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For comment

California's *S*trategic Plan for *Phytophthora ramorum,* cause of Sudden Oak Death

Phytophthora ramorum, the microbe known to cause Sudden Oak Death, is a newly identified plant pathogen impacting California's coastal forests, nurseries, and communities. It has also been found in Oregon nurseries and southern Oregon forests as well as nurseries in Washington, British Columbia, and Europe. Found to be an aggressive pathogen that is able to survive harsh conditions in a dormant state, this pathogen poses a serious threat to the uninfested forests and nurseries of California, the United States, and the world if gone unchecked. Through a comprehensive research, monitoring, management, regulatory, and educational outreach program, we can protect uninfested areas, and in heavily infested areas learn to live with *Phytophthora ramorum*, minimizing its environmental and economic impacts in addition to its artificial spread.

Background

Sudden Oak Death was first recognized in Marin and Santa Cruz Counties in 1995, when oak and tanoak trees in urban/wildland interface areas started dying at an alarming rate. From 1995 to 2000, the unknown pathogen killed thousands of oak and tanoak trees where millions of people live and recreate, creating economic hardships, increasing fire risks, and safety hazards. In July 2000, University of California researchers identified the cause of Sudden Oak Death to be *Phytophthora ramorum*, a previously unknown species of *Phytophthora*.

In nature, *Phytophthora ramorum* has been confirmed in 12 coastal California counties from Humboldt to Monterey, as well as in Curry County, southwest Oregon. (insert map) The list of hosts continues to grow, and presently includes 27 native and ornamental plant species. While California black oak, coast live oak, Shreve's oak, canyon live oak, tanoak, madrone, and several other plants can be killed by *Phytophthora ramorum*, others such as California bay laurel, rhododendron, and camellia are also susceptible to the pathogen, but usually are not killed by it. Instead of dying from the infection, these foliar hosts harbor the pathogen. Spores multiply on foliar host leaves and then spread to other hosts via natural means, such as wind driven rain, or through the artificial spread by humans inadvertently moving infested plant material to an uninfested location.

Until 2003, nursery *Phytophthora ramorum* infections were primarily a European concern, where rapid spread of the disease has resulted in positive detections in more than 250 nurseries. In 2003, positive nursery plant infections were found in five California nurseries as well as two nurseries in Oregon, one in Washington, and one in British Columbia. These new finds have brought concerns of nursery plant infection to the forefront of *Phytophthora ramorum* efforts in the United States. In an effort to limit pathogen spread, State, federal, and international quarantines are in place for movement of nursery host plants, host plants in natural settings within infested areas, plant products from infested areas, and soil from infested areas.

In response to California's need for a *Phytophthora ramorum*/Sudden Oak Death program, the California Oak Mortality Task Force (COMTF) has developed the following five year plan. As a voluntary organization created to coordinate the State's program through a comprehensive and unified approach, the COMTF's program is based on identifying priority disease research and monitoring needs from which management, education, and public policy can be formed. The Task Force brings together federal, State, and local government as well as non-profit

organizations and private interests. It is comprised of over 80 organizations and has more than 1,000 members.

Research

Status. Over $7 million in federal research funds and $1 million in State allocations has been given to projects intended to define pathogen biology, epidemiology; disease management and resource utilization; disease impacts on various ecosystem components; and economic and social impacts. In addition to State and federal funds, the Gordon and Betty Moore Foundation provided a $1 million grant for Sudden Oak Death research (See www.Moore.org). These funded projects have produced the bulk of information available today that is serving as the scientific basis for Sudden Oak Death management and regulatory policy. Over 46 researchers at 21 universities and institutes have been supported**.**

Needs. While a substantial amount of information has been gained about *Phytophthora ramorum* since July 2000, each new discovery leads to further questions, making research needs exponential in this early stage of disease understanding. Quarantines and regulations create an added urgency to research demands as they impact an ever increasing number of nurseries and businesses worldwide.

Research categories remain constant, yet priorities within each continue to shift. Current priorities include:

- Biology - Determine susceptible plant species and plant parts; pathogen behavior on each host; modes of spread in nurseries and nature; and environmental limitations

- Impacts – Quantify economic, social, community, and ecological impacts

- Risks – Develop sound risk models for pathogen migration and likelihood of establishment in other areas

Regulators, affected industries, Native Americans, tree care professionals, foresters, fire fighters, and land and recreation managers are reliant upon research into treatments, sampling protocols, and other technical information to ensure worker safety and enable commerce without fear of spreading the pathogen. Infested counties, counties at risk of disease infestation, and policy makers need risk analysis to serve as the basis for quarantines, disease management, and strategic planning. In order to expedite implementation of new information, research results and new technologies will be immediately transferred to educators, regulators, agencies, and industry leaders.

Identification of research gaps, prioritization of research needs, and awarding of research funding will continue to be coordinated to eliminate duplication and target high priority needs.

Research funding needed = $2.5 million per year for the next five years

Monitoring

Status. From 2001 - 2003, the USDA Forest Service and California Department of Forestry and Fire Protection (CDF), in cooperation with the California Department of Food and Agriculture (CDFA), invested more than $1 million in funding for aerial and ground-based surveys to monitor the distribution and impact of *Phytophthora ramorum* on 20 million acres of California wildlands and urban forests. Resulting maps are downloadable from a UC Berkeley GIS database, accessible via the COMTF website at www.suddenoakdeath.org.

Since *Phytophthora ramorum* symptoms are not distinctive, all confirmations must be based on laboratory diagnosis of foliage or bark samples. Confirmation is based on a combination of molecular testing (PCR) and cultural isolation. Laboratories approved by the State for diagnosis include the Sacramento CDFA laboratory, David Rizzo's laboratory at UC Davis, and Matteo Garbelotto's laboratory at UC Berkeley. Training materials and diagnostic guides are updated annually to include new susceptible species and reflect the current understanding of pathogen detection. Training is provided regularly to field professionals.

Key monitoring findings from 2002 include:

- Preliminary data from the USDA Forest Service, Forest Inventory and Analysis, indicates that five to 10 percent of redwood/tanoak forests and coast live oak woodlands (coastal evergreen forests) in the greater Bay Area are infested with *Phytophthora ramorum*.
- *P. ramorum* was detected in Humboldt and Contra Costa Counties.
- *P. ramorum* was not detected in the Sierra Nevada foothills.

Needs. Monitoring priorities include early detection and development of improved diagnostic methods. Field tests allowing for pathogen confirmation without laboratory diagnosis, in addition to improved remote sensing methods that will result in increased aerial survey accuracy, would greatly facilitate pathogen distribution determination.

Expanded surveys in the North Coast (Del Norte, Humboldt and Mendocino Counties) are crucial in supporting Oregon's eradication program and in protecting high risk counties where the pathogen is not known to be (Del Norte County), or is limited in distribution (Humboldt and Mendocino Counties). Further aerial and ground-based early detection surveys are also needed in counties bordering infested counties as well as in areas with hosts and climate conditions potentially conducive to pathogen viability, such as the Sierra Nevada foothills. Continued monitoring of the 12 known-to-be-infested counties is needed for complete determination of infested areas, but is prohibitively expensive and very difficult.

Quarantine surveys and inspections are required, including surveying areas surrounding infested nurseries. Cogeneration plants accepting infested materials should also be inspected, as should nurseries in unregulated areas, to ensure they are not facilitating long-distance spread.

Continued coordination, development of survey standards, dissemination of results, complete documentation, and tracking of survey activities will be stressed.

Monitoring funding needed = $1 million per year for the next 5 years

Management

Status. An aggressive, slow-the-spread or suppression program is starting for the North Coast (Del Norte, Humboldt, and Mendocino Counties), where the pathogen is very limited in its distribution. There are four infestations in Mendocino County (less than 30 acres) and one confirmed infestation in Humboldt County (less than ¼ mile). The Humboldt infestation is in an old-growth redwood forest in Redway (near Garberville), where several hundred people live. The Redway infestation is being mapped, and surrounding areas surveyed to confirm that the pathogen is not present. A public information campaign is being developed, and pruning or removal of infected California bay laurel trees and redwood branches will be promoted.

California's Central Coast (Sonoma, Marin, Santa Cruz, Monterey Counties) *Phytophthora ramorum* infestation is too widespread to eradicate, making disease containment the priority. To limit pathogen spread and maximize utilization of infested materials, plant debris drop-off sites have been established in Marin and Santa Cruz Counties. These sites accept infested plant debris from arborists, landscapers, and public works personnel. The infested materials are then sent to co-generation plants or composted.

Pesticide treatments are being tested for nursery plants, home landscapes, and Christmas tree farms. Fungicide efficacies are being compared and application methods refined. Since no pesticides are registered for use on landscape oaks, application is being made to the California Department of Pesticide Regulation to register a treatment. Once the registration is complete, educational programs will be needed to ensure appropriate use of the registered pesticide by professionals and homeowners.

State funds were provided in 2002 for hazard tree removal and management resulting in removal of over a thousand hazardous trees. After trees are removed, monitoring for recently dead, hazardous trees needs to continue along with. treatment for invasive weeds.

Best management practices are being developed for affected groups, including plant gatherers, arborists, foresters and timber operators, nurserymen, recreation site managers, and fire fighters. These recommendations will be posted at www.suddenoakdeath.org, provided at training sessions, and offered as handouts. Implementing best management

practices, the Los Padres National Forest and Muir Woods National Monument are installing vehicle and boot wash stations at exits and entry points to prevent pathogen spread. These parks are also posting informative signage, displaying educational materials at kiosks, and providing brochures to visitors.

Needs. Management programs needing to be developed and implemented include:

- North Coast - While North Coast coordination includes a first responder's team and notification plan, an action plan addressing new infestations still needs to be developed. Suppression or slow-the-spread actions (similar to Oregon's program in the Brookings area) should be included in the plan, as such efforts may prevent northward pathogen spread.

- Horticultural nurseries - Many susceptible plants, including rhododendron, camellia, and lilac are common landscape materials that are grown, shipped, sold, and planted all over the State and country. Since nurseries are frequently environmental islands within the areas they reside, they often have specialized needs. High priority needs include diagnostic guides for nurserymen and agricultural inspectors, research to determine if growing media and various soil components support pathogen growth, determination of the role irrigation water plays in pathogen spread, and the risk of utilizing streams or lakes for irrigation. Sanitation and other best management practices also need to be developed and refined for nurseries.

- Recreation areas, forests, and open space - Comprehensive integrated management programs are needed for infested forest, recreation, and open space areas. Employees need to be trained in sanitation, pathogen recognition, and quarantine compliance. Prevention programs are also needed for landowners and managers adjacent to infested parks and wildlands.

Management funding needed = $1.5 million per year.

Regulations

Status. Currently there is no treatment proven to suppress *Phytophthora ramorum,* so prevention measures are critical. Quarantines and best management practices are being used to avoid human-assisted (artificial) spread of *P ramorum*.

CDFA imposed an intrastate regulation for *P ramorum* in May 2001. These regulations restrict or prohibit the movement of commodities from all known hosts in infested counties. For more information on California's regulations, go to the CDFA website at www.cdfa.ca.gov.

In February 2002, USDA Animal and Plant Health Inspection Service (APHIS) issued a federal domestic regulation for the interstate movement of *Phytophthora ramorum.* For federal regulation information, go to the APHIS website at www.aphis.usda.gov/ppq/ispm/sod/.

Needs. California regulations are enforced via a cooperative effort between CDFA and county agricultural commissioners, while forest product regulation is enforced primarily through CDF, the USDA-Forest Service . These agencies must enforce both the State and federal rules. These rules currently differ on a number of critical elements, making enforcement difficult. The greatest regulatory need is harmonization between State and federal *Phytophthora ramorum* quarantines.

Applied research and monitoring programs are required to ensure quarantines are science-based and practical. The rules must be based on replicated, published research, proving how/if the organism spreads via commodities in both natural and artificial environments. Quarantines also rely upon adequate detection methods and extensive monitoring to determine locations of infestations and confirmation of areas not known to be infested.

Annual and pre-shipment inspections are needed for nursery host plants, wreaths, burls, firewood, logs, and other regulated articles. Based on a preliminary CDFA estimate, counties worked over 6,000 hours enforcing *Phytophthora ramorum* quarantines from July to November, 2002. The number and complexity of inspections continues to increase as new confirmations of host species and locations are reported.

Regulation funding needed = $ 2 million annually

Educational Outreach

Status. California's Sudden Oak Death program is composed of many organizations, each contributing resources and expertise to address *Phytophthora ramorum*. New partners are added as the geographic range of the pathogen and list of susceptible plants expands.

Since Sudden Oak Death erupted in the urban/wildland interface forests where more than 6 million people live, there has been a tremendous demand for public and legislative information. The COMTF website (www.suddenoakdeath.org) contains information for homeowners and professionals, and also provides maps and contact information for individuals wanting additional assistance. A monthly newsletter, toll free information number (866-SOD-7411), and general, as well as committee, list serves are provided to facilitate communication.

Brochures, pest alerts, diagnostic and sampling guides, signage for infested areas, and other educational materials have been developed and distributed. Over 800 professionals have attended COMTF training on pathogen recognition, sampling, sanitation, and quarantine compliance. Quarantine educational materials are also being developed for each affected user group and industry to ensure consistent information and enforcement.

Sudden Oak Death's dramatic mortality, fascinating story of discovery, and cherished, threatened landscapes, has captivated coastal California residents. In 2002 alone, over

200 media reports were disseminated on Sudden Oak Death. Hundreds of presentations and interviews have been provided for local, regional, national, and international audiences.

Needs. A clear, consistent voice is needed to deliver all components of the program to the beneficiaries, including the public, resource professionals, leaders of affected industries, Native American tribal members, the media, and legislature.

The COMTF website, monthly electronic newsletter, training programs, and development of outreach materials need to be maintained and updated. To be effective, a public information officer, webmaster/coordinator, and regional outreach educators are needed for Northern and Central California. In addition to assisting and forwarding efforts within infested counties, these staff members would also provide prevention programs and outreach for uninfested counties.

Education funding needed = $250,000 annually

Summary

California's Sudden Oak Death containment program is a multi-faceted program. It strives to further the understanding of this disease; slow pathogen spread; determine the impact and distribution of Sudden Oak Death and *Phytophthora ramorum*; and educate professionals and the public to help ensure responsible activity.

Over $20 million has been invested in Sudden Oak Death to date. The funding provided has been used to protect California's forests and wildlands, in addition to minimizing *Phytophthora ramorum's* potential impact to other states and countries. The collaborative effort of federal, State, and county governments; universities; private industry; non-profits; and communities will continue to address current Sudden Oak Death issues as well as prepare for, future needs. With $7.25 million annually over the next five years, California's Sudden Oak Death program will be able to maintain public safety, allow affected industries to operate without inadvertently causing new infestations, and protect wildlands and recreation areas for future generations.

Table 1. Funding needs for California's Sudden Oak Death program

Program Area	Annual Program Needs
Research	**$2.5 million**
Monitoring	**$1 million**
Management	**$1.5 million**
Regulations	**$2 million**
Education/Outreach	**$250,000**
Total	**$7, 250,000**