimulate root development, and allow the surface to dry between waterings. Taper off watering during the second and third year.



**12** frequently used exclosure devices designed to protect seedlings from ground squirrels, birds, and deer.

# ENHANCING PROPERTY

## Wildlife Enhancement

**O**ak environments are among California's richest wildlife habitats; 110 species of birds use oak habitats during the breeding season, and 35 percent of California's land mammals utilize oaks during some time of their lives. California's deer herds are particularly dependent on oak habitats. By maintaining the health of your oak woodland, you also maintain an abundance and diversity of native wildlife.

Aside from reducing oak seedling and sapling survival, wildlife do not harm oaks, and instead provide benefits through maintaining ecological balances. Some birds and mammals even "plant" acorns during their foraging activities. The presence of wildlife often adds beauty to a woodland and value to property. When desired, landowners can take some measures to increase the abundance and diversity of wildlife on their lands. Here are a few suggestions.

**Leave brush piles** in areas where they do not pose a fire hazard. These environments are used by quail for cover and by a variety of small animals for food and shelter.

**Leave a few snags** if they do not pose a fire hazard or safety concerns. Snags—dead, standing trees—are often rich environments for wildlife, especially birds. Woodpeckers and other cavity-nesting birds rely on these habitats, and predatory birds use snags as perches. Many birds will move acorns, inadvertently distributing them to new germination sites.

**Add water impoundments** (well away from oaks). Not only does year-round water increase wildlife diversity, it also improves fire-fighting capabilities.

**Manage vegetation** for diversity. The diversity of wildlife depends upon the diversity

of habitats and age classes of vegetation. If you maintain grassland, oak woodland, shrubland, as well as diverse gradations between these vegetation types, you will encourage diversity in wildlife occupants. The edges between these zones are particularly rich in wildlife. For example, if you allow a field to become shrubby on the edges where it borders shrubland or woodland, you will be inviting deer, quail and other animals

## Thinning

Individual oaks and groves of oaks can be thinned to meet many landowner needs. Thinning can increase tree growth, stimulate young trees, produce firewood, encourage wildlife, provide forage for livestock, and improve fire safety, while maintaining or even enhancing the oak ecosystem. The degree of thinning and trees selected depend upon the nature of the woodland and the objectives of the landowner. Assistance in designing thinning objectives and how to meet them can be obtained from Cooperative Extension, local Resource Conservation Districts, and professional foresters.

## Commercial Prospects

Because of the ever-increasing demands of a growing population on dwindling open-space resources, owners of rural and semi-rural lands can use their lands for a variety of commercial ventures. Consider raising Christmas trees, specialty or nursery crops, or mushrooms. You could also open your lands for recreational uses such as camping, hiking, hunting, horseback riding, birdwatching, photography, fishing or mushroom-picking. The references in the bibliography provide further information.

# ADDITIONAL RESOURCES

Landowners have a number of resources at their disposal for assistance and additional information. A few of these are:

### Public Agencies:

University of California Cooperative Extension, Natural Resources Program, 163 Mulford Hall, Berkeley, Calif., 94720 (415) 642-2360

California Department of Forestry and Fire Protection, 1416 9th St., Sacramento, Calif., 95814

Local fire protection districts

U.S.D.A. Soil Conservation Service, 2121—C, 2nd St. Suite 102, Davis, Calif., 95616

Local Resource Conservation Districts

California Department of Fish and Game, 1416 9th St., Sacramento, Calif., 95814

### Private Sector:

American Farmland Trust, 512 2nd St., San Francisco, Calif., 94107, (415) 543-2098.

California Native Plant Society, 909 12th St., Suite 116, Sacramento, Calif., 95814, (916) 447-2677.

Circuit Rider Productions, 9619 Old Redwood Highway, Windsor, Calif., 95492, (707) 838-6641

Marin Agricultural Land Trust, P.O. Box 807, Pt. Reyes Station, Calif., 94956, (415) 663-1158.

Sacramento Tree Foundation, P.O. Box 15824-A Sacramento, Calif., 95852 (916) 924-8733.

The Trust for Public Land, 116 New Montgomery 4th Fl. San Francisco, Calif., 94105, (415) 342-3282.

### Newsletters:

"Oaks and Folks" published by University of California Cooperative Extension

Other publications by Cooperative Extension (see below)

"Fremontia," A Journal of the California Native Plant Society, 907 12th St., Suite 116, Sacramento, CA 95814.

### Publications:

Brown, Leland R. et al. 1979 "Oaks on Home Grounds." Div. of Ag. Sci., Univ. of Calif. Leaflet 283.

George, Melvin R. 1980. "Management of Small Pastures." Div. of Ag. Sci., Univ. of Calif. Leaflet 296.

Hardesty, Nancy M. 1984. "Oak Woodland Preservation and Land Planning: Portola Valley Ranch." Hardesty Assoc., 855 Oak Grove Ave., Suite 205, Menlo Park, Calif., 94025, (415) 326-4268.

Harris, Richard W. and Andrew T. Leiser. 1979. "Direct Seeding Woody Plants in the landscape." Div. of Ag. Sci., Univ. of Calif. Leaflet 2577.

Harris, Richard W. and William B. Davis. 1976. "Planting landscape trees." Div. of Ag. Sci., Univ. of Calif. Leaflet 2583.

Heritage Oaks Committee. 1976. "Native Oaks, Our Valley Heritage." Sacramento County Office of Education, Sacramento.

Koehler, C.S., et al. 1983. "Protecting Trees when Building on Forested Land." Div. of Ag. Sci., Univ. of Calif. Leaflet 21348.

Lobel, Denise E. and Alan G. George. 1983. "Plant your Own Oak Tree." Div. of Ag. Sci., Univ. of Calif. Leaflet 21334.

Maire, Richard. 1979. "Landscape for Fire Protection." Div. of Ag. Sci., Univ. of Calif. Leaflet 2401.

\*Numerous other publications of interest to rural landowners are available from Agriculture and Natural Resources, Univ. of California, 6701 San Pablo Ave., Oakland, Calif. 94608, (510) 642-2431.

This is a publication of University of California Cooperative Extension, Natural Resources Program, additional copies may be obtained at 163 Mulford Hall, Berkeley, CA 94720, (510) 643-5428.

# COMMUNITY ACTIVITIES

**T**hroughout California, landowners are working together to solve common problems in the hardwood range. Many regional problems can only be solved by landowners working together in innovative ways. Here are a few examples of landowner efforts:

**Landowner associations.** In many areas, particularly newer subdivisions, landowner associations are working on a variety of issues including fire safety, regional landscaping, and woodland protection. One excellent example of such an endeavor is the Portola Valley Ranch, a Hardesty Associates project. This planned unit development in the foothills of the Santa Cruz Mountains includes areas of shared open space that are managed and maintained by the Ranch Homeowners Association.

**Open space easements and dedications of land.** In many areas individual landowners, entire developments, and local land trusts are dedicating lands to open space

uses through easements and a variety of other legal tools. Landowners dedicating such lands often enjoy some tax relief as well. The Trust for Public Land and the American Farmland Trust (both headquartered in San Francisco), the Marin Agricultural Land Trust, and many small community land trusts are just a few of the organizations that operate such programs.

**Community groups** have developed throughout California to sponsor a variety of education, protection, and woodland enhancement activities. These groups pursue public awareness and educational programs, tree planting projects, registry programs for significant individual trees, and lobbying efforts with local jurisdictions for ordinances to protect local tree resources. An excellent example of one such program is the Sacramento Tree Foundation.

Written by Sharon G. Johnson

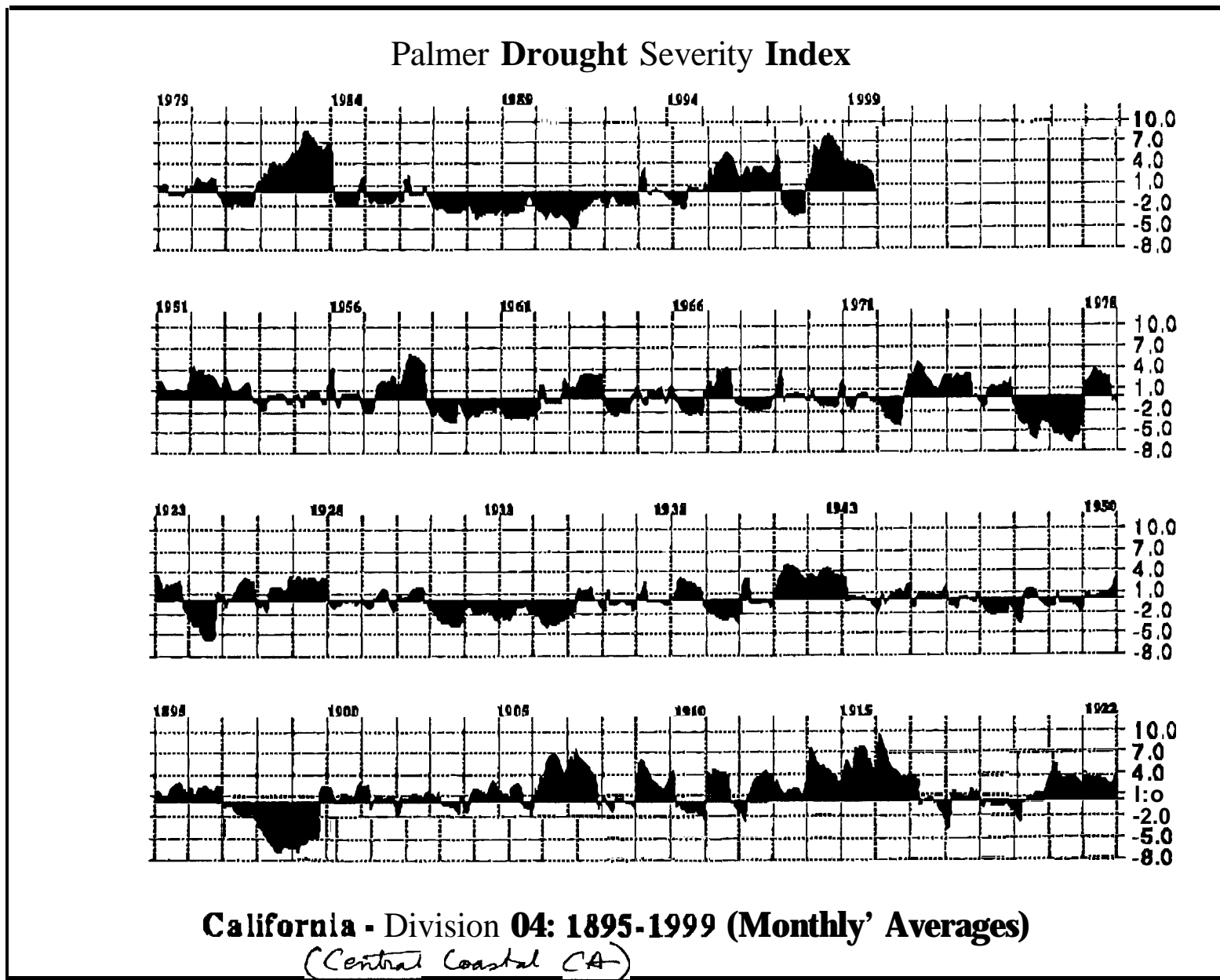
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CALIFORNIA

Pete Wilson  
Governor  
State of California

# TREE NOTES

## DEPARTMENT OF FORESTRY AND FIRE PROTECTION

Richard A. Wilson  
Director

Douglas Wheeler  
Secretary for Resources  
The Resources Agency

NUMBER: 3

December 199 1



## Controlling Bark Beetles in Wood Residue and Firewood

Sherburn R Sanborn

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Each year, timber losses in California forests due to bark beetle attack exceed those caused by wildland fire. During the last several years, drought conditions and related bark beetle problems have caused increased conifer mortality on private and public forest lands. It has been estimated that 10 million average-sized trees were killed throughout the state in 1989 and 1990 alone, destroying enough timber to build one million three bedroom homes. In some areas, mortality has been so severe that the California Board of Forestry has declared Zones of Infestation.

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Many valuable urban landscape trees are also being killed due to drought stress and bark beetle attack. In some urban areas of Southern California, pines are frequently killed by bark beetles transported in infested firewood obtained from dead and dying trees in the Southern Sierra Nevada (personal communication, Eric Oldar, CDF Regional Service Forester, Region III). Firewood often harbors immature beetles (larvae) which complete their development, emerge, and kill nearby pines in the urban landscape. This problem may be occurring in other urban areas as well.

This article discusses several techniques that may be used by both forest landowners and urban dwellers to reduce tree mortality by reducing local bark beetle breeding sites. An important first step before applying any of the following techniques is to determine if a potential bark beetle problem exists. Next, identify the species of bark beetle infesting the wood as well as the species of tree (host) infested. Because host preference and life cycle are so variable among different species of bark beetles, reducing tree mortality may depend on the proper selection and timing of control techniques. Because these techniques are preventative in nature, their use may be justified even where bark beetle problems do not exist. This is particularly true where high value trees, such as those in parks or residential areas, are at risk.

### Firewood Pests and Regulations

Wood from tree removals, salvage logging, and forest thinning are often used for firewood. The freshly cut wood of many trees cut attract bark beetles which can breed in it, while the wood of trees killed by bark beetles may harbor developing brood. Trees of particular importance are pine, true fir, Douglas-fir, elm and eucalyptus. Whenever wood is moved, there is a risk that associated insect and/or disease pathogens are moved as well. This can result in the introduction of new pests or exacerbate existing pest problems. Some bark beetle species become so numerous during periods of drought that they will mass attack and kill healthy trees.

Elm wood is of particular concern because the European elm bark beetle which breeds in it vectors the Dutch Elm Disease (DED) fungus. Elm wood is quarantined in eight bay area counties, Sacramento County, and parts of San Joaquin and Yolo Counties. The spread of DED over long distances has invariably been due to the movement of elm firewood from infected areas.

The eucalyptus longhorned borer (ELHB), a native of Australia, was introduced into Southern California in 1984. Since then, it has spread to several locations in the San Francisco bay area. Many mature eucalyptus trees have been killed in areas of the state where this

insect has become well established. This is due to a lack of effective controls and natural enemies. The movement of eucalyptus wood has become an increasing problem because this introduced insect can be carried great distances in firewood. The transport of ELHB infested wood is prohibited under section 4714.5 of the Public Resources Code. A violation of this section is a misdemeanor punishable by a fine and/or imprisonment.

### Firewood Tarping

Tarping and sealing wood piles with clear plastic is a very effective way to prevent the emergence of beetles from the wood. This technique will also prevent them from colonizing freshly cut uninfested wood. To properly tarp a wood pile you will need the

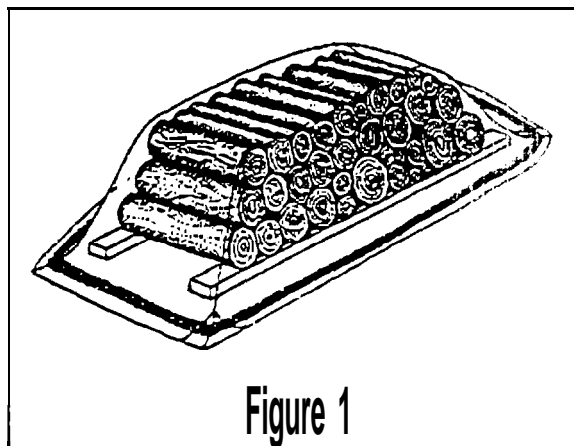


Figure 1

following materials:

- » Six mil clear plastic sheeting of a size sufficient to cover your wood pile. This material is available in various sizes at most hardware supply stores. If available, six mil ultra violet (UV) resistant plastic sheeting such as CIL Durafilm Polyethylene Greenhouse film is excellent. Do not use black plastic because beetles are attracted to areas that are lighter in color and they chew through it.
- » Lumber such as 2x4's to use as runners to keep the wood off the ground.
- » An old tarpaulin, carpet, cardboard, automobile tires or similar material to protect the plastic from tearing.
- » Soil, gravel or other material to seal the plastic along the ground.

Figures 1 & 2 are examples of how to stack the wood. Use these examples and the following procedures to tarp it:

1. The wood stack can be any size provided it can be covered by a single sheet of plastic that will allow for 12 inches of overlap along the ground.



2. To rid in drying, keep the wood off the ground by stacking it on 2x4 runners. Placing the stack in partial sunlight will reduce drying time, minimize the breakdown of non-UV resistant plastic and render the wood unsuitable for beetle breeding.

3. Prior to covering the stack, make sure there are no sharp projections which could pierce the plastic. Place a tarpaulin, cardboard, automobile tires (see diagrams) or similar material over the top of the stack to protect the plastic.

4. Cover the stack with plastic allowing 12 inches of material to overlap along the ground (see diagram).

5. Seal overlap against the ground with soil, gravel or similar material. Tarp must be sealed entirely around stack.

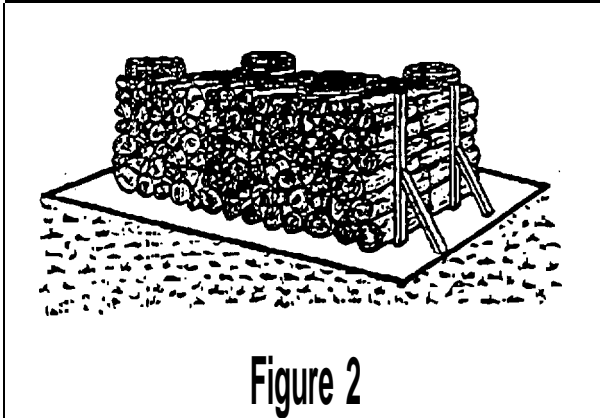


Figure 2

6. After sealing, the plastic may become tightly stretched over the wood stack. If this occurs, gently pull up on the plastic allowing 2-3 inches of slack to relieve strain. This will reduce punctures and tears. If the plastic is held too firmly against the bark, tarpaulin, cardboard or other materials, beetles will get between that material and the plastic and escape by chewing their way out. This would necessitate retarpling the wood.

7. Inspect tarping frequently for damage. Repair small holes and tears with duct tape. Larger tears may require retarpling.

Wood should be tarped for one season after cutting, from April 1 until November 1. Firewood seasoned in this manner through one spring and summer will not support beetle colonization. Any beetle brood present in the wood when it is tarped will be killed. Wood that is tarped dries more rapidly, particularly during the winter.

## Slash Treatment

Slash is woody material generally consisting of branches and bolts (large pieces of tree trunk) left behind after commercial logging or thinning operations. Those materials with bark still attached may become a breeding site for bark beetles and can lead to bark beetle population buildup. There are several techniques which can be used to render this material unsuitable for beetle breeding. To be effective, the following techniques must be completed within five weeks of slash creation or before beetle brood emerges:

**Log and scatter** involves the evergreen branches or bolts 3 inches or larger in diameter. This technique is recommended where pine trees are being logged or thinned particularly when beetles of the genus *Ips* are already abundant. To be effective, slash must be scattered in an area that receives partial or full sunlight. Heat from the sun increases the temperature under the bark and hastens drying. Both heat exposure and drying can greatly reduce the breeding success of bark beetles. As an alternative, avoid activities in pine stands that will place 'green' slash on the ground during the spring.

**Piling and burning** is another effective technique which will render the slash unsuitable for beetle colonization. This may be a very cost effective approach in rural areas where burn permits (LE-7) can be obtained through CDF.

Chipping is a very effective way of reducing bark beetle population buildup in logging slash and wood residue from pruning, thinning or tree removals in urban areas. Chipping destroys most beetle brood present in the wood while leaving chips that are unsuitable for bark beetle breeding. Many tree services have chippers that can chip wood up to 12 inches in diameter. Whole-tree chippers are also available for biomass production.

**Debarking** logs or bark removal destroys the habitat where bark beetles breed and their larvae food. Once removed, the bark and the wood are unsuitable for bark beetle breeding. The wood can then be left on site or used for firewood without concern. Wood that is still green or freshly cut is easier to debark than dry or seasoned wood. There are various devices available that can speed the process. They range from steel bars and chain saw attachments to commercial log debarking machines.

## Chemical Control

Controlling bark beetle infestations through the application of pesticides have demonstrated varying levels of success. On commercial forest land, insecticides are costly and difficult to apply on a large scale. They can also disrupt the effect of natural enemies, and their effectiveness in controlling beetle outbreaks has been variable. In the urbanizing forest, it is possible to manage bark beetle caused mortality with insecticide application as a temporary prevention measure or to reduce pocket killing. However, this should be considered a short term remedy used in conjunction with long term practices that improve the growing conditions for the tree.

## Conclusion

Whichever technique(s) you choose, be sure to investigate the legal requirements pertinent to your activities. If you are involved in timber harvesting, insure that you are in compliance with the California Forest Practice Rules. The Registered Professional Forester (RPF) or Licensed Timber Operator (LTO) responsible for the timber harvest plan will be aware of current rules. If you plan to burn woody material you will need a burn permit from the California Department of Forestry and Fire Protection (CDF) or other local agency. There are many communities that have ordinances restricting the removal of trees. Whenever you are working with elm wood, you should contact the nearest CDF Forest Pest Management office or the County Department of Agriculture for quarantine information pertaining to the movement of elm wood. Do not move elm material, either living or dead, into or out of a quarantined county even when the county of origin is not under quarantine.

## Further Reading

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# Sudden Death of Tanoak, *Lithocarpus densiflorus*

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Fig. 1. Tanoak forest showing different stages of dieback. Wilted, faded and brown foliage clinging to entire crown since mid-spring draws the attention of concerned residents. More than 100 trees have been killed by this mysterious disease in the area shown.

Tanoak, tanbark-oak or chestnut-oak, *Lithocarpus densiflorus* is a large tree (some varieties are shrubby) that grows naturally in Marin County and many other areas of the state. It is rarely planted as an ornamental but if the tree begins to grow from seed in the garden, our residents favor it because this tree grows rapidly and in the past has not suffered significant dieback from biotic or abiotic agents. In the summer of 1995, the first serious episode of spontaneous tanoak death was reported in Mill Valley. Homeowners residing in the urban forest interface observed death of tanoaks in the forest close to their properties. I visited these sites and found several large trees with brown foliage scattered among apparently healthy trees. I checked the root system of one brown tree and found well-developed oak root fungus, which led me to the conclusion that *Armillaria mellea* was the cause. By early spring of 1996 the tanoak death rate reached epidemic proportions (Fig. 1).

## Symptoms of this unusual tanoak dieback

From a distance, the first prominent symptoms are drooped (wilted) new shoots (Fig. 2A). Shoot wilting

is spontaneous and occurs throughout the crown. Older leaves become pale green. Approximately two-three weeks later the foliage turns brown but remains clinging to branches, visibly announcing the death of tanoak.

Chisel cuts into the inner bark and sapwood at breast height of affected trees, reveal saturated tissue that drips burgundy-red sap. Samples of the symptomatic branches, whether at the time of drooping or later when all foliage becomes brown, have not shown staining in vascular tissues. Close inspection of a lower trunk may show an exudation of dark-brown sap that stains a few squares inches of the bark surface (Fig. 2B). Samples of the bark, inner bark and phloem-xylem tissues beneath stains were cultured in different laboratories several times without revealing pathogens. However, the western oak bark beetle was found beneath the bark.

In the summer, the bark splits and breaks as a result of drying. Gum often exudes from these splits, and is then occupied with prominent clusters of *Daldinia* spp. fruit bodies (Fig. 2C). Long striations of a different tan to pinkish discoloration become visible on the bark surface. Examination of the root-crown

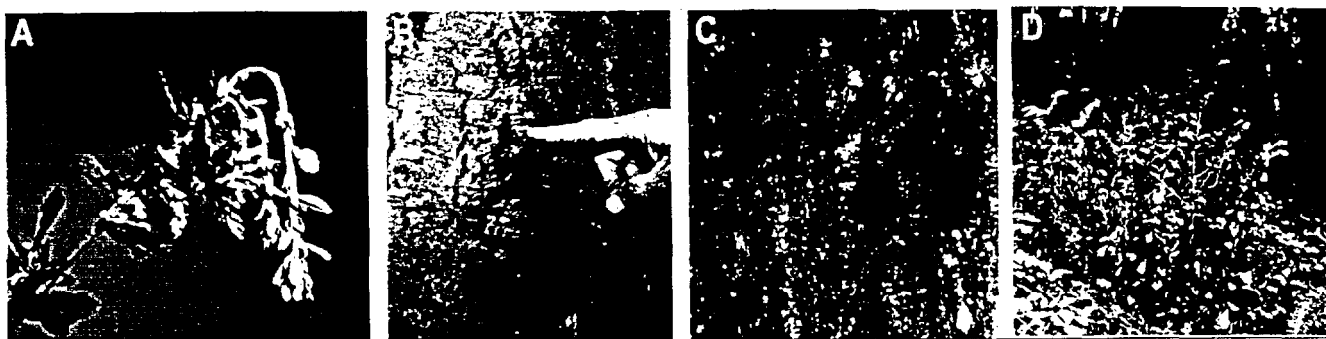


Fig. 2. Wilted shoots (A) signal the sudden death. None of the tree recovered after the wilt appeared. (B) Oozing near the base of tree stem. (C) *Daldinia*'s fruiting bodies. (D) Suckers display dieback resembling treatment with phenoxy herbicides.

area has not revealed development of oak root fungus nor *Phytophthora* disease on most dying trees. Roots of tanoaks undergoing above ground symptoms often have a pungent alcoholic odor, but appear sound. The following year after the tree dies, suckers sprout near the base. Soon their tips bend, become chlorotic and die (Fig. 2D).

A very noticeable feature of the dead tanoah is massive infestation of the whole stem with ambrosia beetles in mid summer.

### Sampling, and information from experts

Samples of dying tanoaks were sent to State Laboratories and University of California Plant Pathology Departments at Berkeley, Davis and Riverside on the five separate occasions. In the beginning I suspected that tanoaks were infected with chestnut blight fungus, *Cryphonectria parasitica*, mainly because the initial symptoms closely resembled those caused by chestnut blight, which occasionally infects, without killing, some oak species in the east. Besides selecting branch-twig samples with different stages of wilted, dying and dead tissues, I also focused on abnormalities (swellings at the tree base) to collect samples of inner bark. No pathogens were ever isolated from the branches or stem sections, and no *Armillaria* or *Phytophthora* was cultured from the roots. In each of three separate samples *Hypoxylon* sp., *Pseudomonas tolaensis* and *Diplodia quercina* were found.

### Speculations about causes of the dieback

Sudden death of tanoaks is localized in the Mill

### Valley-Mount Tamalpais region and Inverness.

Differences of opinion exist among plant pathologists and tree experts as to whether the cause of dieback is a single pathogen or if this species has been locally predisposed to physiological weakening by drought or other environmental factors that have caused damage. Opinions may have merit but with one recent exception: very young trees have been killed as though they were treated with a systemic herbicide. It seems probable that drought was an important factor in placing the mature trees under stress that triggered their death. However, the same hypothesis does not hold for young trees that are dying now.

There is no question, that after these trees have gone through the progressive stages of the above-described symptoms, their vigor rapidly declines and they become vulnerable to secondary insect pests such as bark beetles *Pseudopityophthorus pubipennis*, which produce a pile of fine red boring dust near tiny holes, and ambrosia beetles *Monarthrum* spp., which produce a pile of fine white boring dust near tiny holes. While *Pseudopityophthorus* occupies the phloem-xylem portion of the tree, ambrosia beetles penetrate deeper to the heartwood region. These insects are not capable of invading healthy trees but are very destructive to weakened ones. Since several hundred tanoaks have died since 1995 these trees have become an especially favorable target for building up bark beetle and ambrosia beetle epidemics.

**Recommendation:** Prompt removal of dead trees is the only control that can be advised at this time. Cut logs and stored firewood should be covered with clear plastic sheeting to prevent beetle emergence and infestation...

**Acknowledgments:** This research study has been supported by many public, private organizations and private citizens: Marin County Stormwater Pollution Prevention Program (MCSTOPPP)—for information on protecting local creeks call 499-6528; Bartlett Tree Service; Gardenworks; Garden West; Drs. Paul and Geraldine Alpert; City of San Rafael; and City of Novato.



UNIVERSITY OF  
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Cooperative Extension in Marin County

Pest Alert #3A

October 1999

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## Western Oak Bark Beetles and Ambrosia Beetles Associated with Dying Live Oaks

by Pavel Švihra, University of California Cooperative Extension

Oak bark beetles and ambrosia beetles are very small insects (1.7 to 4 mm long) that attack and may kill oaks by boring beneath or through the bark into the sapwood and heartwood. Three species are common and widespread throughout California: the Western Oak Bark Beetle, *Pseudopityophthorus pubipennis*; the Oak Ambrosia Beetle, *Monarthrum scutellare* (Fig. 1); and the Minor Oak Ambrosia Beetle, *M. detingeri*. These beetles have appeared very suddenly, and have reached epidemic proportions, in California live oaks, *Quercus agrifolia*, in the landscape and natural forests of many coastal counties.

Western oak bark beetles and ambrosia beetles attack wounded and stressed trees. If environmental conditions contribute to oak stress in areas where bark beetle populations have reached epidemic proportion, the beetles may attack and kill trees that appear to be healthy. Such a situation has developed during the last four

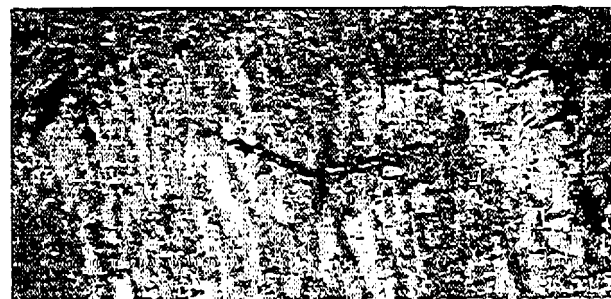
years, when apparently healthy oaks in gardens and natural forests have died in large numbers between Big SIR and Santa Rosa. Timely removal of infested trees may reduce further tree losses, but there is little that can be done directly to stop bark beetle and ambrosia beetle epidemics in the natural forest. The best defense that arborists, pest control advisors and homeowners have against such losses is to understand oak health care and the beetles' habits.

### Life History and Habits

**Western Oak Bark Beetle, *P. pubipennis*.** These beetles usually attack severely injured, dying or dead trees. They reproduce primarily in great numbers in oak firewood, emerging to attack live oaks and tanbark oaks in the landscape. Adults emerge in the spring and fly to dead or dying oak material, where they bore through the bark and construct two transverse egg galleries in the phloem and xylem tissues (Fig. 2). Females lay



**Fig. 1.** Tree heavily infested by ambrosia beetles. Only when their population is high do these beetles attack stems so high. Foliage was still green, yet this tree's death was hastened by ambrosia beetles' arrival.



**Fig. 2.** Initiation of egg galleries by the western oak bark beetle. The transversely excavated egg galleries are marked deep in the sapwood. This oak had no sign of ambrosia beetles, which arrived 10 days later.

eggs along both sides of galleries. As beetles continue to bore through the bark, they inoculate a fungus (not yet identified) that stains and kills the inner bark and sapwood around the egg galleries excavated perpendicular to the grain. The construction of egg galleries girdles and plugs the tree's vascular system (the vessels that transport

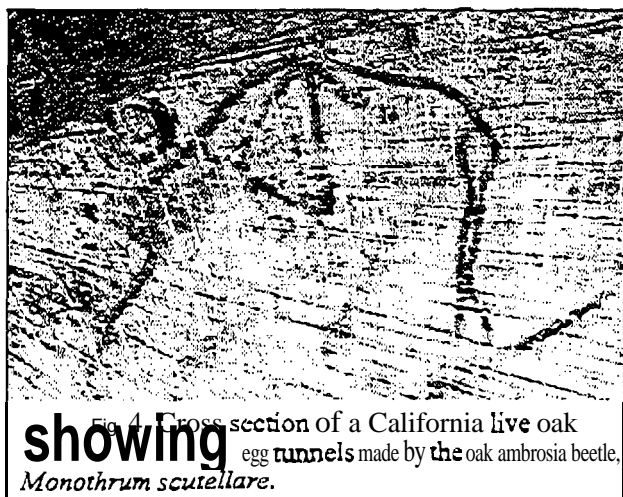
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water and nutrients to the tree [Fig.3]). After eggs hatch, the larvae make fine threadlike tunnels through the phloem into the inner bark where they pupate. Newly formed adults make their own exit holes through the bark and fly to attack oaks in the vicinity or far away. This beetle has two or more generations a year.

### Oak Ambrosia Beetle, *M. scutellare*. These

beetles attack dying, weakened, or diseased trees, but most prefer just-killed trees, stumps or parts of trees. In March, the male penetrates the sapwood to a depth of 2 ½ inches. The female joins the



male, mates and introduces the symbiotic fungus, *Monilia brunnea*. Both sexes excavate two to four diverging galleries deep into the heartwood, each 2 to 6 inches long (Fig.4). The female excavates

egg niches in the sidewalls of the galleries, which the larvae extend into "larval cradles." The ambrosia fungus grows into the cradles and serves as a food source. Excavation of egg galleries lasts 2 to 4 months; larval development, 6 to 8 weeks; and pupation, 2 to 3 weeks. After 3 to 4 months, new brood beetles emerge through the same entrance holes made by parent beetles. There are two generations per year with two major flight periods; the first in March and the second in September. However, beetles may fly almost every day during the growing season because different developmental stages overlap.

Minor Oak Ambrosia Beetle, *M. detinger*. The biology of this beetle is unknown but is probably similar to *M. scutellare*.

### Look for Symptoms

The first step in dealing with potential bark beetle and ambrosia beetle problems is to learn to identify symptoms of their attack. In apparently healthy California live oaks dark brown- to black-colored granules and stained bark surface (Fig.5) below entrance holes of western oak bark beetles are the first signs of a fresh



infestation near the trunk base. Reddish-brown boring dust appears on the lower bark surface

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near the tree base.

Sap flow and bark beetle borings attract oak ambrosia beetles and other associated insects to the same tree. They also bore in extremely high numbers into bark already occupied by oak bark beetles. However, the ambrosia beetles penetrate through the bark deep into the heartwood and fine white sawdust appears on the tree trunk (Fig. 6). The amount of their feeding depends on the

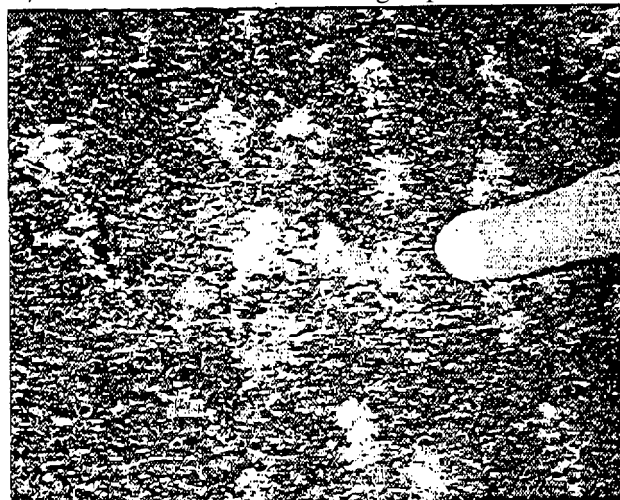


Fig. 6. Fine white sawdust streams on the lower and middle trunk indicates ambrosia beetle attack

wood's moisture and surrounding temperature.

Large trees more than 10 inches in diameter, with healthy appearing green foliage, are mostly attacked near ground level and succumb rather quickly. The foliage of an attacked live oak becomes pale green and then rather rapidly changes into red.

Very soon after successful gallery construction commences, fruiting bodies of *Hypoxylon* sp. fungus appear on the bark's surface (Fig.3).

### Proper Oak Health Care Prevents Bark Beetle and Ambrosia Beetle Attack

There is no historical record about such a rapid and massive dieback of live oaks as we are now experiencing in coastal counties of Northern California. The adage that "an ounce of prevention is worth a pound of cure" is certainly true in the

protection of landscape oaks. Epidemics of these beetles originated in naturally growing tanbark oaks, *Lithocarpus densiflorus*. In 1995 massive deaths of tanbark oaks from unknown causes began in the Mt. Tamalpais-Mill Valley region. These dead trees may have served as a source for new brood beetles to emerge and attack nearby live and tanbark oaks in the natural forest and landscape. Tanbark oak and California live oak diebacks in forest stands cannot be controlled with chemicals. Once these beetles have completed their attack, there are no chemical controls that will save the tree (Fig.7.).



Fig.7. Cross- and longitudinal section of a live oak trunk killed by ambrosia beetles. Or was it? Ambrosia beetles were blamed for the death of this tree but once the bark was removed, phloem and xylem were found to be girdled by oak bark beetles. Also notice the growth of *Monilia* fungus that caused black discoloring of tunnels and invaded the conductive system. Compare the infested section with the uninfested one on the left. It is clear that chemicals injected to the system cannot reach and kill the feeding larvae, because water-conductive vessels are plugged.

While these species are native to California, they have never before reached pest status and thus very little biological information exists about their habits. In natural forests the success of chemical and silvicultural treatments is uncertain as it is difficult to predict how long the epidemics will last. In contrast, in urban forest situations oaks are often used as design elements. Whether they grow singly or in groups, homeowners demand that their oaks be protected from infestation by these pests. Oaks that are overmature, stressed,

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damaged by **cultural** practices, infected with root pathogens or suffer **from** water imbalance demand prompt **arboricultural** and **horticultural** response by:

- ♦ Regularly checking coast live oaks and **tanoaks** from March to October for the presence of bleeding (Fig. 5.) and reddish-brown boring dust. **Immediately** spraying the infested **trunk** (up to 8 ft. above the ground) with insecticide **permethrin (Astro)** to prevent further infestation.
- ♦ Promptly cutting down infested trees **with** symptomatic **brown** foliage, chipping **smaller** branches and **splitting** the wood for firewood. **Firewood must immediately be covered with clear plastic** for six months to prevent new brood emergence and subsequent attack of oaks in the vicinity (Fig. 8.).
- ♦ Pruning oaks to achieve desired beauty, form and **structure from** November to February when beetle-s are not active. Avoiding heavy **intermediate** pruning cuts that open the oak canopy to physiological stress.
- ♦ Removing dying, dead and damaged branches to maintain healthy, vigorous oaks.
- Grinding the stomp after the oak is removed. Stumps are very attractive to ambrosia beetles.
- Preventing damage and physiological **stress** by insect defoliators such as **oakworm** and tent caterpillars, which are **on** the rise.
- **Irrigating drought stressed oaks** during the summer to reduce drought damage to roots and improve tree **vitality**. Apply soaker hose to the area within the drip line of a tree once every six weeks. Lay down soaker hose across (at right angles to) the slope.
- ♦ Reducing damage to roots and **the root crown area** caused by **soil** compaction and **frequent irrigation**. Too much supplemental water or water applied too often denies oxygen to the roots, reduces tree vigor, predisposes trees to beetle **attack**, and favors **certain** serious diseases such as oak root fungus and *Phytophthora* fungus.
- Protecting individual trees by spraying the **trunks** (up to 8 ft. above ground) Twice a year with the insecticide **permethrin (Astro)** (in March and at the beginning of September), especially over-aged high-valued ornamental oaks and oaks whose root systems were disturbed by any **construction** or soil compaction. If properly applied (the bark is soaked to **runoff**) this chemical acts as a successful preventative **treatment**.



**Fig. 8. Firewood, cut from an oak killed by western oak bark beetles and ambrosia beetles, was immediately covered with clear plastic. Two days after cutting and covering, the inside of the plastic was "black" with beetles trapped and drowned in condensed pools of water (insert). This environmentally sound system is much more effective than any chemical treatment.**

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# Observations on Tanoak (*Lithocarpus densiflorus*) Dieback and Mortality in Marin County, California

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Additional key words: Tanbark-oak, chestnut oak, tanoak sudden death, tanoak decline

According to various reports, decline and death of tanoak (*Lithocarpus densiflorus*) trees has become common in a number of California coastal counties. Some of the earliest reports of unusual tree mortality were from the Mt. Tamalpais vicinity in Marin County (Robertson 1996). The number of affected areas has apparently increased markedly in the last year. According to most reports, trees of all age classes within an area are typically affected. Various symptoms have been associated with the decline, including wilting of young shoot tips, leaf and twig necrosis, cankers on small stems, dark sap bleeding from the lower portion of the trunk, and water-soaking and discoloration of the inner bark and outer sapwood. Basal sprouts or suckers frequently develop at the base of top-killed trees, but it is reported that these sprouts typically do not survive long (Svihra 1999).

Having studied disease and arthropod impacts on native oak stands in California (Swiecki 1990, Swiecki et al 1990, 1991a, 1991 b, 1997), I have been following reports of tanoak problems with some interest. To gain some insight into the problem, I talked to a number of people who have investigated and/or observed the mortality problem over the past several years and reviewed reports and data which were provided by Susan Frankel, USFS. On 9/22/93, I made a field inspection of affected sites in Muir Woods National Park and on Marin Municipal Water District lands near Fairfax. This report describes a number of my field observations and some thoughts about the nature of the tanoak problem. I hope that these remarks can contribute in some way to the understanding of the problem.

## Spatial pattern of affected trees

Affected tanoak stands are found across a rather wide geographic area, but so far, reports of the decline syndrome appear to be limited to stands of tanoak in the Coast Ranges. Within an affected area, the distribution of affected plants is patchy. Individual symptomatic trees can be found sprinkled across the landscape around Mt. Tamalpais. Patches of affected trees also occur, and the size of individual patches varies.

Trees that have died during the current season are particularly obvious because dead leaves remain attached to the tree and turn a light brown color. The fact that affected trees are so obvious may bias visual assessments of disease incidence. Although a high proportion of tanoaks in a small area may be symptomatic, the incidence of disease at the forest level appears to be moderate at best. Statistically valid survey work is needed to ascertain the level of mortality at the stand and forest level. In some areas it may be possible to use aerial photo interpretation or other remote sensing techniques to assess mortality over wide areas. However, the fact that many of the affected trees are overtopped (discussed below) may limit the usefulness of remote sensing methods.

remain attached to the tree and turn a light brown color. The fact that affected trees are so obvious may bias visual assessments of disease incidence. Although a high proportion of tanoaks in a small area may be symptomatic, the incidence of disease at the forest level appears to be moderate at best. Statistically valid survey work is needed to ascertain the level of mortality at the stand and forest level. In some areas it may be possible to use aerial photo interpretation or other remote sensing techniques to assess mortality over wide areas. However, the fact that many of the affected trees are overtopped (discussed below) may limit the usefulness of remote sensing methods.

The distribution of affected trees is consistent with the hypothesis that one or more native (or long-naturalized) agents may be involved in the disease syndrome. It is less likely that an introduced agent would become so widely distributed over such a short time period, although it would be possible for a highly mobile agent. Although mortality centers exist, these centers do not necessarily appear to function as disease foci. In the areas I inspected, it appeared that newly symptomatic plants were as likely to occur at some distance from an existing center as they were to occur adjacent to an existing center. Quantitative data on this aspect of disease epidemiology would be useful.

Although I looked at a limited number of stands, virtually all of the symptomatic trees that I observed were growing under stressful conditions. Most of the affected trees were either overtopped or in fairly dense stands in which competition for soil moisture and light were likely to be intense. At one site, symptomatic trees were open-grown and widely spaced. However, site conditions appeared to be hotter and drier than is optimal for tanoak, so these trees would also have been under stress. In urban areas, it is likely that many if not all affected trees have been subjected to a range of stressful impacts (soil compaction, root damage, altered moisture regimes, etc.). Based on my limited observations, it seems possible that decline is more likely to occur in stressed plants, and may in fact be limited to stressed trees. Local differences in soil type, hydrology, and competition that affect levels of stress could help explain the distribution of the disease, but it is not necessarily easy to quantify these differences. Direct measurements of plant water stress and/or carbohydrate storage may be needed to help tease out these relationships.

The patchiness of disease development may also have a genetic component. Tanoak can reproduce vegetatively from burls produced on shallow lateral roots (Burns et al 1990). Therefore, trees in a given localized area can actually be a set of interconnected vegetative clones. Even where trees have arisen from seed, tanoaks in a localized area will tend to be genetically related because most tanoak acorns germinate in the vicinity of the maternal tree. If certain plant genotypes are more susceptible to the agent(s) involved in the decline, or are more prone to become stressed by current stand conditions, we would expect a somewhat patchy distribution of disease symptoms.

## Symptoms and agents

### Wood-boring insects

Several wood-boring insects that are normally associated with stressed, dying, and/or dead trees have been reported on affected trees. These include oak bark beetles (*Pseudopityophthorus* spp.) and ambrosia beetles (*Monarthrum* spp.). I also observed the larvae



of an as-yet unidentified small wood-boring beetle (probably Cerambycidae) boring beneath the bark of a killed tanoak in Muir Woods. I observed evidence of wood boring beetles in some but not all of the dead and dying trees that I inspected. This suggests that attack by beetles is not required for tree death to occur. It is likely that many dead trees eventually become infested with wood-boring insects, and the activity of these insects may hasten the decline of at least some trees. However, at this point I do not think that there is sufficient evidence to suggest that these wood boring insects play any more than a secondary role in the decline.

### Root symptoms

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Other investigators have generally not observed root symptoms on affected plants, although Svihra (1999) noted the presence of *Armillaria mellea* on a recently-killed tree in 1995. I inspected the root crowns of perhaps 10 symptomatic tanoaks (6 to 8 inch DBH size class) on 9/22/99. I found clear evidence of decay in the root crown area in at least three of these trees, all of which were widely separated. One symptomatic tree in Muir Woods was heavily colonized by *Armillaria* (presumably *A. mellea*); a tree near Bon Tempe Reservoir had a white rot of a buttress root that was not typical of *Armillaria* and was presumably caused by another basidiomycete; and a third tree near Lake Lagunitas showed incipient decay of the root collar area.

Although most affected trees sucker from the base after topkill, various observers indicate that these sprouts generally do not survive long enough to give rise to healthy sprout origin saplings. Given tanoak's propensity to reproduce through vigorous sprouting, the failure of topkilled trees to sprout successfully suggests that root diseases probably play some role in the decline syndrome. The fact that I observed evidence of root disease in the small sample of trees that I inspected indicates that root diseases may be a common, if not completely consistent, factor contributing to tree decline.

### *Hypoxylon* not *Daldinia*

Some additional confusion about the nature of the decline is related to the misidentification of one fungal species that is commonly associated with dead and declining trees. I collected fruiting bodies of a *Hypoxylon* species that we have identified as *H. thouarsianum* (Lev.) C.G. Lloyd from tanoak trees in Muir Woods and in the vicinity of the Bon Tempe reservoir. I also collected this fungus from a large canker on a declining coast live oak (*Quercus agrifolia*) in Muir Woods. We have long noted this fungus in association with cankers on declining and recently killed coast live oak as well as other native oaks (Swiecki et al. 1990). Other reported hosts for the fungus include *Q. chrysolepis*, *Q. douglasii*, *Q. lobata*, and *Q. kelloggii* (Swiecki et al. 1998). Identification of the species has previously been confirmed by Dr. Isabel Tavares of the UC Berkeley Herbarium. We sent six samples of the fungus from three different hosts (*L. densiflorus*, *Q. agrifolia*, and *Q. douglasii*) to Dr. Jack Rogers (Dept. of Plant Pathology, Washington State University), the world authority on this group of fungi. Dr. Rogers confirmed that all of the samples were *H. thouarsianum*.

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The first image above shows the stroma (fruiting body) of the fungus. The stroma is sliced open to show the carbonaceous interior and the single outer layer of perithecia. The above light micrograph shows the brown, unicellular ascospores and slender asci of the fungus. The asci are apparently evanescent, which is characteristic of *H. thooarsianum*. We observed them in a section of a fresh stroma collected from a *Q. agrifolia* in Muir Woods. Only ascospores were visible in older stromata collected from various tanoaks.

The surface of newly-formed stromata may be covered with the conidial or imperfect stage (= anamorph) of the fungus. The conidia are dark olive green and powdery when observed without magnification. Under the microscope, the conidia are subglobose, about 6 microns in diameter, and olivaceous. Conidiophores are densely packed and appear to be sparingly branched. The imperfect stages of *Hypoxylon* are in the form genus *Nodulisporium*, but Rogers et al (1999) do not describe the anamorph of *H. thooarsianum*.

It appears that this same fungus has erroneously been identified as a *Daldinia* species (e.g., Svihra 1999; this error has been corrected in the second printing). Unfortunately, the species is also incorrectly identified and illustrated in David Arora's (1986) book *Mushrooms Demystified* (p. 887), and this may be the source of the misidentification. Regardless of the source of the error, the differences between *Daldinia* and *H. thooarsianum* are of more than strictly taxonomic significance.

Both *Daldinia* and *Hypoxylon* cause a white rot of host wood, i.e., they degrade both cellulose

and lignin. *Daldinia* species are primarily saprophytes, although Rogers et al. (1999) note that they may function as weak facultative parasites that continue to decay the wood following decline and death of their hosts. At least in the US, no species of *Daldinia* is considered to be a significant pathogen. In contrast, most *Hypoxylon* species range from weak pathogens with high saprophytic capacity (facultative parasites) to virulent pathogens with low saprophytic capacity (facultative saprophytes) (Rogers et al. 1999). The association of *H. thouarsianum* with cankers on living trees and other field observations suggest that this species can function as a pathogen on at least some hosts, particularly on stressed trees.

Many *Hypoxylon* species initiate latent (dormant or inactive) infections in healthy hosts. These infections can rapidly become active when the host is stressed, and extremely rapid infection and decay of the sapwood can ensue. We believe, but have not rigorously confirmed, that the water-soaking and discoloration of the inner bark and outer sapwood seen in tanoaks and in various oak species is associated with attack by these fungi. It is possible that secondary colonization of the killed sapwood by bacteria and yeasts is related to the "sap" bleeding and fermented odor observed in such trees.

It is of interest that species of *Hypoxylon* (sensu lato) have frequently been associated with regional oak declines in the eastern US. It seems likely that *H. thouarsianum* may play a significant role in the ongoing tanoak decline syndrome, especially given the fact that many affected stands are clearly stressed.

#### Other foliar and stem diseases

The fungus *Diplodia quercina*, which causes stem cankers on various California oaks, has previously been identified on stem samples by the CDFA lab. My limited observations suggest that the list of foliar and stem-infecting fungi on symptomatic tanoaks could be increased substantially with further investigation. I observed several different fungi associated with necrotic leaf spots as well as two different fungal species associated with dead stems that were at least possible pathogens. I did not attempt to definitively identify the various fungi, which included both Deuteromycetes and Ascomycetes.

I was interested in these foliar and stem-infecting fungi because it appeared to me that at least two disease syndromes may be operating in some stands - a foliar/stem canker syndrome affecting primarily understory seedlings and small saplings, and a separate trunk/root disease syndrome affecting larger trees. Symptoms of the foliar/stem canker syndrome include:

- partial and complete necrosis of individual leaves, apparently associated with foliar and/or twig infections;
- partial to complete dieback of shoots associated with stem lesions; foliage beyond the lesion dies, sometimes resulting in both dead and live leaves on the same stem;
- cankers on stems of intermediate size (about 1-4 cm diameter); in some cases, these coalesce to girdle and kill the entire stem.



In the branch shown in the image above, the terminal end of the shoot (to the left) is still healthy, but several lateral branches have been girdled by cankers and are dead. The image below shows a stem canker on a small (about 1 cm diam) stem. This canker has not yet girdled the branch.



Given that a number of different foliar and stem-infecting fungi attack tanoak, it is possible that the assortment of fungi responsible for the foliar/stem canker syndrome may vary from place to place. This possibility is further supported by the variable combination of symptoms on understory seedlings and saplings and the fact that no single agent has consistently been associated with this syndrome. Nonetheless, most of these foliar- and stem-infecting fungi have a similar *modus operandi* and are largely favored by the same types of conditions, i.e., free moisture on plant surfaces. Above normal rainfall, including significant amounts of rain late in the season, has occurred in most of Northern California in several years prior to the largest dieoffs. These weather conditions have favored foliar and stem canker diseases in both cultivated and native plant populations. For example, unusually severe leafspot and defoliation caused by *Septoria sambucina* was observed in blue elderberry (*Sambucus mexicana*) during the 1998 growing season.

At least some of the increase in understory dieback seen in 1999 may still be associated with

the prodigious 1998 wet season. This would be the case if any of the infections initiated in 1998 had a relatively long latent period and/or if stem cankers initiated in 1998 developed slowly. Furthermore, foliar and stem disease impacts are frequently greater in the understory than in the overstory because inoculum from the overstory is washed down onto understory plants. Disease cycling in the understory can also be aided by summer fog drip from overstory trees in places such as Muir Woods. A 1996 report on the tanoak decline (Neisess 1996) noted that precipitation had been greater than normal for the two years prior to the rash of mortality investigated in that year. The occurrence of favorable disease conditions in several seasons over the past 4 years may have led to an increase in inoculum levels of foliar and stem canker fungi. This could lead to elevated disease levels for several years even if environmental conditions become less favorable for disease development. 0135

### Other agents

Tanoak is thought to represent a link between the chestnut, *Castanea*, and the oak, *Quercus*. In fact, tanoak was originally described as a species of *Quercus* by Hooker and Arnott. Because tanoak is closely related to oaks, it is no surprise that tanoak is attacked by a number of the same pathogens and arthropod pests that attack California oaks. The number of agents that attack tanoak is undoubtedly much less than the over 850 arthropod species and 380 fungal species that have been recorded on oaks in California (Swiecki et al 1997). Nonetheless, we can expect that a goodly number of native arthropods and microorganisms are capable of attacking tanoak.

Among the few recently-killed trees that I inspected, I did not note much evidence of basidiomycete wood decay fungi. This was somewhat surprising, especially because these fungi are probably the most important pathogens in native oak stands. Other investigators have not reported much evidence of wood decay other than sapwood decay and discoloration, which is sometimes restricted to sectors of the stem when seen in cross section (Susan Frankel, personal communication). I observed a few stumps and trees with extensive white rot, such as is associated with *Inonotus* species and other polypore fungi in the oaks. I also observed *Ganoderma* basidiocarps on associated tree species. Several *Ganoderma* species cause root rots of California oaks, and can result in the apparently rapid collapse of trees that do not show chronic symptoms of decline.

It is possible that a more thorough survey of affected stands would show more involvement of these pathogens in the tanoak decline, in at least some areas. It can be somewhat difficult to associate wood-decaying pathogens with decline because they cannot be isolated with standard techniques and some (e.g., *I. andersonii*) may not fruit on affected trees until they have been dead for an extended period.

### Forest conditions contributing to decline

An obvious question to ask is why these stands are being affected now. I have already discussed the fact that weather conditions have been somewhat unusual during the period that the problem has been observed. In addition, we need to bear in mind that stand conditions have been changing over time. Stand composition, density, and stratification are probably much different now than they have been at any time this century. Virtually all of these stands have been greatly altered by human activities that were initiated with the settlement of

California. Most stands have been affected by episodes of logging of conifers and/or hardwoods, destruction of mature tanoak stands through stripping of bark for tannin, alterations in fire frequency and intensity, and/or changes in vegetative composition and structure. In Marin County and many other areas, cutting and other more intensive activities ceased by the early decades of this century. As a result of continued growth and a lack of other stand-thinning events, such as fire, the second and third growth stands that constitute much of the tanoak resource may have reached a stage in which competition has become critical. 0136

As noted by Skelly and Innes (1994), declines in natural forests affecting one or more related species are fairly common events in both North America and Europe. These declines typically involve a suite of agents and site and environmental conditions. In many of the oak declines that have affected the eastern US, affected trees are typically stressed by one or more biotic or abiotic factors and are subsequently killed by various opportunistic agents (Kessler 1989).

At this point, the tanoak decline problem has been investigated by a number of professionals who have failed to find a causal agent that can explain all of the observed mortality. If tanoak decline is similar to most other forest declines, it is unlikely that a single culprit will surface. It is likely that tanoak decline results from a complex of interacting factors, including the current status of tanoak stands, environmental conditions, and an array of native pathogens and insects.

Is there a possible relationship between the foliar/stem disease syndrome and the trunk/root disease syndrome that affects larger trees? If trees are already growing under stressful conditions (e.g., high levels of competition and shading) and have latent infections of opportunistic pathogens such as *H. thouarsianum*, then any additional stress may be sufficient to tip the balance in favor of disease development and cause a relatively rapid plant decline. A heavy episode of defoliation and stem dieback could provide this triggering stress. In other words, many of the trees that have died during the last few years might well have died anyway within the next 10 to 15 years. Unusual weather conditions have set off a cascade of events that have helped to synchronize some of this mortality over a relatively wide geographic area. Furthermore, once the decline has started in an area, the buildup of fungal inoculum and insect populations on dead and dying trees provides additional pressure that may accelerate the decline of trees that might resist a lower intensity of attack.

## Conclusions

Clearly, there are still questions to be answered about the unusual mortality affecting tanoak in the Coast Ranges. It may take some time to thoroughly investigate this problem because very little research effort has been directed toward the understanding of tanoak pests and diseases to date. Tanoak is not only a non-commercial species, but it is considered a weed in many commercial conifer stands. Nonetheless, tanoak is an important component of various forest types in the North Coast Ranges of California and the urban forests of Marin and other coastal counties. Public agencies and private landowners need sound information to both understand the impacts of the decline on their stands and determine what, if any, actions can or should be taken. At this point, we lack the data needed to provide useful management recommendations.

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Initial release 9/30/99

Last update 11 /15/99

10710



11/24/1999

## BEETLES **KILL** STATELY CALIFORNIA LIVE OAKS: A SYNOPSIS OF THE PROBLEM AND PRACTICAL GUIDE FOR LANDOWNERS

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### Background

In localized areas of **Marin** County, the Santa Cruz Mountains and Big **Sur**, tiny beetles have killed hundreds of the stately California live oak. The epidemic is unprecedented in modern time. **Normally**, these beetles only successfully **attack** weakened, dying or dead trees. They have been part of the natural oak ecology, perhaps for centuries, selecting weakened trees and **delivering** the **final** deathblow. Beetle attacks are normally fended off by the natural defense reactions of a healthy oak. **But** what makes the present situation unique is that in some areas apparently healthy trees are being attacked and killed in great numbers by an unusually high population of beetles.

Typically the western oak bark beetle is the first beetle to attack the California live oak near its trunk base. The beetles bore through and construct galleries just under the bark, in the living cambium tissue, a part of the tree that is essential for its life. The first symptoms associated with the infestation invariably include areas of bark on the lower trunk that are obviously darkened and have dark brown globules or oozing sap on the surface. Fine reddish-brown boring dust will be pushed out of actively mined galleries and, if **left** undisturbed, will accumulate in small piles on the rough bark surface. After bark beetles are established, oak ambrosia beetles **often** attack very near areas infested **by** the bark beetles. These beetles bore into the heartwood of the trunk several inches deep. Fine whitish boring dust may be pushed out **from** active galleries onto the bark surface. Both beetles carry **fungi** on their bodies that grow in their galleries and ostensibly blacken the galleries. The **fungal** growth may plug the vascular system of the oak preventing water from being conducted from roots to the leaves of the tree. As beetles feed and reproduce, more vital cambium and vascular system are compromised and the entire tree may die.

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There are many theories as to why some areas **in** California have beetle epidemics **that** eventually kill so many California live oaks. **First**, a large proportion of oaks in the California native oak **woodland** are considered to be old and thus possibly **more** susceptible to disease and insect attacks. **Second**, the major beetle epidemics, so far, have been noted in very dense forests. The occurrence of natural fires have been slowed in these areas and competition for water, nutrients and sunlight between forest species and the older oaks might be enhancing tree stress. And **third**, an unusually high number of beetles are in **these** dense forests and, at least in the initial stages of the epidemic, they may have spilled over from, yes, another unusual epidemic in nearby **tanoaks**.

**Tanoaks** (related, but not a true oak) are also dying suddenly in unprecedented numbers. Their sudden death has preceded the beetle epidemic in nearby California live oaks, so far, in all areas from **Marin** County, the Santa **Cruz** Mountains and Big Sur. The **tanoaks** have been an integral part of the California redwood ecosystem and sometimes are an important part of the natural landscape around homes. The diseased **tanoak**, here and there in the forest, suddenly dies and every brown leaf clings rigidly to its branches. Although there are many theories, the cause of death is still unknown. Western oak bark beetles and the oak ambrosia beetles can also colonize these dying and dead trees in tremendous numbers creating a nursery of new adults that can fly and infest nearby susceptible **tanoaks** and California live oaks. There is a strong suspicion that the **tanoak** problem may have spawned a dramatic increase in the number of beetles that spill over into and overwhelm the California live oaks, making it **especially** important to find the cause of the **tanoak** mortality.

The exact sequence of events that lead to the death of the oaks is still not completely understood. Although beetles seem to play an important role in the death of the California live oaks, there are many other factors that could contribute to the decline of the trees.

#### What landowners with California live oaks should do:

California live oaks are hosts of hundreds of insect pests and diseases. It is important to know that just because there is serious tree limb-dieback or mortality, does not mean, necessarily, that oak bark beetles or ambrosia beetles are the cause of the problem. Often **beetle** attack has obvious symptoms as described above. An inspection by a knowledgeable arborist may help discern the cause of this and other problems.

Until the cause of these epidemics is better known, maintaining a healthy environment around the California live oaks is the single most important measure that can be taken to 'prevent a serious beetle infestation. Particularly important is the care needed to maintain root health and to resist root disease. Foot and vehicle **traffic** compacts soil and reduces water, air, and nutrient movement **to** the roots. Soil trenching under the drip line of the tree may **injure** a significant mass of roots. Frequent irrigations enhance some root diseases. In pastures, it is important to reduce soil compaction around oaks and eliminate excessive bark chewing by grazing animals. The University of California publication "Living Among the Oaks" is an excellent oak management guide for landowners.

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In the residential landscape or woodland/landscape interface, a more intensive preventative approach might be taken. Since the western oak bark beetle initially attacks the lower trunk of the California live oak, applying a chemical barrier to this vulnerable part of the tree might prevent the initial attack. Preliminary research indicates that permethrin, contained in the products **Astro®** or Dragnet®, used at recommended rates, can be effective in controlling these beetles. **Astro®** and Dragnet® are only registered for use by professional pesticide applicators. Other pesticides registered for bark beetle control may be effective too.

**Only** consider sprays if they are within a short distance from areas with known beetle **epidemics** of **tanoaks** or California live oaks. Where practical and desirable, within an epidemic area, California live oaks would be best sprayed before an infestation occurs. However, it may not be possible or desirable to apply sprays to all **trees**. A less intensive regimen might be to regularly inspect the lower trunk of oak trees from February to October for the darkened areas of bark, black oozing sap and the reddish-brown boring dust, which can be a sign of an active bark beetle attack. Immediately spray the infested tree up to 10 feet above the ground. Chemical applications should not be 'made in the winter months when beetles are not active. February or March 2000 may be the next best time to make an application.

Dead **tanoaks** and California live oaks should be cut down as soon as possible **after** they die. Insure that the tree or limbs are actually dead. In a fatally attacked California live oak, the entire Leaf canopy will suddenly wilt slightly, leaf *color* will fade, and then finally all the foliage will dry. Certain foliage diseases or insects might sometimes defoliate trees making the branches appear dead, but trees will usually recover, growing new leaves. If a single trunk of a multi-trunked tree is attacked, then the entire infested trunk should be pruned **out** and the remaining healthy trunks should be sprayed. The dead logs can be split for firewood and smaller branches chipped into small pieces and **left** on site. Firewood must immediately be covered with heavy (6 mil) clear plastic for six months. Stumps should be ground out or covered with clear plastic. This will reduce the chances of the infested firewood and stumps from becoming a nursery for new beetles that might emerge and attack other trees. Where it is not practical to remove or cover cut wood, for example in extensive oak woodland, it still would be desirable to fell dead trees and cut the wood into pieces, as **small** as possible. Firewood should be covered during transport and at the location of use. Undesirable wood might be covered and transported immediately to a wood recycling facility, such as the Monterey Regional Waste Management District in Marina (83 1) 384-53 13, the Buena Vista Landfill in Watsonville (83 1) 763-3 I 19 or the Ben Lomond Transfer Station in Ben Lomond (83 1) 336-3950

Research may be funded soon to help elucidate the full extent of the **cause** of the **tanoak** and California live oak epidemics. Aerial surveys will help determine the extent of these epidemics in California. Research is planned to help determine approximate beetle emergence dates in the epidemic areas so that chemical protectants can be timed better. **Research** will continue to evaluate and improve the effectiveness of permethrin sprays made on tree trunks.

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References and more information are available:

**University of California Monterey Bay Master Gardeners**

University of California Cooperative Extension, 1432 Freedom Blvd., Watsonville, CA.  
**95076. (83 1) 763-8007**

**Oak health and related publications**

"Living Among the Oaks", for example. Available at your local University of California Cooperative Extension **office** (locations listed at <http://danr.ucop.edu/regional.htm>) or online catalog at <http://anrcatalog.ucdavis.edu/>

**Western Oak Bark Beetles and Ambrosia Beetles Associated with Dying Live Oaks**

Pest Notes #3A. October 1999. University of California Cooperative Extension, Marin County, by Pavel Svihra. (Available through U.C. Cooperative Extension **offices** in Santa Cruz and Marin Counties)

**University of California Integrated Hardwood Range Management Program**

<http://danr.ucop.edu/ihrmp/>

**A Technical Study of Insects Affecting the Oak tree in Southern California**

Bulletin 8 10. University of California Division of Agricultural Sciences, by L.R. Brown and C.O. Eads. (Out of print reference)

**University of California Integrated Pest Management Program**

For oak disease and insect identification and control:

<http://www.ipm.ucdavis.edu/>

**Observations regarding the tanoak problem;**

<http://phytosphere@phytosphere.com/>

**The California Oak Disease and Arthropod (CODA) Database**

<http://phytosphere@phytosphere.com/CODAms1.htm>