United States Government Accountability Office

GAO

Report to the Chairman, Committee on Resources, House of Representatives

April 2006

# INVASIVE FOREST PESTS

# Lessons Learned from Three Recent Infestations May Aid in Managing Future Efforts


GAO-06-353

April 2006

# INVASIVE FOREST PESTS

# Lessons Learned from Three Recent Infestations May Aid in Managing Future Efforts

GAO Accountability · Integrity · Reliability

Highlights

Highlights of GAO-06-353, a report to the Chairman, Committee on Resources, House of Representatives

## Why GAO Did This Study

Invasive forest pests have seriously harmed our environment and imposed significant costs upon our economy. The U.S. Department of Agriculture (USDA) is the lead agency for responding to forest pests. This report evaluates the federal response to three invasive forest pests—the Asian longhorned beetle, the emerald ash borer, and the pathogen *Phytophthora ramorum (P. ramorum)*. Specifically, GAO describes (1) the status of efforts to eradicate these species, (2) the factors affecting the success of those efforts, (3) overall forest health monitoring programs, (4) coordination and communication of the three pest response efforts, and (5) USDA's use of panels of scientific experts to aid in the response efforts.

## What GAO Recommends

GAO recommends that the Secretary of Agriculture (1) expand efforts to monitor forest health conditions to include urban areas, particularly those deemed high risk for potential infestations; (2) regularly update and publish management plans for pests that include status information and funding needs; and (3) implement written procedures that broadly define when and how to operate science panels for specific pests. USDA did not directly disagree with GAO's recommendations, but took issue with GAO's presentation of some of the findings that supported the recommendations. GAO continues to believe that its findings fully support the three recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-06-353.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Robin Nazzaro at (202) 512-3841, or nazzaror@gao.gov.

## What GAO Found

On the basis of the available evidence, it appears that the Asian longhorned beetle will be eradicated in the three states that have infestations, although funding reductions have extended the likely completion date. In contrast, the emerald ash borer and *P. ramorum*—the pathogen that causes Sudden Oak Death—are likely to continue to infest and damage forest ecosystems in the Midwest and West Coast, respectively, despite efforts to control them.

The success of the federal responses to these infestations has been affected by several factors. First, the unique biological characteristics of each species greatly influenced the ability to effectively control them. Second, several years elapsed between each pest's arrival and its discovery, thereby giving it time to become established in the environment before control programs began. This situation cannot be fixed retroactively, but it could be avoided in the future with better monitoring. Third, quarantines have helped contain the spread of the pests, but implementation and enforcement have been difficult. Fourth, the only available method for eradicating these pests is to destroy the infested trees and plants—a costly and sometimes impractical approach. Lastly, despite budgeting over $420 million on these pests, USDA program managers told GAO that funding has not been sufficient to fully implement their programs.

USDA conducts a range of forest health monitoring programs, including a pilot project in some urban areas; however, these programs do not provide for comprehensive monitoring in urban forests or other locations considered at high risk from pest invasions. Monitoring in such areas is important because they are common destination points for internationally traded cargo that is a frequent pathway for pests.

Federal and nonfederal stakeholders involved in these efforts told GAO that appropriate mechanisms to coordinate response efforts are generally in place, although many noted that better coordination among agriculture and natural resource agencies would have helped produce a more effective initial response. In addition, USDA's *P. ramorum* control plan does not fully comply with a congressional requirement that it communicate future funding needs. Furthermore, USDA has not updated plans for the Asian longhorned beetle or emerald ash borer to communicate to decision makers or the public how it will modify its response efforts in light of fiscal years 2005 and 2006 funding reductions, and how those reductions have affected the long-term prospects for managing the pests.

Panels of scientific experts have assisted USDA with each of the three pest responses, although GAO and stakeholders have some concerns about how they were formed or operated. For example, some stakeholders believed that the agency should have convened the panels more frequently and made the panel process more open to interested parties. GAO found that USDA does not have written procedures for forming and using science panels.

# Contents

## Tables



## Figures

## Abbreviations

| | |
|---|---|
| APHIS | Animal and Plant Health Inspection Service |
| CCC | Commodity Credit Corporation |
| CPHST | Center for Plant Health Science and Technology |
| DHS | Department of Homeland Security |
| FACA | Federal Advisory Committee Act |
| IPPC | International Plant Protection Convention |
| ISPM | International Standards for Phytosanitary Measures |
| OMB | Office of Management and Budget |
| PPD | Policy and Program Development |
| PPQ | Plant Protection and Quarantine |
| SPS | Sanitary and Phytosanitary |
| USDA | U.S. Department of Agriculture |

This is a work of the U.S. government and is not subject to copyright protection in the United States. It may be reproduced and distributed in its entirety without further permission from GAO. However, because this work may contain copyrighted images or other material, permission from the copyright holder may be necessary if you wish to reproduce this material separately.

GAO
Accountability * Integrity * Reliability

**United States Government Accountability Office**
**Washington, D.C. 20548**

April 21, 2006

The Honorable Richard Pombo
Chairman, Committee on Resources
House of Representatives

Dear Mr. Chairman:

Hundreds of nonnative, invasive insect and pathogen species have infested our nation's forests, causing damage to our environment and costing our economy billions of dollars in lost revenue and cleanup. For example, starting in the early 1800s, American chestnut trees were devastated by a succession of two nonnative pathogens—ink disease and chestnut blight. These trees were a major component of the nation's deciduous forests, were valuable to wildlife, and had wide use as a source of lumber. Today, chestnut trees still survive in much of their former range, but only as sprouts from the old root systems; unfortunately, these sprouts are struck down by the blight before they reach maturity. Gypsy moth is another serious invasive forest species that is still harming our nation's forests more than 130 years after its accidental release by an amateur entomologist studying silkworms. The caterpillar of the moth defoliates oak, birch, poplar, and other important tree species, sometimes leading to the death of the tree. Forest pests such as these are not limited to damaging trees in wildland forests but may also devastate trees in suburban and urban neighborhoods. When forest pests kill trees, they reduce the value of timberlands and residential property, harm businesses, increase the risk of wildfire, degrade ecosystems, and place upon homeowners and local governments the costly burden of removing dead trees before they become a safety hazard. While the pests previously described have been in the United States for over 100 years, they continue to have an impact on the environment and economy.

The U.S. Department of Agriculture (USDA) has federal responsibility for protecting agricultural commodities and the health of the nation's public and private forests and grasslands and private forests from harmful pests and diseases. Within USDA, the Animal and Plant Health Inspection Service (APHIS) and the Forest Service have primary responsibility for managing forest pests. In doing so, these agencies often work with other federal, state, and local agencies to manage and eradicate invasive species infestations. The Secretary of Agriculture may also draw upon the expertise of people outside of the federal government when developing a

response plan for invasive species.[1] Funding for pest management activities comes through annual appropriations and the Commodity Credit Corporation (CCC), which is a government-owned entity that finances farm commodity, conservation, and trade programs and provides funding for agricultural-related emergencies.[2] The Secretary may transfer funds from the CCC (or other available USDA appropriations) for the arrest, control, eradication, and prevention of the spread of a plant pest and related expenses.

This report evaluates the federal response to three invasive forest pests—the Asian longhorned beetle; the emerald ash borer; and *Phytophthora ramorum* (hereafter *P. ramorum*), the pathogen that causes Sudden Oak Death. Specifically, we reviewed (1) the status of efforts to eradicate these three species; (2) factors that have affected the success of the response programs; (3) overall forest health monitoring programs; (4) coordination of the three pest response efforts among federal and state agencies and other stakeholders, and communication about the response efforts; and (5) USDA's use of panels of scientific experts to aid the responses. We also discuss in appendix VI APHIS's use of risk assessments to support decisions about forest pest programs. When we use the term "forest pest," we are referring to species that negatively affect trees in forested and urbanized areas. When we use the term "natural environment," we are referring to places other than a plant nursery operation that have trees and plants vulnerable to a particular invasive species. These places could include forested and urbanized areas.

To address these objectives, we conducted in-depth reviews of these three forest pests. These species were chosen because of their relatively recent discovery in the United States; their potential threat to the nation's forests; and the existence of a federally funded research, control, and management program for each species, and because they comprise a significant portion of USDA's efforts to address specific forest pests. To analyze the efforts to address each pest, we visited three of the areas currently infested by the

[1]When obtaining advice from a committee or similar group comprising, in part, nonfederal officials, it is possible that the committee may meet the Federal Advisory Committee Act's (FACA) definition of a federal advisory committee and be subject to FACA's requirements. For example, the act requires that advisory committees be fairly balanced in terms of points of view and the functions to be performed by the committee, and the act generally requires that committee meetings be open to the public.

[2]The corporation has the authority to borrow up to $30 billion. The borrowed funds are repaid through periodic congressional appropriations.

species and observed program activities, such as detection, control, and inspections of regulated materials, and visited with regulated industries. To obtain opinions from key stakeholders, we also conducted structured interviews with 37 USDA, state, local, and nongovernmental officials. More specifically, we administered the interview to 9 Asian longhorned beetle stakeholders, 12 emerald ash borer stakeholders, and 16 *P. ramorum* stakeholders. The government officials included federal, state, and local officials directly engaged in one of the pest management efforts. Nongovernmental officials included academic scientists with expertise in one of the pests and representatives from the nursery industry affected by one of the pests and by quarantine regulations. A more detailed description of our scope and methodology and questions from the structured interview guide are presented in appendixes I and II. We performed our work between May 2005 and February 2006 in accordance with generally accepted government auditing standards.

## Results in Brief

Evidence suggests that efforts to eradicate the Asian longhorned beetle appear likely to succeed, while the emerald ash borer and *P. ramorum* are likely to continue to infest and damage forest ecosystems indefinitely despite efforts to control them. The Asian longhorned beetle is a wood-boring insect from Asia that has caused separate infestations in parts of New York, New Jersey, and Illinois. Over 8,000 trees infested with the beetle have been removed, and over 600,000 trees have been chemically treated to protect against the beetle. As a result of these and other actions, federal and state agencies have been able to reduce the size of the infested areas. Program managers currently believe they could eradicate the beetle and end their program by 2014 if 2005 funding levels are maintained; however, fiscal year 2006 funding has dropped significantly below the 2005 level. The emerald ash borer is also a wood-boring insect from Asia that has infested large areas in Michigan; Ohio; Indiana; and Ontario, Canada, killing an estimated 15 million trees. The pathogen *P. ramorum* is the causal agent of the disease known as Sudden Oak Death. It is of unknown origin and has infested large areas in central and northern coastal California and a small area in southern Oregon. Although federal and state agencies have taken steps to reduce the spread of these two species—including attempting to stop the spread caused by people inadvertently moving infested material—the infestations are growing and few managers with whom we spoke believed that these species can be removed from the natural environment because of the size of the areas that are already infested.

Several factors have affected the success of the federal responses to these three forest pest species. Specifically:

- The biology of each of the three forest pests greatly influences the potential successfulness of eradication efforts. The Asian longhorned beetle is a large, conspicuous bug that does not fly far from the core infestation. As a result, it is fairly noticeable and does not spread quickly. Conversely, the emerald ash borer and, in particular *P. ramorum* are more insidious and can spread over greater distances and more rapidly.

- Delays in detection and identification allowed the three pests we reviewed to become established and spread before control efforts began. In each instance, several years elapsed between the arrival of the pest and its discovery, thereby giving the pest time to become firmly established in the environment.

- Quarantines have been helpful in containing human-induced spread of these forest pests. Federal and state agencies have placed restrictions on the movement of potentially infested materials, such as nursery plants and firewood. They also have mounted large public education campaigns to inform the public about the need to refrain from activities that could spread the pests. While program managers with whom we spoke believed that the quarantines have limited the spread of each pest, managers of the emerald ash borer and *P. ramorum* programs also noted that the quarantines were difficult to establish and enforce, and that they have not completely stopped the movement of those pests.

- Efforts to address the three forest pests are limited by the lack of cost-effective technologies for eradicating them. To date, the only method available to eradicate these pests in infested areas is to destroy the trees and plants that have been infested. Agencies have destroyed thousands of trees infested with the Asian longhorned beetle in New York, Illinois, and New Jersey and hundreds of thousands infested with the emerald ash borer in Michigan, Ohio, and Indiana. In the case of the ash borer, many more infested trees remain to be removed. On the West Coast, few trees infested with *P. ramorum* have been removed relative to the number infested because the pathogen is so widespread, but over 1 million nursery plants have been destroyed. Chemical treatments that can eradicate infestations of the three pests on a broad scale are not available, although they can be helpful in preventing the pests' spread. Such treatments have been used extensively for the Asian longhorned

beetle; however, they are impractical in the cases of the emerald ash borer and *P. ramorum* because of the size of the infestations. Research on alternative control technologies is ongoing for all three pests.

- While USDA has budgeted over $420 million on control programs for these pests, program managers told us that funding has not been sufficient to fully implement their programs. For example, according to managers of the Asian longhorned beetle program, reduced funding in fiscal years 2002, 2003, and 2006 delayed the estimated date of eradication from 2009 to as late as 2020 and increased the risk that the pest could spread to new locations during this time. In the case of the emerald ash borer, funding in fiscal year 2005 was about one-half of what the management team estimated was needed, while funding for fiscal year 2006 is less than one-third of the estimated need. As a result, state agencies have not been able to fully implement a tree removal plan recommended by the scientific advisory panel to contain the pest.

USDA has monitored the health of the nation's public and private forests for decades. Some programs are focused on broad issues, such as tree species composition and general health conditions, while others are focused on identifying specific problems. However, for the three forest pests we reviewed, as well as others, delays in detection and identification that allowed the pests to become established and spread before control efforts began illustrate that forest health monitoring has not been adequate. This is particularly the situation in urban areas that are common destination points for internationally traded cargo—a frequent pathway for pests. For example, the Asian longhorned beetle is thought to have begun infesting trees in New York City in the mid-1980s. It had been intercepted at warehouses around the country and was known to be a problem in its native range. However, there was no specific effort to determine whether it had made its way into the natural environment. It was not detected in the natural environment until 1996, when a New York City homeowner noticed suspicious holes in one of his trees. While a citizen report is an important component of an early warning system, a thorough government monitoring program—triggered by the detection of the beetle at U.S. ports—might have detected it sooner. The Forest Service and APHIS have taken steps in recent years to increase monitoring and otherwise improve their early warning system for forest pests, but these agencies could expand forest health monitoring in urban areas to further reduce the risk that new introductions will escape detection and result in substantial natural resource damage. Agency officials have estimated the cost of expanding existing programs to improve urban forest health monitoring to be about

$3 to 4 million per year, and they believe that doing so could help avoid more costly pest impacts and management costs. We are recommending that the Secretary of Agriculture expand current efforts to monitor forest health conditions, particularly in urban areas that are at high risk of receiving invasive insects and diseases.

For the three infestation response programs we reviewed, we found that coordination between federal and state agencies was initially lacking, and that USDA had not adequately kept management plans up to date to communicate with the public program accomplishments, strategies, and long-term funding needs, despite major changes in the programs. For each pest program we reviewed, a majority of the 37 stakeholders with whom we spoke told us that appropriate federal and state mechanisms are now in place to coordinate the work of multiple agencies and levels of government but highlighted weaknesses that had occurred and made suggestions for improvements. A common stakeholder complaint was that agriculture and natural resource agencies at either the federal or state level did not always work well together at the beginning of the response effort, thereby delaying management progress. Such problems could be averted in new pest response efforts if attention is paid to the lessons learned from the three pest management efforts we reviewed. Regarding communications about the response efforts, general principles of transparency and accountability, as well as the National Invasive Species Council's guidelines for rapid response programs, stress the importance of informing the public about the status of management programs, planned strategies, and funding needs. Along these lines, Congress passed a law in 2004 requiring that USDA, subject to the availability of appropriated funds, prepare a national plan for the control and management of Sudden Oak Death, which is caused by *P. ramorum*. The national plan is to include certain information. However, the agency published a plan in 2005 that did not include required cost estimates. Similarly, while the Asian longhorned beetle and emerald ash borer programs have publicly available management plans, the plans do not reflect the significant impacts that funding reductions have had on the prospects for controlling the infestations. We are recommending that the Secretary of Agriculture prepare, publish, and regularly update management plans for pests for which USDA has initiated a management program.

USDA has convened panels comprising federal and nonfederal scientific experts to assist the agency in responding to each of the three pests we reviewed. While program managers believe that these panels have been useful, we and some stakeholders have concerns about how they were

formed and are being operated. For example, some stakeholders believed that USDA should have convened specific panels more frequently and made the panel process more open and transparent to interested parties. We found that USDA does not have written procedures for how science advisory panels are to be formed and operated and when such panels should be chartered as federal advisory committees under the Federal Advisory Committee Act (FACA). There are certain principles in FACA that, if included in operational procedures for pest advisory panels, could address or minimize some of the concerns raised about their use. We are recommending that the Secretary of Agriculture implement written procedures that broadly define when and how to operate panels of scientific experts for the purpose of assisting pest management teams, including a discussion on how to determine when such panels should be chartered as advisory committees under FACA.

USDA provided comments on a draft of this report and said that it was comprehensive and well written. However, USDA stated that it believed the report contained an overly critical tone regarding its response to the three infestations and expressed the view that the coalition of federal and nonfederal entities had done a reasonable job. We believe the report fairly captures the agency's performance recognizing the daunting challenges that USDA and its collaborators have faced in responding to the infestations, while also accurately portraying the comments and opinions of the government officials we interviewed. Unfortunately, despite considerable effort, the fact remains that two of the three pests are spreading and are not likely to be eradicated. Our intention is to draw lessons from these pest infestations that can be used to reduce the effects of future infestations.

USDA also wrote that while it did not have major concerns about our recommendations, it did not completely agree with them. With regard to our recommendation that USDA expand forest health monitoring, the department suggested that we also examine the role that nonfederal entities play, their responsibilities, and the outcomes of their efforts. We recognize that nonfederal entities make important contributions to forest health monitoring; in fact, the USDA monitoring programs we discuss in this report are collaborative programs with nonfederal entities, including state forestry and agriculture agencies and private landowners. As the lead federal agency, USDA has an important leadership role to play with these nonfederal agencies. We believe that adopting our recommendations would enhance USDA's leadership position and help lead all responsible parties to more effective results. USDA commented that it supported our second

recommendation to keep management plans up to date, but the agency also stated its belief that it had done a reasonable job on the plans for the three pests we reviewed, given competing demands for time and resources. USDA characterized our third recommendation as calling for putting "more rigor into how science panels are formed" and said that "seemed reasonable." It appears, however, that the agency interpreted our recommendation to imply that science panels should always be chartered under FACA. The agency stated that chartering panels under FACA would hamper their ability to address invasive species issues. We recognize that the FACA process requires that certain steps be taken that could slow the establishment of a science panel at a time when one is quickly needed. However, our recommendation does not state that science panels always be chartered under FACA, but rather that USDA develop written procedures that clarify when a science panel needs to be chartered under FACA. The letter from USDA is reprinted in appendix VII.

# Background

Invasive species pose significant risks for the United States and can cause serious economic and environmental damage. The U.S. Department of Agriculture (USDA) is the lead federal agency for protecting the nation's agriculture and public and private forests from harmful pests and diseases. USDA often collaborates with other federal, state, and local agencies in carrying out these duties. Three recent infestations—the Asian longhorned beetle; the emerald ash borer; and *Phytophthora ramorum* (hereafter *P. ramorum*), the pathogen that causes Sudden Oak Death—offer valuable illustrations of how the federal government manages the threats posed by invasive species.

## Potential Economic and Environmental Impacts of Invasive Species

As we have previously reported, the impact of invasive species in the United States is widespread, and their consequences for the economy and the environment are profound.[3] They affect people's livelihoods and pose a significant risk to industries such as agriculture, ranching, and fisheries. The cost to control invasive species and the cost of damages they inflict, or could inflict, on property or natural resources are estimated to total billions of dollars annually. Among the broad universe of invasive species are

[3]GAO, *Invasive Species: Cooperation and Coordination Are Important for Effective Management of Invasive Weeds*, GAO-05-185 (Washington, D.C.: Feb. 25, 2005); and *Invasive Species: Clearer Focus and Greater Commitment Needed to Effectively Manage the Problem*, GAO-03-1 (Washington, D.C.: Oct. 22, 2002).

insects and pathogens that can harm trees, including trees that are important to industry, homeowners and communities, wildlife, and the environment.

## Federal and State Responsibilities

In 1999, President Clinton signed Executive Order 13112 creating the National Invasive Species Council, which now comprises the heads of 13 departments and agencies, in part to coordinate federal efforts on invasive species. In 2001, the council issued a national management plan that contains numerous recommendations for managing invasive species, including several on improving early detection and rapid response to infestations. For example, in response to the management plan, the council issued in 2003 general guidelines for establishing and evaluating invasive species early detection and rapid response systems.

Within USDA, the Animal and Plant Health Inspection Service (APHIS) is the lead agency for responding to forest pests and diseases that might harm U.S. agriculture. The Department of Homeland Security (DHS) also plays a critical role in protecting agricultural interests by inspecting ships, airplanes, vehicles, cargo, and passengers and their baggage for prohibited agricultural materials that may serve as carriers for pests and disease. USDA conducted some of these inspections in the past, but the Homeland Security Act of 2002 transferred this function, among others, to DHS.[4] This report does not address DHS pest inspection programs. However, we plan to issue a separate GAO report on inspection programs later this spring.[5]

This report focuses on USDA programs to address forest pests that have arrived in the United States despite preventive efforts. APHIS manages pests that have arrived by conducting detection surveys; issuing quarantines; directing eradication efforts, such as removing infested trees or applying pesticides; developing control technologies; and performing public outreach. The Forest Service—whose mission of forest protection extends to all public and private forest land—undertakes reforestation of areas affected by pests and plays an important role in surveys, research, and management. Other federal agencies may also be involved in some aspects of invasive species management, including managing federal lands

[4]Pub. L. No. 107-296, 116 Stat. 2135 (2002).

[5]The report will be available on GAO's Web site, identified as GAO-06-644.

that may be impacted by invasive species and administering programs to address them.

State agencies also play an important role in managing invasive species. For example, state agencies impose quarantines to prevent the movement of infested materials within their state and take actions to eradicate pests. APHIS and the Forest Service enter into cooperative agreements with states to jointly carry out eradication programs and provide funding assistance for these programs. APHIS and the states also monitor for specific plant pests, including some that have already arrived in the country and others that have not.

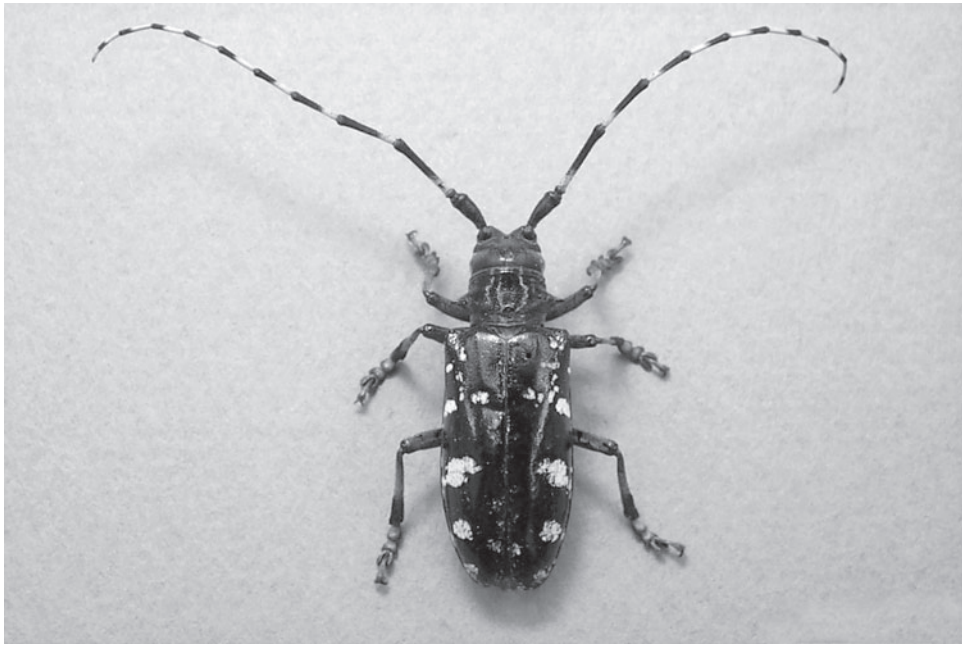
## The Asian Longhorned Beetle

The Asian longhorned beetle was initially detected in the United States in Brooklyn, New York, in August 1996, and is suspected to have entered the country years before in solid wood packing material from Asia, where it is a pest of hardwood trees. Subsequent infestations were discovered in Chicago, Illinois, in July 1998, and in New Jersey in October 2002. The beetle was also discovered in Toronto, Canada, in September 2003. The beetle infestations have been limited to urban forests in New York; Illinois; New Jersey; and Ontario, Canada.

While the natural spread of the Asian longhorned beetle has been very slow to nonexistent, the beetle represents a serious threat to forests and urban trees. The potential impact to forests is the loss of 71 billion trees valued at over $2 trillion dollars. In addition, urban areas could lose as much as 35 percent of their tree canopy cover and 30 percent of their trees (1.2 billion trees), with an estimated loss of value of $669 billion.[6] Other potential adverse impacts could affect the forest products industry (lumber and furniture), maple syrup production, and fall foliage tourism, as well as decrease property values, cause aesthetic damage, and lessen the environmental benefits of trees. The potential also exists for the beetle to seriously alter the ecological diversity of the natural forests in North America, with additional impacts on wetlands. Figure 1 shows the beetle, and appendix III contains more detail on its infestation and the management program.

[6]David J. Nowak, Judith E. Pasek, Ronaldo A. Sequeira, Daniel E. Crane, and Victor C. Mastro. "Potential Effect of *Anoplophora glabripennis* (Coleoptera: Cerambycidae) on Urban Trees in the United States." *Journal of Economic Entomology*, vol. 94, no. 1 (2001).

**Figure 1: Asian Longhorned Beetle (*Anoplophora glabripennis*)**



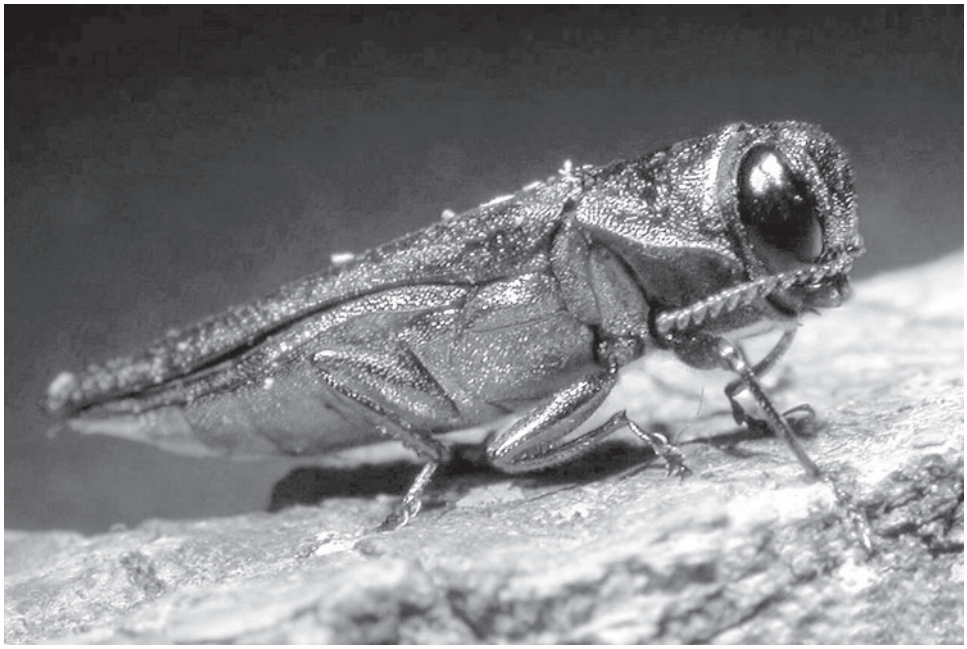
Source: Donald Duerr, USDA Forest Service, www.forestryimages.org.

## The Emerald Ash Borer

The emerald ash borer was initially detected in the United States in 2002 in southeastern Michigan, but the insect is estimated to have arrived in the country in the early 1990s, in solid wood packing material. Emerald ash borer infestations cover roughly 40,000 square miles in Indiana; Michigan; Ohio; and Ontario, Canada, and the natural spread of the species continues. Surveys also regularly find new areas in the three states infested with beetles that inadvertently were moved by people.

The emerald ash borer can kill all 16 species of North American ash trees and, as of November 2005, the pest had killed an estimated 15 million trees. The potential economic impacts of the infestation are significant because ash trees represent billions of dollars in ornamental, industrial, and environmental value. Figure 2 shows the ash borer, and appendix IV contains more detail on its infestation and the management program.

**Figure 2: Emerald Ash Borer (*Agrilus planipennis* Fairmaire)**



Source: David Cappaert, www.forestryimages.org.

## *P. ramorum*

*P. ramorum* (the pathogen that causes Sudden Oak Death) was initially detected in the United States in 2000. While it is believed to have appeared in the country as early as the mid-1990s, how it arrived here is unknown. Currently, *P. ramorum* infects natural areas in 14 counties of California and part of Curry County, Oregon. The pathogen has also been inadvertently shipped to, and in most cases eradicated from, nurseries in 22 states. The natural and artificial spread of *P. ramorum* continues. However, improved detection of the pathogen in nurseries has led to a decrease in the number of detected interstate shipments of infected plants. For example, in 2005, 99 confirmed positive detections of *P. ramorum* were associated with nursery plants in 7 states, down from 176 positives in 22 states in 2004.

*P. ramorum* affects oak trees and other host and associated host plants in natural areas and nurseries. *P. ramorum* can kill valuable oak trees in urban and natural environments and can infect and devalue, but not necessarily kill, ornamental plants such as rhododendron. Currently,

*P. ramorum* is known to infect species in more than 50 plant genera.[7] These plants are worth billions of dollars in ornamental, timber, wildlife, and environmental value. The pathogen has killed tens of thousands of trees and led to the destruction of hundreds of thousands of nursery plants. Appendix V contains more detail on the *P. ramorum* infestation and management program.

The Asian longhorned beetle, the emerald ash borer, and other invasive species arrived in the United States in solid wood packing material accompanying cargo from overseas. This review did not address government regulations or practices aimed at preventing this from occurring. Following is a brief description of actions USDA has taken to reduce the risks posed by solid wood packing material.

[7]The term "genera," the plural form of genus, refers to a category of biological classification ranking between the family and the species, comprising related species.

**Figure 3: Cable Spools, an Example of Solid Wood Packing Material That Could Harbor Pests**

Source: Nick Humphreys, Natural Resources Canada.

**Recent USDA Regulations for Solid Wood Packing Material Are Intended to Reduce Pest Introductions, but Some Have Questioned Their Future Effectiveness**

A major pathway through which forest pests enter this country is solid wood packing material. This material includes pallets, crates, boxes, cable spools, and pieces of wood used to support or brace cargo. The Asian longhorned beetle and the emerald ash borer—as well as many other pests—are thought to have arrived in this country hidden in this type of material. We did not review the federal government's efforts to prevent the introduction of pests. However, one major development in this area bears noting. In December 1998, an APHIS interim rule took effect requiring that solid wood packing material arriving in the United States from China be treated to reduce the likelihood that it harbored live pests. In September 2004, APHIS published a final rule that adopted an international standard for treating solid wood packing material. The new standard requires that wood packing material from all places be treated either with heat or a fumigant known as methyl bromide. APHIS will phase in enforcement of the rule, with full enforcement by July 2006. According to APHIS, there has been a decrease in pests associated with solid wood packing material from China since APHIS began requiring that the material be treated prior to importation. The agency believes that the new and broader regulations will further reduce the introduction of new species. If the standard does add protections, the need for early detection and rapid response may decrease. Although, as a Forest Service entomologist noted to us, detection is still needed for pests that have arrived in recent years.

However, solid wood packing material is not the only pathway by which new pests are introduced, and some interested parties commented during the rulemaking process that the new regulations are not protective enough to kill all pests. Comments included concerns that the heat treatment and fumigation standards are not adequate, and that it will be too difficult to ensure that those treatments were conducted. (Methyl bromide is also controversial because it contributes to stratospheric ozone depletion.) Others commented that a more protective approach would be to phase out the use of solid wood packing materials and replace them with other materials, such as manufactured wood or plastic. In September 2005, California, Connecticut, Illinois, and New York sued USDA, claiming that the new regulations are not adequately protective and seeking a court order directing the agency to examine more effective and less environmentally harmful methods of preventing destructive insects from entering the country.

## Eradicating the Asian Longhorned Beetle Appears Likely, While Success on the Emerald Ash Borer and *P. ramorum* Is Less Promising

Evidence suggests that the Asian longhorned beetle will be eradicated, while the emerald ash borer and *P. ramorum* are likely to continue to infest and damage forest ecosystems indefinitely, despite efforts to control them. When first discovered, the areas infested with the Asian longhorned beetle were tens of square miles. Although the known boundaries of the infested areas expanded as surveys were conducted, government efforts in Illinois, New Jersey, and New York have been able to reverse the trend and reduce the size of the infested areas. Program managers with whom we spoke believed they could eradicate the beetle and end their program by 2014 if funding remained at 2005 levels. However, recent funding reductions raise doubts about achieving their goal by that date. In contrast, the areas infested with the emerald ash borer and *P. ramorum* were already many hundreds, if not thousands, of square miles in size by the time the pests were identified. While government agencies have taken steps to reduce the human-induced spread of these two species, the infestations are still growing, and few officials we spoke with believed that the pests can be removed from the natural environment.

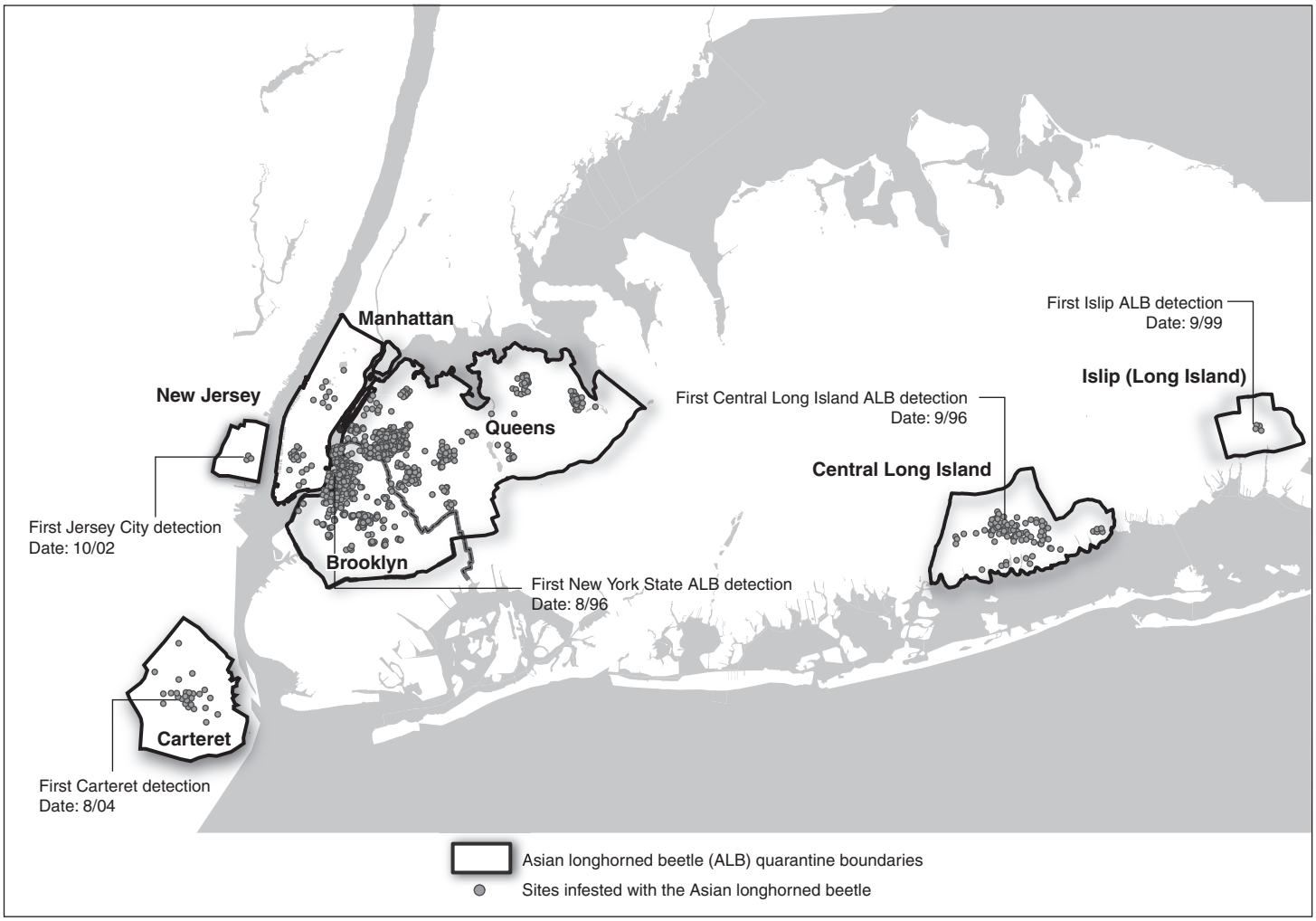
### Program Officials Believed That the Asian Longhorned Beetle Will Be Eradicated

Eight of the nine stakeholders we interviewed regarding the Asian longhorned beetle believed that it will be eradicated from Illinois, New Jersey, and New York.[8] APHIS's current goals for Illinois and New Jersey are to confirm eradication and end the management programs in 2008 and 2011, respectively. The current goal for completing the program in New York is 2014, although that estimate is dependent upon consistent and adequate funding.

The stakeholders' opinions on the likelihood of eradication are based on a number of factors, including the relatively small areas of infestation and the success to date in eradicating the beetle in nearly all of the Illinois locations and one of two locations in New Jersey. At their peak, quarantines covered 183 square miles in the three states (see figs. 4 and 5).

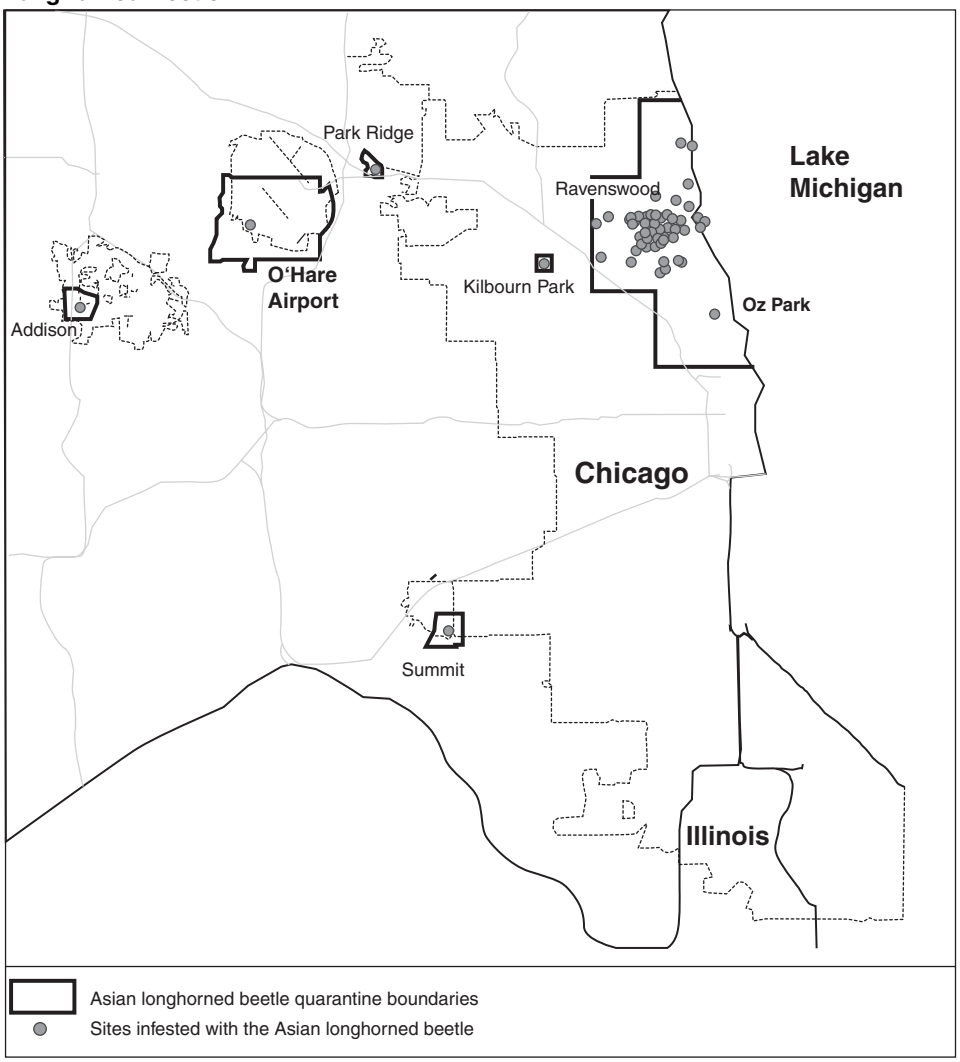
[8]One stakeholder, a member of academia, did not believe eradication is possible under the current management program.

**Figure 4: Areas in New Jersey and New York Quarantined for the Asian Longhorned Beetle**




Sources: USDA, APHIS, and GAO.

**Figure 5: Areas in Metropolitan Chicago, Illinois, Quarantined for the Asian Longhorned Beetle**




Sources: APHIS and GAO.

After 2 years of surveys in these locations have shown no evidence of the beetle, program officials can begin removing the quarantines, and they have done so in some areas. According to agency guidelines, after 4 years of negative surveys, program officials can declare that the beetle has been eradicated from these areas.

Prior to the implementation of regulatory controls, the Asian longhorned beetle was spread artificially through the movement of wood products, such as firewood and wood debris. Program managers are confident that quarantines and other regulatory actions have stopped the artificial spread of the beetle. The natural spread of the Asian longhorned beetle has been very slow because it does not travel far from its original nesting site, unless forced to do so by a lack of food. In addition, adult beetles and the exit holes they create when they emerge from trees are relatively easy to see, and the public, having been educated about the beetle, has helped find new infestations.

The damage to trees caused by the Asian longhorned beetle has been relatively minor in comparison to the threat USDA estimated it could pose and in comparison to the damage caused by the emerald ash borer and *P. ramorum*. The beetle attacks hardwood tree species that grow primarily in the eastern United States, including many that are valued in both urban and forested areas.[9] While it appears that the beetle will be eradicated, according to USDA, if left unchecked the pest has the potential to do more damage to a wider range of hardwood tree species in North American forests than the Dutch elm disease, chestnut blight, and gypsy moth combined. Presently, the known beetle infestations have been confined to trees in large urban areas. For urban areas, USDA estimates that property owners and municipalities could lose 35 percent of their tree canopy cover and incur 30 percent tree mortality (1.2 billion trees), damage valued at $669 million.[10] Losses that are difficult to quantify include property value depreciation and the loss of the aesthetic and environmental benefits to property owners. If the beetle were to escape its current urban environment and establish itself in natural forests, USDA estimates that about 30 percent, or 71 billion trees on timberland, valued at over $2 trillion could be lost.[11] (These are worst-case scenarios, and we present them to indicate the potential magnitude of the problem.) The $2 trillion does not

[9]The various trees that serve as hosts for the Asian longhorned beetle include the following: very good hosts are maple, boxelder, horsechestnut, buckeye, willow, and elm trees; good hosts are birch and London plane trees; and occasional hosts are mimosa, hackberry, ash, poplar, and mountain ash trees.

[10]David J. Nowak, Judith E. Pasek, Ronaldo A. Sequeira, Daniel E. Crane, and Victor C. Mastro. "Potential Effect of *Anoplophora glabripennis* (Coleoptera: Cerambycidae) on Urban Trees in the United States." *Journal of Economic Entomology*, vol. 94, no. 1 (2001).

[11]The Forest Service Web address for this information is http://www.fs.fed.us/ne/syracuse/Data/Nation/data_list_alb.htm.

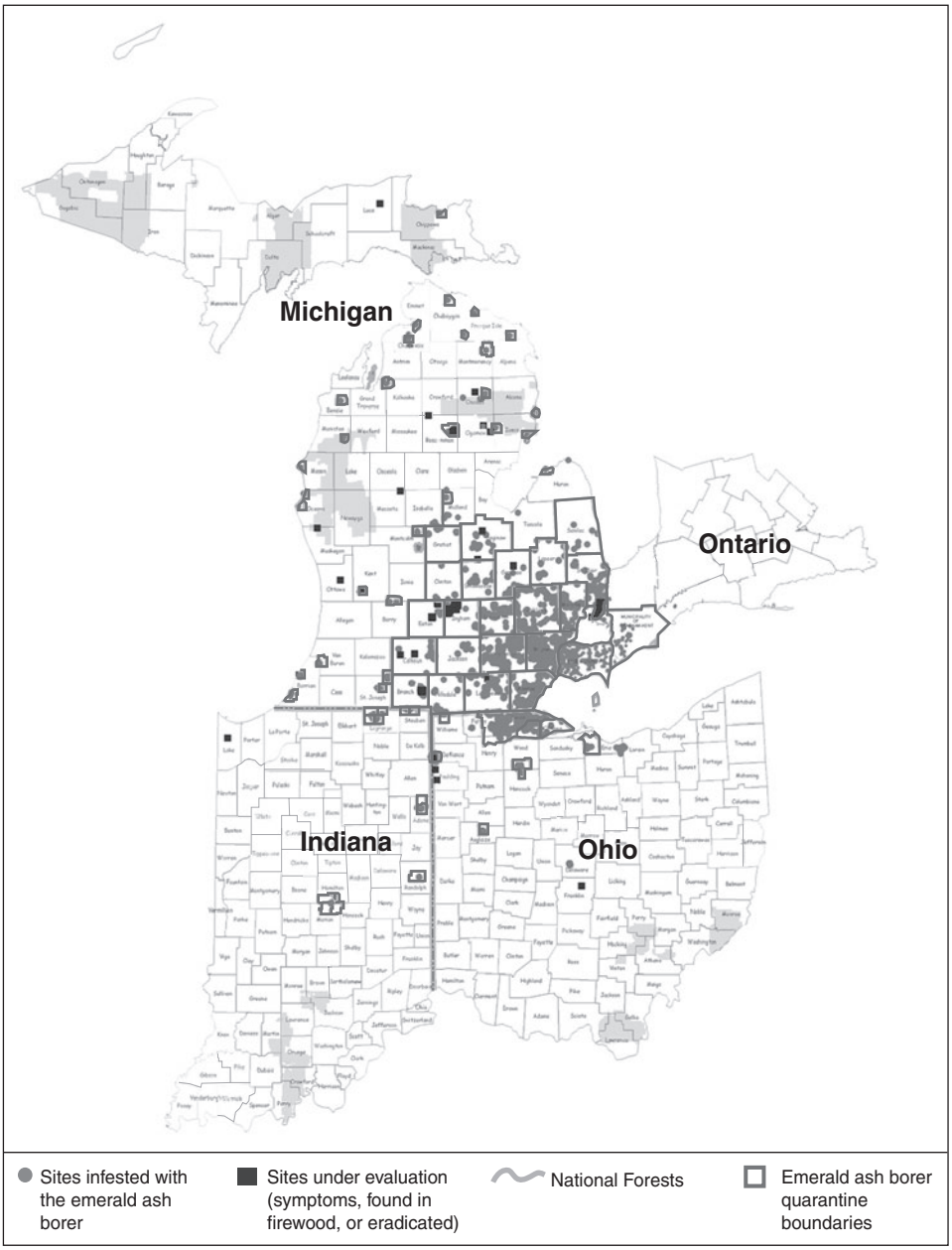
include the adverse impact to such industries as forest products, maple syrup, and fall foliage tourism in the Northeast. Additionally, the spread of the Asian longhorned beetle could alter the ecological diversity of the natural forests in North America and significantly alter the tree makeup of wetlands.

Other factors contributing to stakeholders' optimism about eradication of the Asian longhorned beetle include the existence of a focused and cooperative management team in each location and an effective mix of control measures, including good cooperative working relationships and an aggressive public outreach and education program.

## Eradicating the Emerald Ash Borer Does Not Appear Likely

None of the 12 stakeholders we interviewed believed that the emerald ash borer could be eradicated in the United States, given our current knowledge and level of effort. The areas infested with the emerald ash borer have exceeded 40,000 square miles in Michigan; Indiana; Ohio; and Ontario, Canada, and continue to grow (see fig. 6). The pest has spread by both natural and artificial means. Research has shown that ash borers, particularly mated females, are capable of flying several miles. Government studies have used the estimate that ash borer populations can spread 5 to 10 miles per year as they grow in number and search for new host trees. More dramatically, the artificial movement of the pest in infested logs, firewood, or nursery trees can start new infestations hundreds of miles away.

**Figure 6: Areas with Emerald Ash Borer Infestations in Indiana; Michigan; Ohio; and Ontario, Canada, as of January 2006**



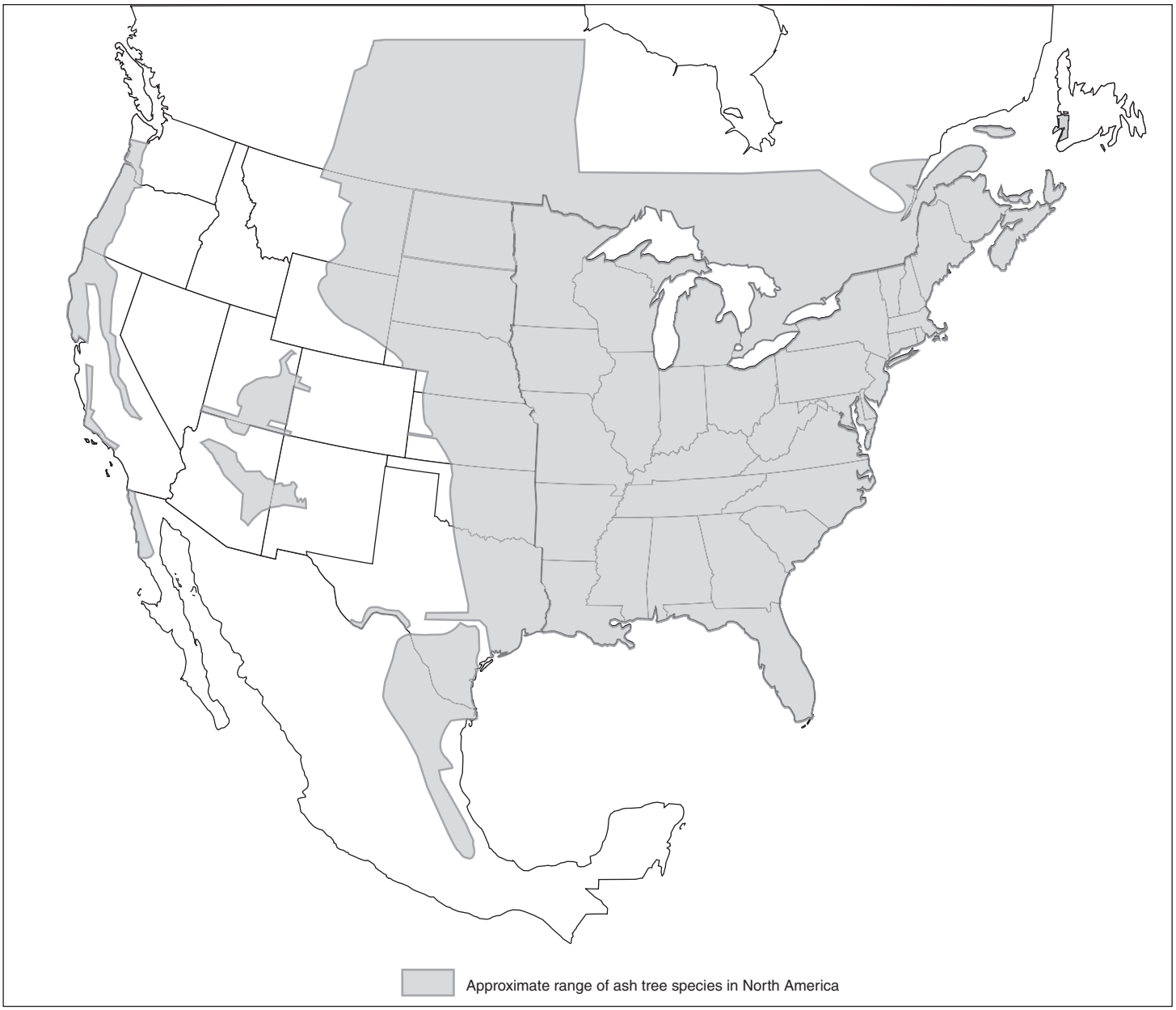

Sources: APHIS and GAO.

According to the Michigan Department of Agriculture, the ash borer has killed an estimated 15 million trees and has caused "staggering costs for tree removal, disposal, and replanting [that] have overwhelmed local units of government." There are16 species of ash trees in North America, and all are believed to be vulnerable to the ash borer (see fig. 7 for the geographic range of ash species).[12] Several stakeholders with whom we spoke were concerned that all ash species in U.S. forest were at risk. USDA also estimated that the cost of removing and replacing dead ash trees in urban and suburban areas could reach $7 billion over a 25-year period.[13]

[12]USDA estimates that there are approximately 8 billion ash trees in U.S. forests.

[13]USDA is in the process of refining this estimate.

**Figure 7: Approximate Range of North American Ash Tree Species**




Sources: USDA Forest Service and MapArt.

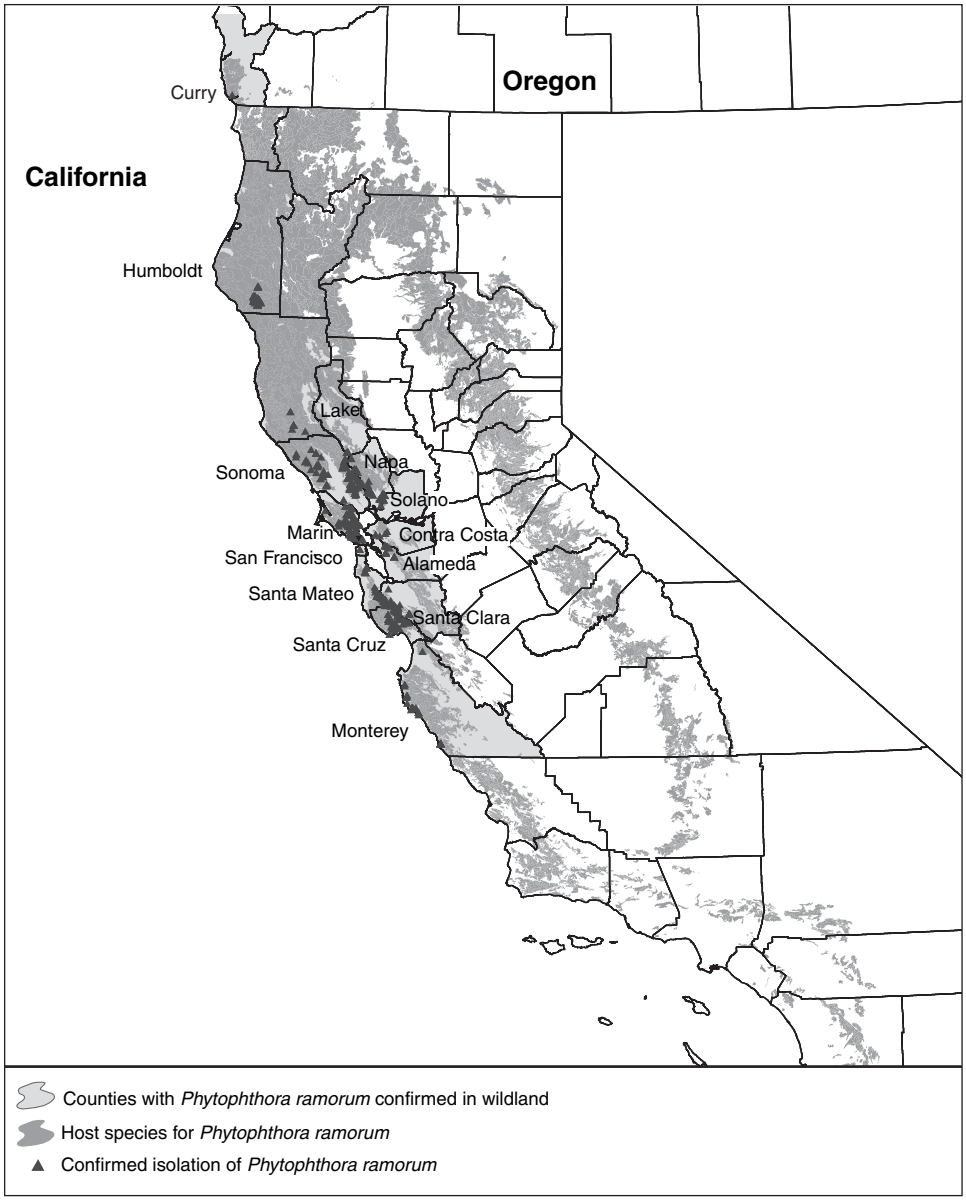
The current federal management approach calls for eradicating the ash borer in Indiana and Ohio and containing, but not eradicating, the ash borer in Michigan. This approach reflects the enormity of the task of trying to eradicate the pest in Michigan, given its widespread distribution and the lack of low-cost management tools. What it means, though, is that even if the program is able to contain the beetle within Michigan, the pest will continue to kill ash trees across the Michigan landscape and also continue to pose a threat to other states. While several stakeholders told us they believed that North American ash species are in danger of being eliminated as a component in forested areas, others suggested that it is possible to slow the spread of the ash borer as has been done with the European gypsy moth. A significant difference between those two pests, however, is that while the gypsy moth is a serious tree defoliator, it does not inevitably kill trees as the ash borer does.

## Eradicating *P. ramorum*—the Pathogen That Causes Sudden Oak Death—Does Not Appear Likely

None of the 16 stakeholders we interviewed believed that *P. ramorum* could be eradicated from California's natural environment because of the current size of the infestation, its potential for spread, and the lack of effective management tools.[14] The area currently infested by *P. ramorum* has exceeded 19,000 square miles in central California and continues to grow as the pathogen is spread by both natural and artificial means (see fig. 8).

[14]Fifteen of the 16 stakeholders did not believe eradication was possible; 1 stakeholder was uncertain.

**Figure 8: Map of Area Infested with *P. ramorum* in California and Oregon, as of December 12, 2005**




Sources: Karen Tuxen and Maggie Kelly, http//kellylab.berkeley.edu/SODmonitoring and GAO.

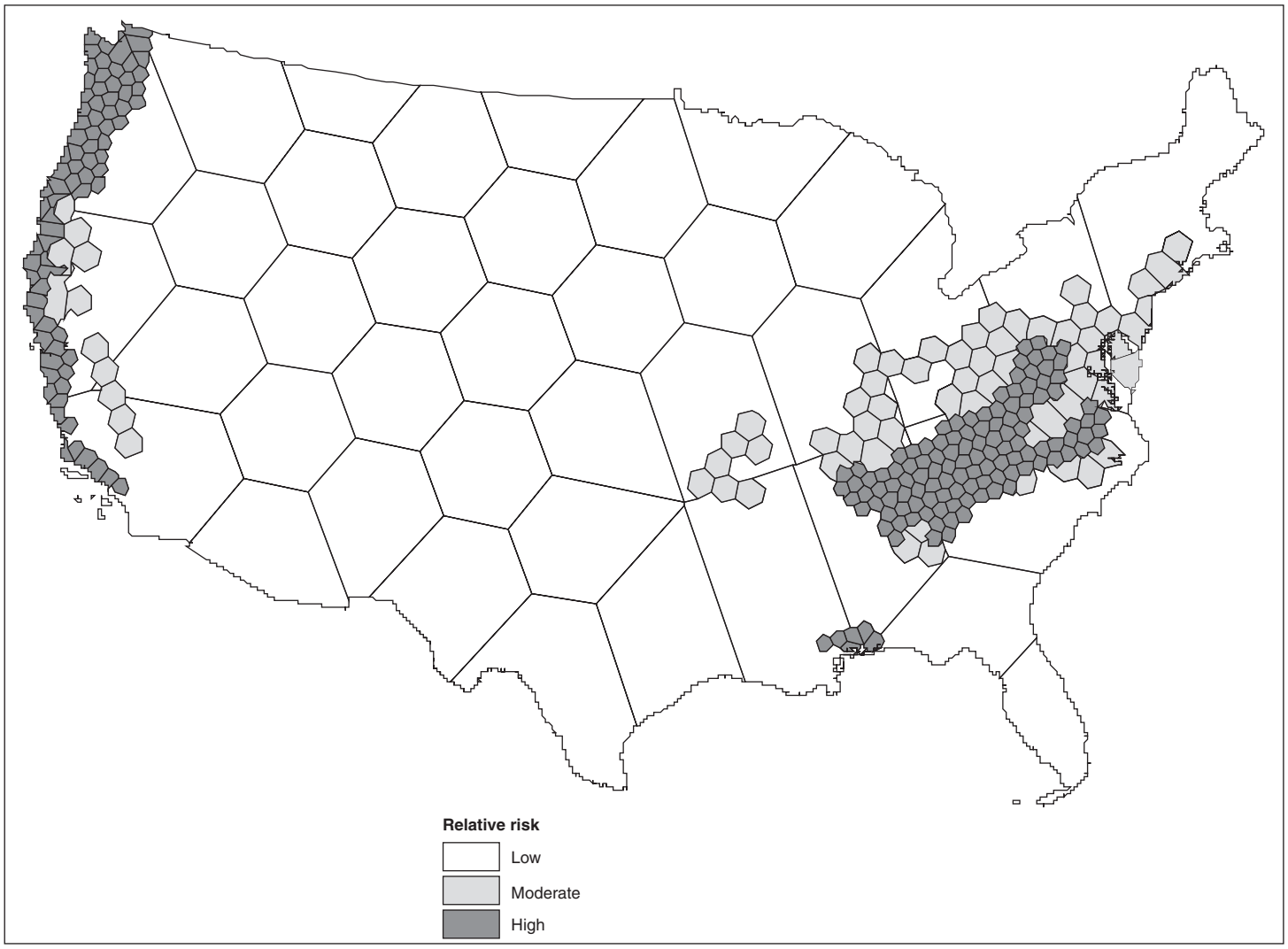
One stakeholder who is familiar with forest pathogens stated that no invasive forest pathogen has ever been eradicated from North American forests. Consistent with this belief, the USDA management strategy in California calls for control of *P. ramorum* in the natural environment, rather than eradication.[15] APHIS and state agencies are, however, striving to eradicate the pathogen from nursery environments to reduce the risk that infected ornamental plants will spread the pathogen throughout the country. Six stakeholders—federal, state, and nursery officials—told us they believed the pathogen could be eradicated from nurseries, a belief bolstered by evidence of the control of other *Phytophthoras* in nurseries.

In the United States, the only known forest infested with *P. ramorum* outside of California is a small area in Curry County, Oregon (see fig. 8). Oregon, with assistance from APHIS and the Forest Service, is working to eradicate this infestation. Five of the 16 stakeholders—federal, state, university, and nursery officials in Oregon—we interviewed told us that they believed small-scale eradication efforts such as this can succeed.

Research has shown that the pathogen thrives in wet, moist weather, and spores from infected plants spread naturally in water, air, or soil. People and animals can also track spores into uninfected areas, and the movement of infected plants or soil could start new infestations across the country. *P. ramorum* is known to threaten and could potentially kill numerous species of oak in North America and kill other trees, such as tanoak (not a true oak species). *P. ramorum* can also infect, but not necessarily kill, other trees, including California bay laurel, as well as ornamental plants, such as rhododendron and camellia. *P. ramorum* has already killed tens of thousands of tanoaks, coast live oaks, and black oaks with a mortality rate as high as 85 percent in some areas of California. A preliminary risk map created by the Forest Service, on the basis of potential pathways, susceptible plant species, and favorable weather conditions, shows that the natural areas at highest risk for *P. ramorum* are in the coastal areas of California, Oregon, and Washington and the Appalachian Mountains (see fig. 9).

[15]In July 2001, APHIS designated *P. ramorum* as a domestic control program rather than an eradication program after determining that the infestation in California was too widespread to eradicate. A domestic program is one in which the agency expects to engage in suppression for an indefinite period of time.

**Figure 9: Forest Service *P. ramorum* Risk Map**




Sources: USDA Forest Service and GAO.

Many stakeholders believe that the tanoak—a valuable tree for wildlife, certain Indian tribes, and soil stability along steep inclines—is in danger of being eliminated as a component of the forest understory in California and Oregon because of *P. ramorum*. However, the same risk does not apply to true oak trees because they have shown greater resistance to the pathogen. Still, the potential threat to the commercial timber industry could exceed $30 billion dollars if *P. ramorum* were to become established in Eastern

deciduous forests. California timberlands alone are valued at over $500 million for forest products. In addition to the timber industry, the potential impact of the pathogen on the U.S. nursery industry is high. Since detection of the pathogen in a Santa Cruz nursery in 2001, damage to the nursery industry has been estimated to be between $3 and $17 million, not including lost sales. The California Association of Nurseries and Garden Centers estimated that California nurseries lost $25 million in sales in the spring of 2004 alone when other states prohibited nursery shipments from California. In addition, the economic impact on homeowners is potentially significant if trees that contribute to property value are lost to the disease. The cost of removing infected trees, such as large ornamental oaks, is also high, anywhere from $500 to $5,000 per tree. According to a Forest Service official, there are no government reimbursement programs to cover tree removal costs, except in Oregon where federal funds are used for eradication purposes, including tree removal on private lands in the Curry County quarantined area.

## Efforts to Eradicate These Pests Have Been Affected by Several Factors

Several factors have affected the federal response to these three infestations. First, specific biological characteristics of each species affect the ease with which the pest is detected and its ability to move across the landscape. Second, in each instance, several years elapsed between the arrival of the pest and its discovery, thereby giving the pest time to become firmly established in the environment. Third, quarantines have helped to slow the spread of the pests, but they are difficult to implement and enforce. Fourth, in all three situations, program managers have noted that they lack cost-effective technologies for controlling the pests. Finally, insufficient funding has (1) restricted program managers' ability to use the tools they do have to minimize the spread of the pests and (2) raised concerns among managers about being able to achieve future goals.

### Biological Characteristics of Each Species Greatly Affect the Success of Control Efforts

The three invasive forest pests we reviewed are quite different organisms, and those differences have affected the success of management programs. The most basic characteristic is that two of these pests are insects while the third—*P. ramorum*—is a pathogen. More important, however, is how species-specific characteristics affect the relative ease of their detection; their ability to reproduce and move across the landscape; and their vulnerability to safe, available pesticides. The Asian longhorned beetle exhibits fewer of the characteristics that hinder control efforts than do the

emerald ash borer and *P. ramorum*; hence control of the beetle has been more successful.

Asian longhorned beetle

The Asian longhorned beetle has some biological characteristics that make its detection difficult, but others that make its management generally feasible. The beetle is a wood-boring insect that spends most of its life within the inner wood of its host tree, thereby hindering their detection during much of the year. During these months, the beetle can be easily and unknowingly moved in firewood, live trees, or fallen timber, thereby contributing to its spread; the beetle is also less vulnerable to insecticide applications during this time. In addition, government researchers have not been able to develop a lure that will attract the beetle to a trap.

On the other hand, when adult beetles emerge from the trunks of trees, they are relatively conspicuous because of their size (up to 1½ inches long), their shiny black body with white spots, and their long antennae that are banded with black and white stripes. After emerging, the adult beetles also leave behind a conspicuous, perfectly round exit hole somewhat larger than the diameter of a pencil. In addition, females chew a small hole into which they deposit their eggs. Although less conspicuous than exit holes, these holes—known as oviposition pits—are nevertheless useful in intensive detection surveys and allow for the detection and removal of trees before the eggs hatch and beetles emerge and spread to other areas. Exit holes may ooze sap and deposits of frass (i.e., insect waste and sawdust) that may collect on the tree trunk and limbs. In fact, it was the beetle's size and coloring that piqued people's interest and led to private landowners' detection of the beetle in Illinois, New Jersey, and New York. According to Asian longhorned beetle management officials, public reports of beetle sightings soar after public service announcements that discuss the beetle. While many sightings reported by the public turn out to be false leads because the beetle is similar to some noninvasive beetles, other sightings have been productive. For example, shortly after hearing about the beetle on a radio show about gardening, a New Jersey resident called with a report that led to the detection of one of two infestations in the state. The beetle's dispersal habit is perhaps the most important biological factor contributing to management success. One program official noted that the beetle is "lazy" and tends to remain on the tree from which it emerged, unless, for example, the beetle is forced to move to another host due to a shortage of food. In short, the beetle does not naturally spread quickly over large areas. When taken together, these characteristics have made it easier for management teams to detect, contain, and eradicate infestations. On the other hand, according to one state Asian longhorned beetle program

manager, less than 1 percent of potential host trees are infested, thereby making detection of the beetle more difficult.

Emerald ash borer

A number of biological factors contributed to the lag time between the start of the emerald ash borer infestation and the positive identification of the pest. First, the ash borer spends most of its life hidden inside trees. Female beetles lay tiny eggs in bark crevices, thereby making them difficult to detect. Visible symptoms of infestation, such as branch dieback and epicormic shoots, do not appear until at least 1 year after attack and could be attributed to other causes.[16] When adult beetles do emerge from a tree, they are relatively small and inconspicuous.

Once the ash borer was identified, scientists in the United States had little information to use in developing a control program. Only two short scientific papers were available from Asia that described the beetle's biology and habits. Similar to the Asian longhorned beetle, and in contrast to some other agricultural and forest pests, the ash borer is not known to respond to chemical lures. This appears to be typical of this family of beetle (Buprestidae) and has greatly hampered the management program's ability to define the extent of infestation.

*P. ramorum*

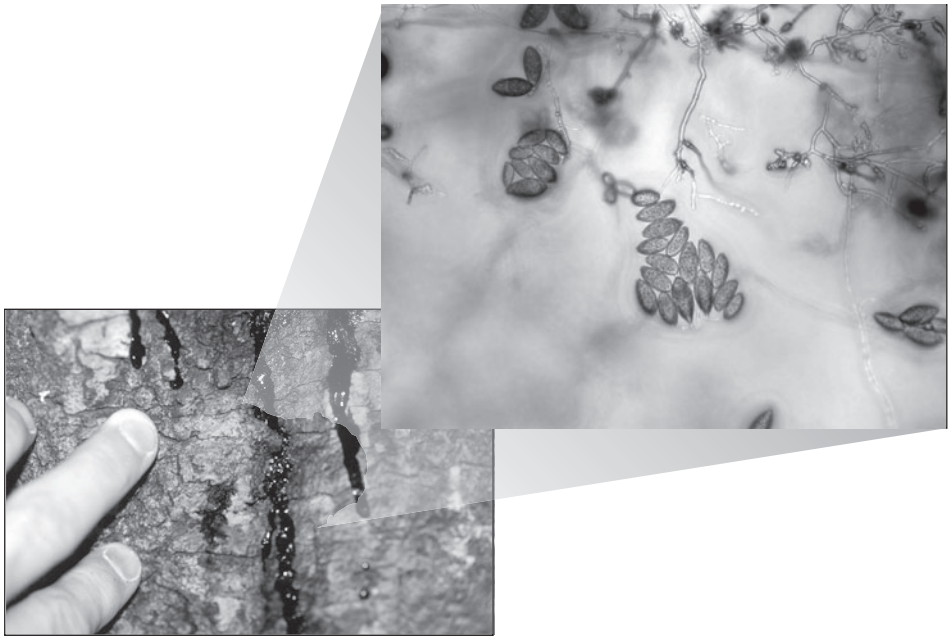
Similar to the Asian longhorned beetle and the emerald ash borer, *P. ramorum* has several biological characteristics that have contributed to the pathogen's spread. First, unlike many forest pathogens, *P. ramorum* affects a wide range of host plants—ranging from common forest tree species, such as tanoaks and oaks, to common nursery species, such as rhododendron and camellias. *P. ramorum* infects species in more than 55 plant genera, and the known number continues to grow as more research and monitoring is done. On the other hand, not all host plant species are equally vulnerable to the pathogen; while some species die from infections, others only show symptoms of ill-health. Infected plants act as carriers and help spread the pathogen to other plants.

Another characteristic that makes managing *P. ramorum* difficult is that its symptoms can differ widely among host species and often resemble other diseases, making visual detection difficult. Symptoms appear seasonally and generally are of two types, bark cankers and foliar blights. Bark cankers, typically associated with oaks and tanoaks, often appear to be

[16]Epicormic shoots are sprouts that emerge from dormant buds along the trunk or branch of a tree. They can form in response to stress inflicted upon the tree.

"bleeding" on the trunks of infected trees (see fig. 10). The mortality caused by bark cankers can often resemble other conditions known as oak wilt and oak decline.

**Figure 10: "Bleeding" on Tree Trunk Caused by *P. ramorum***



Sources: Joseph O'Brien, USDA Forest Service, www.forestryimages.org (left); Cheryl Blomquist, California Department of Food and Agriculture (right).

The second type of symptom, foliar blight, appears on host plants—such as camellia and rhododendron—as spots or blotches on leaves, or shoot dieback. Foliar blight can serve as a reservoir of *P. ramorum* spores that may spread to other plants. Unlike bleeding cankers on oaks, hosts with foliar blight rarely die from the infection. Foliar blight can be confused with the symptoms caused by common fungi and other pathogens. Regardless of what host plant is suspected of having *P. ramorum* and regardless of what symptoms are seen, it is impossible to positively detect *P. ramorum* on-site. Samples of potentially infected plants found in nurseries must be sent to an APHIS-approved laboratory for diagnostic tests to confirm the presence of *P. ramorum*, which can be expensive and time-consuming.

In addition to being difficult to detect, and therefore easily spread on nursery plants, *P. ramorum* is able to spread in water. Spores of the pathogen can travel in streams or even wind-driven rain or fog, making control of the spread very difficult, if not impossible, in the natural environment.

## Delays in Detecting and Identifying the Asian Longhorned Beetle, the Emerald Ash Borer, and *P. ramorum* Allowed These Pests to Become Established and Spread

For each of the three forest pests we reviewed, several years elapsed between the arrival of the pest and its discovery, thereby giving the pest time to become firmly established in the environment. Specifically:

- *Asian longhorned beetle*: The Asian longhorned beetle is thought to have begun infesting trees in New York City in the mid-1980s. However, the beetle was not detected until 1996 by a homeowner who noticed suspicious holes in one of his trees. The homeowner thought the holes were the work of vandals, but upon investigation, government officials determined that the damage was caused by the Asian longhorned beetle. The beetle was known to APHIS port inspectors who had intercepted the beetle twice between 1985 and 1998 in solid wood packing material accompanying shipments from China. According to APHIS, inspectors probably intercepted Asian longhorned beetle larvae and the larvae of related species repeatedly before 1996, and would have taken mitigating actions to prevent their entry without needing to identify which species they were. However, despite its presence at U.S. ports and the potential for damage to natural resources, no systematic monitoring or surveys were performed to determine if the beetle had been introduced to the natural environment. Had such surveys been conducted, the pest might have been found years earlier.

- *Emerald ash borer*: Government agencies misdiagnosed early symptoms of ash mortality in Michigan, thereby giving the emerald ash borer a running start that has greatly diminished the likelihood that control efforts will succeed. Scientists believe that the ash borer arrived in southeastern Michigan by the early 1990s in solid wood packing material accompanying products shipped from Asia. For several years prior to the detection of the insect, ash trees displayed high rates of sickness and death throughout metropolitan Detroit in southeastern Michigan. However, observers from government and academia attributed the mortality to other causes, including a native borer and a disease known as “ash yellows.” A former forest health official with the Michigan Department of Natural Resources told us that the department did not focus its attention on monitoring the health of trees in developed

areas within the state, such as suburban Detroit where the ash borer first appeared, but instead focused on state-owned forestland. The Michigan Department of Agriculture official leading the state's management program told us that agricultural inspectors did not identify the pest, in part, because they inspected trees in the fall after the ash borers had stopped flying and they did not see the inconspicuous exit holes that ash borers had made in the trees. It was not until June 2002 that state and university officials actually discovered that a nonnative insect was the cause of the tree mortality, and they sent a sample of the insect to an expert in Slovakia for positive identification. By then, however, the ash borer had already infested thousands of square miles. Following the new identification in Michigan, Canadian officials confirmed in August 2002 that the ash borer was also in Windsor, Ontario.

- *P. ramorum*: Nearly 6 years elapsed between the first signs of tree mortality and the discovery of *P. ramorum* as the cause, in part because it initially affected trees that are not an economically valued resource. Scientists have not determined *P. ramorum*'s source and do not know with precision when it arrived in central California. However, symptoms of declining health in tanoak trees were reported as early as 1994. Tanoak is one of the main tree species that make up the understory of coastal redwood forests, and its acorns support abundant wildlife. However, tanoaks are not true oaks, and forestry officials generally consider them to be a weed species with little economical value. In 1997, when coast live oaks, an abundant and valuable landscape tree, began to show similar symptoms, local officials and the public called for a concerted effort to identify the cause. The Forest Service and the University of California provided the first funds for research in 1999. Initially, researchers believed that the symptoms pointed to other known possible causes, including insects or a condition known as standard oak decline. These possibilities needed to be ruled out before progress in addressing the disease could be made. Three forest pathologists now working on *P. ramorum* told us the lack of laboratories and forest pathologists at any level of government or in California's universities at the time contributed to the slow progress in ruling out these other potential causes and identifying the pathogen. Another delay came from resistance within the scientific community to accept the pathogen as a member of the genus *Phytophthora*, which typically affect a plant's roots and do not normally cause the symptoms that *P. ramorum* does. University researchers definitively identified

*P. ramorum* as the causal agent in June 2000, but by then the pathogen had infested a widespread area.

Although several years elapsed before government agencies identified these three pests, a recent case involving the citrus longhorned beetle in Washington State illustrates the value of early detection and rapid response. Following is a brief description of that situation.

**Figure 11: Citrus Longhorned Beetle (*Anoplophora chinensis*)**

Source: USDA Forest Service, www.forestryimages.org.

**Early Detection and Rapid Response Contributed to the Likely Eradication of the Citrus Longhorned Beetle**

The value of early detection and rapid response is clearly demonstrated in the case of the citrus longhorned beetle (*Anoplophora chinensis*). In this instance, infested bonsai trees were inadvertently allowed into the country and shipped to a nursery. However, ongoing surveys appear to indicate that quick detection and response prevented the outbreak of a new invasive pest. This event also indicates the significant level of effort necessary to eradicate even a relatively small infestation.

In August 2001, the owner of a nursery in Tukwila, Washington, found a citrus longhorned beetle in an imported maple bonsai tree being held at the nursery as part of routine 2-year plant disease quarantine. The beetle is native to parts of Asia and is not known to occur in the United States. It is related to the Asian longhorned beetle and is known to be a major pest of alder, maple, oak, poplar, and willow trees. It is also a pest of fruit trees, including apple and citrus.

Washington State Department of Agriculture employees inspected the nursery and suspected that as many as five beetles, possibly including pregnant females, had flown from the quarantined trees to trees surrounding the nursery. USDA and the state formed a science advisory panel to address the issue of the beetle. The panel included personnel from USDA's Forest Service, Agricultural Research Service, and APHIS; Oregon's Department of Agriculture; and the University of Washington. The panel made recommendations to APHIS and Washington State in October 2001. Citing the small area in which the beetle might be, the panel

(continued on the next page)

**Early Detection and Rapid Response Contributed to the Likely Eradication of the Citrus Longhorned Beetle** (con't)

recommended control actions that it said might be considered unacceptably harsh if implemented at a larger scale, including removing known and potential host trees and treating remaining trees with insecticides.

In November 2001, the Washington State Department of Agriculture quarantined all properties within a one-half mile radius of the nursery. On June 25, 2002, the Governor of Washington declared a state of emergency and authorized the state Department of Agriculture to use emergency measures to prevent or abate the infestation. In the summer of 2002, the state, in cooperation with APHIS, cut down and destroyed approximately 1,000 possible host trees within about one-eighth mile of the nursery. It also injected insecticide into about 1,500 potential host trees within one-quarter mile of the nursery. The state also implemented a revegetation program where the trees had been removed, which included giving vouchers to property owners. The state has done extensive surveying of the quarantined area in 2003, 2004, and 2005. For example, in 2005, state personnel surveyed more than 32,000 trees in and around the quarantined area and found no evidence of beetle activity. The state will continue to survey through 2006 and will end the program if it finds no evidence of the beetle. According to APHIS officials, the agency allocated about $2.2 million to Washington under a cooperative agreement in fiscal years 2002 through 2005, to carry out surveying, quarantine enforcement, and the eradication program.

## Stakeholders Believed That Quarantines Have Helped Slow the Spread of These Pests, but Implementation Is Difficult

Government quarantines have helped to slow the artificial spread of all three forest pests we reviewed by regulating activities that are possible conduits for transporting the pests. However, difficulties in quarantine implementation have minimized their effectiveness, particularly for the emerald ash borer and *P. ramorum*. Specific problems in implementation include a failure to quarantine the correct geographic area or all potentially infested materials in a timely fashion because of a lack of information about the pests or the extent of the infestations. In addition, because of the vast number of potential conduits for transporting the pests to new locations—namely, various seemingly benign actions of individuals—ensuring full compliance with quarantines is nearly impossible. Because of the nature of invasive species, even one quarantine violation may lead to a new infestation. As a result, enforcement efforts largely focus on public education and outreach as well as inspections.

### Quarantines Have Helped Limit the Artificial Spread of Pests

Officials involved with all three pests believed that quarantines have helped to reduce the spread of the pests. Quarantines help limit the spread of an invasive species by eliminating movement of potentially infested materials. However, few stakeholders involved with the emerald ash borer and *P. ramorum* programs (1 of the 11 and 2 of the 16 asked, respectively) believed that the quarantines had stopped all artificial movement of the pests. Stakeholders involved with the Asian longhorned beetle program were somewhat more optimistic about the effectiveness of the quarantines, with 4 of 9 stating that they have stopped the artificial spread, 2 saying that they have not, and 3 saying that they were uncertain.

Under the Plant Protection Act, if APHIS considers it necessary to prevent the dissemination of a plant pest that is new to the United States or not known to be widely prevalent or distributed within and throughout the United States, the Secretary of Agriculture may take certain remedial measures, including quarantine of the plant pest, plant product, article, or means of conveyance that

"(1) is moving into or through the United States or interstate, or has moved into or through the United States or interstate, and the Secretary has reason to believe is a plant pest or is infested with a plant pest at the time of the movement or is in violation or has violated the Plant Protection Act;

"(2) has not been maintained in compliance with a post-entry quarantine requirement; or

"(3) is the progeny of any plant, biological control organism, plant product, plant pest, or noxious weed that is moving into or through the United States or interstate, or has moved into the United States or interstate, in violation of the Plant Protection Act."

In addition, APHIS may issue quarantines if it determines (1) that an extraordinary emergency exists because of the presence of a plant pest that is new to the United States or not known to be widely prevalent in or distributed within and throughout the United States and (2) that the presence of the pest or weed threatens U.S. plants or plant products. However, APHIS is only authorized to issue a quarantine under its extraordinary emergency authority upon finding, after review and consultation with the Governor or other appropriate official of the affected state, that measures being taken by the state are inadequate to eradicate the plant pest. Under state law, states might limit the movement of products within the state and, under certain circumstances, might regulate the importation of products from other states.[17]

[17]The Plant Protection Act generally prohibits states from regulating the interstate movement of any article, means of conveyance, plant, biological control organism, plant pest, noxious weed, or plant product in order to control a plant pest or noxious weed, eradicate a plant pest or noxious weed, or prevent the introduction or dissemination of a biological control organism, plant pest, or noxious weed, if the Secretary has issued a regulation or order to prevent the dissemination of the biological control organism, plant pest, or noxious weed within the United States. However, a state may impose prohibitions or restrictions if (1) they are consistent with and do not exceed APHIS regulations or orders or (2) the state (or political subdivision of a state) demonstrates to APHIS that there is a special need for additional prohibitions or restrictions based on sound scientific data or a thorough risk assessment.

Quarantines have been used in each of the three forest pest infestations we reviewed. In each case, the quarantines identify specific geographic areas and plant materials to be regulated. For example, for the Asian longhorned beetle and the emerald ash borer, state and federal quarantines regulate or restrict the movement of regulated articles, such as firewood and wood debris, out of the quarantined areas. The areas include locations where the infestations have been found and a buffer area to account for potentially undetected spread of the pest. A key part of the federal and state quarantines for these pests has been education and outreach to the public and businesses that may unwittingly transport the pests. For example, firewood dealers, tree maintenance companies, and garden centers have been sent educational materials identifying particular pests and explaining the regulations and compliance issues. Much effort has also been put into educating the general public through displays at community fairs, homeowner association meetings, newspaper articles, and public service announcements. Program officials with whom we spoke believed that public education has helped to slow the spread of the pests and emphasized that it is critical to the success of the quarantines.

Quarantines have played a vital role in containing the spread of *P. ramorum* through the movement and sale of nursery plants. The state and federal quarantines in California restrict the movement of regulated articles, such as certain plants, woody material, and logs, from a 14-county area that is known to have natural areas infested with the pathogen. The state and federal quarantines in Oregon are similar to the California quarantines, but they cover a much smaller area—22-square miles as of March 2006. In addition, under a USDA emergency order, APHIS now regulates all California, Oregon, and Washington businesses that want to ship plants susceptible to *P. ramorum* interstate; those businesses—regardless of whether they are in a quarantined area—must demonstrate that their products are free of the pathogen before being allowed to ship them.

## Quarantine Boundaries May Not Have Been as Inclusive as Needed Due to Limited Information

While officials believed that quarantines have helped to reduce the spread of the three forest pests, quarantine effectiveness is limited by the prevailing knowledge about a pest and the extent of the infestation. Quarantines must be based on sound scientific information because, as regulatory tools, they can have significant impacts on businesses, individuals, and the economy. For example, the quarantines on plant material from potential hosts to *P. ramorum* have resulted in the destruction of over $4 million worth of products in from one nursery in California. However, as we have previously discussed, much was unknown

about the three pests when they were first discovered. As a result, quarantines were, in hindsight, conservative in their inclusion of areas to be regulated and, in the case of *P. ramorum*, in the plant material that was initially regulated.

Regarding the Asian longhorned beetle, as surveys found new infested trees, the management team of federal, state, and local officials discussed and agreed upon new quarantine boundaries using protocols that accounted for known biological characteristics of the beetle and data on its dispersal patterns. Fortunately, the Asian longhorned beetle does not move quickly; therefore, infestations did not grow very rapidly during the time it took to definitively identify the extent of the infestations. This was not the case, however, with the emerald ash borer. Michigan imposed its initial quarantine for five counties in July 2002, not realizing that the infested area was already much larger than that. Similarly, USDA did not quarantine the interstate movement of ash material until October 2003, even though Ohio had discovered the beetle in February 2003, and it was likely to have been in Ohio for several years. Not having the infested area fully quarantined increases the chances that infested material will be moved to uninfested areas, either within the state or to new states.

Although *P. ramorum* was detected from "bleeding" oaks and tanoaks in June 2000, Oregon issued an emergency quarantine for California in January 2001. California and APHIS imposed their first quarantines in May 2001 and February 2002, respectively.[18] Program officials attributed at least part of the time lag in establishing the quarantines to the lack of knowledge about the pathogen—specifically, knowledge on how the pathogen was spread. State and federal governments must continue to adjust their quarantine regulations as scientists identify additional host and associated host plants in the natural environment. Initially, *P. ramorum* infestations were seen primarily in the natural environment, and stakeholders believed that if nurseries were infected it was because of exposure to infested natural areas. As a result, the original state and federal quarantines placed regulations on nurseries only within the quarantined area. These regulations required nurseries to enter into compliance agreements whereby they would certify that host and associated host plants were free of *P. ramorum* before shipping them outside of the quarantined area. At

[18]The California State Board of Forestry declared known areas of infestation to be "zones of infestation" in April 2001, thereby effectively regulating all timber harvesting plans in those zones.

that time, nurseries outside of the quarantined area were not regulated and could freely ship host plants, because officials did not believe that they posed a high risk of artificially spreading *P. ramorum*. However, in May 2003, an investigation of infested camellias found within the quarantined area determined that the infected plants had come from a nursery outside of the quarantined area. The origin of the infestation in that nursery was unknown, and no *P. ramorum* was detected in the surrounding natural environment. Subsequent *P. ramorum* detections were made in nurseries outside of the quarantined areas in California and Oregon as well as the first case of *P. ramorum* in Washington (and British Columbia). Because surveys did not find the pathogen outside of these nurseries, the state and federal agencies did not establish quarantines in these areas. However, the finds did start a process that has led to restrictions on the interstate movement of nursery stock from nurseries outside of the quarantined areas.

## Enforcing Compliance with Quarantines Is Difficult

In each of the three forest pest species we reviewed, actions of individuals—such as moving firewood or even hiking—can result in transporting the pests to new locations. As a result, educating the public about activities that could spread the pests and then enforcing compliance with the quarantine are daunting tasks. For example, millions of ash trees in Michigan have died, creating a supply of firewood in a state where firewood is a large commodity. According to stakeholders with whom we spoke, the greatest risk of artificial movement of the emerald ash borer comes from the movement of firewood. The people likely to move firewood, including residents traveling to campgrounds or vacation homes and small firewood dealers, comprise a large and diverse population that is hard to define and reach with quarantine enforcement efforts. A similar situation exists in New Jersey and New York where movement of firewood or wood debris could easily spread the Asian longhorned beetle to new locations.

Quarantines for *P. ramorum* are even more difficult to enforce because the pathogen can be spread in several ways. *P. ramorum's* natural infestation is in an area known as the wildland-urban interface, which is an area where houses meet or intermingle with undeveloped wildland, including several state and national parks, and that is estimated to have over 7 million residents. In addition to transporting infested firewood or debris, *P. ramorum* can also be spread in soil that is inadvertently moved on shoes, bike or car tires, or other equipment. Although state and federal agencies and nongovernmental organizations have produced several pamphlets to teach the homeowner, arborist, fire fighter, recreational land

user, forest product gatherers, and others about how to decrease the risk of spreading the pathogen outside of the infested area, it is impossible to reach each individual who might come in contact with it.

While stakeholders believed that outreach efforts have helped educate the public about the dangers of individual actions, such as moving firewood, it is not possible to stop all illegal or uninformed behavior. Potentially, all it takes is one piece of infested firewood or contaminated soil to start a new infestation.

## Agencies Lack Effective Technologies for Detecting and Eradicating These Forest Pests

Government agencies lack effective technologies to address the three forest pests we reviewed. Over three-fourths (29 of 37) of the pest managers we interviewed said that government agencies do not have the technological tools—such as detection, eradication, or prevention methods—to effectively manage these forest pests.[19] Detection methods for these pests consist largely of visual observations and, in the case of *P. ramorum*, costly laboratory diagnostics. Such methods are not always effective, are time-consuming, and may have resulted in slower than desired management responses because of the time it takes to delineate infested areas. Current eradication methods for these three pests are limited to destroying infested trees and plant material—a resource-intensive action that is not practical on large infestations, such as the emerald ash borer or *P. ramorum* in California; destruction has been effective with the Asian longhorned beetle because many fewer trees have been infested. Although some preventative chemical treatments have been shown to be effective on the Asian longhorned beetle and emerald ash borer, these treatments are only used on the beetle because they are cost prohibitive when used on a larger scale. Research is under way to address these gaps.

### Delineating Infested Areas Is Resource Intensive and Not Always Reliable

Relying on visual detection has hampered thorough and rapid delineation of the infestations for all three forest pest species. For all three species, visual observations are the first sign of a potential problem. With the Asian longhorned beetle and the emerald ash borer, telltale signs include exit holes on tree trunks and branches. In addition, holes in which female Asian longhorned beetles lay eggs—known as oviposition sites—can also be a

[19]Four of the 9 Asian longhorned beetle stakeholders, all 12 of the emerald ash borer stakeholders, and 13 of the 16 *P. ramorum* stakeholders we interviewed noted the lack of control technologies.

sign of infestation. However, in some cases, these visual signs of infestation may be very high in trees and not visible from the ground or inconspicuous because of their small size. As a result, ground-based surveys can often miss signs of infestations. For example, program officials stated that the effectiveness of visual observations of the Asian longhorned beetle from ground surveys were only about 30 percent accurate. Because of this, managers for the Asian longhorned beetle used bucket trucks and sought assistance from "smoke jumpers," (i.e., forest firefighters accustomed to climbing trees) and commercial tree climbers to improve surveying success. As a result, the effectiveness of visual inspections more than doubled. Surveys for the emerald ash borer also look for symptoms of infested trees, such as thinning crowns and dead branches. However, these symptoms appear gradually and may not provide rapid evidence of an infestation. In general, however, visual observations are still time-consuming and resource-intensive, particularly for widespread infestations, such as the emerald ash borer and *P. ramorum*. For *P. ramorum*, visual observations are just the first step in identifying potential infestations. To confirm the pathogen's presence, plant material must be sent to a laboratory for analysis. This process adds considerably to the time and cost required to make positive infestation determinations. Another option for identifying where pests occur is through the use of chemical lures that would attract beetles, borers, or other target pests if they were nearby. However, neither the beetle nor the borer responds to any known chemical lures. The emerald ash borer program uses what are known as "trap trees" to detect the pest. Trap trees are ash trees that have had a large strip of bark removed from the trunk. The premise is that wounded trees give off chemical signals that might attract the ash borer. The trees are later cut and inspected for ash borer larvae. However, government agencies have not clearly shown that trap trees attract the beetles.

Research into traps, lures, acoustic devices, and remote sensing is ongoing to help with detection of the Asian longhorned beetle. Research is also under way to develop traps for the emerald ash borer that use chemical attractants. In addition, research is under way to develop better methods for detecting *P. ramorum* in the field.

## Methods for Eradicating Pests Are Limited to Destroying Infested Material

For each of the three forest pest species we reviewed, the only effective eradication method is to destroy the infested tree or plant material as well

as nearby trees and plants suspected of being infested.[20] There are no chemical or biological treatments available to effectively kill the pests on a broad scale. In total, hundreds of thousands of trees and over 1 million nursery plants have been destroyed because of the three pests. For the emerald ash borer and the Asian longhorned beetle, infested trees are cut down, chipped to a very small size to kill any insect life stages that may be inside the tree, and then burned. This method is obviously very expensive and only practical on a relatively small scale. Due to the relatively small size of the Asian longhorned beetle infestations, cutting and burning has been used wherever infested trees were found. (Over 8,000 trees have been removed.) Conversely, for the emerald ash borer, managers have used cutting and burning selectively—although still removing hundreds of thousands of trees—by focusing on small, outlying infestations and at the perimeter of infestations in an attempt to contain the pest to specific areas. This approach lost momentum in January 2006, however, when the Indiana Department of Natural Resources announced that it no longer would require or fund the removal of infested trees because it did not believe that removal was working. Similarly, in February 2006, the Governor of Ohio announced that the state would be able to focus its eradication efforts only on extreme outlier infestations because of a lack of federal funding.

In Oregon, trees infested with *P. ramorum* were first detected in 2001 in a relatively small forest setting. According to the Oregon Department of Forestry, the infested acreage was initially determined to be 40 acres but has grown to 88 acres. This area was clearcut, and host plants were burned to destroy the pathogen. However, cutting and burning is not practical in California because the infested areas are so large and are intermixed with residential areas and old-growth redwood forests. In California, most tree removal is performed to remove dead and dying trees that pose safety hazards. One exception to this occurred in Humboldt County, California, in 2004 when a suppression project removed infected California bay laurel trees in an effort to limit the pathogen's spread.

Destroying infested plants is routinely used to control *P. ramorum* in the nursery or "artificial" environment. There are more than 55 plant genera, many of which are sold to contractors and the public, which may transport

[20]By "eradication," we mean the actual killing of pests that are infesting trees and plants. We recognize that there are other important components of a management program, including surveys, quarantines, preventive treatments, and public outreach, that may help reduce their spread.

the pathogen. If an infestation is found at a nursery or garden center, federal and state regulators inspect the facility to determine how much plant material needs to be destroyed to avoid spreading the pathogen to other locations. Such widespread destruction represents a huge loss to the nursery producer, particularly smaller operators.

Research is ongoing in the area of chemical treatments to identify methods to kill these pests without requiring the removal and destruction of infested trees and plants. However, chemical treatments are problematic when used as a curative treatment for nursery plants against *P. ramorum*. For example, while fungicides are often used in nurseries to guard against pathogens and diseases, such treatments can retard the development of symptoms in already infected plants, thus effectively masking symptoms until such time that the effects of the treatments wear off. Consequently, such fungicides are not allowed on *P. ramorum* host plants that a nursery is holding to be destroyed because it may undermine detection of the pathogen.

Research is under way to identify possible biological controls for the emerald ash borer, the Asian longhorned beetle, and *P. ramorum*.[21] Some biological agents for the three pests show promise, but more research is needed. Biological controls have been a relatively effective treatment alternative to combat other invasive species, such as gypsy moth, on a large scale. However, it takes many years of testing before USDA will approve the use of biological controls with confidence that they will not prey on native species or create other problems. Research also is under way on all three species to better understand their biology and how they spread so that more effective management tools can be developed.

## Preventative Treatments Are Only Practical in Limited Applications

Chemical treatments are available that can be used on uninfested host trees surrounding an area that has been infested with any of the three forest pests we reviewed, in order to prevent or reduce subsequent infestation. These treatments have been used extensively by the Asian longhorned beetle program. To help ward off beetle infestation, a pesticide is injected into the ground or trunk of a tree near infested areas in the spring or fall; the process must be done on an annual basis for a minimum of 3 years to be effective. According to the national Asian longhorned beetle program

[21]"Biological control" is the use of an animal, insect, or disease to reduce the population of an invasive species. Ideally, the controlling animal, insect, or disease affects only the targeted species.

manager, preventative chemical treatments provide effective control for the beetle when used as part of an integrated pest management approach. In contrast, preventative treatments have been used to just a limited extent on *P. ramorum* and the emerald ash borer, primarily by homeowners to protect valuable landscape trees, because the treatments are not practical or cost-effective on a larger scale.

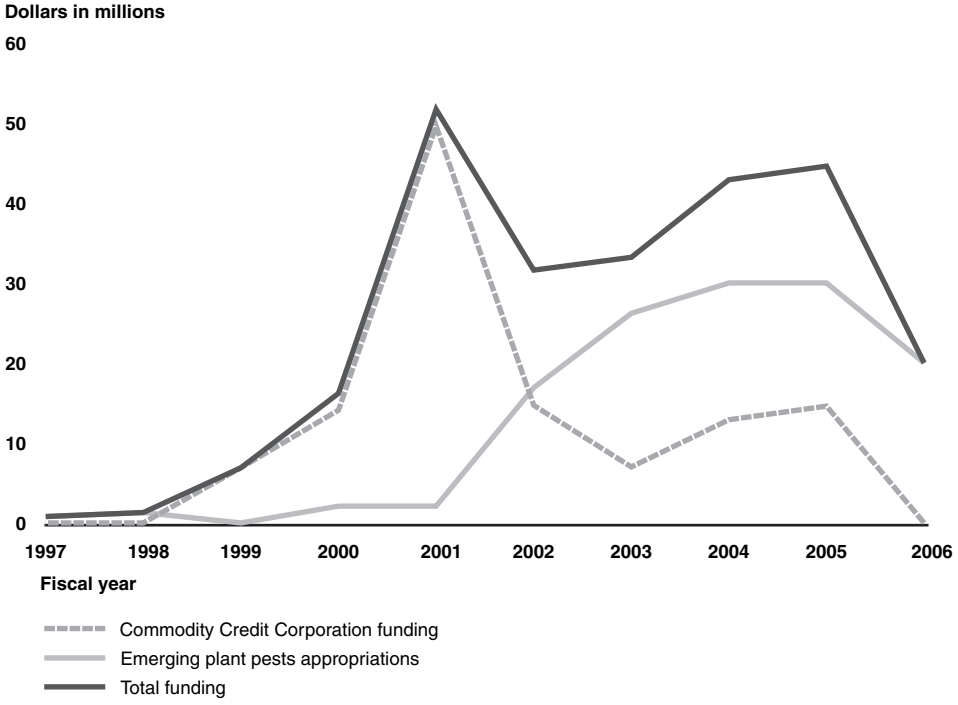
## Insufficient Funding Has Delayed Eradication of the Asian Longhorned Beetle and Threatens Containment of the Emerald Ash Borer and *P. ramorum*

The federal government has provided the vast majority of the funds for controlling the three forest pests we reviewed, although funding limitations threaten the success of these programs. A large percentage of the federal funding for the pests has come from the Commodity Credit Corporation (CCC) to supplement congressional appropriations to APHIS's emerging plant pest program. However, program managers have noted that reductions in funding levels in both of these funding sources have pushed the expected eradication date for the Asian longhorned beetle out 5 years and have raised concerns about their ability to contain the emerald ash borer and *P. ramorum*. Reducing investments in control and eradication activities means that these pests will persist in the environment and may potentially spread to new locations, perhaps resulting in larger expenditures in the long run than if these infestations had been addressed more aggressively in the short term.

### Federal Funding for These Three Pest Programs

For the three pests we reviewed, the federal government has provided the majority of funding for programs to address the infestations, primarily through the CCC and appropriations to APHIS's emerging plant pest program. The Secretary of Agriculture, in connection with an emergency in which a plant pest threatens any segment of U.S. agricultural production, may transfer funds from CCC or other available USDA appropriations for the arrest, control, eradication, and prevention of the spread of the plant pest and related expenses. Use of CCC funds for pest management is significant. The Congressional Research Service reported that from 1998 through June 30, 2004, CCC transfers for all pest and disease management were more than the amounts appropriated for those activities ($1.52 billion versus $1.32 billion). Over $420 million of federal funds have been budgeted for the three forest pests we reviewed (see figs. 12, 13, and 14).

**Figure 12: APHIS Funding for the Asian Longhorned Beetle Program, by Source, for Fiscal Years 1997-2006**



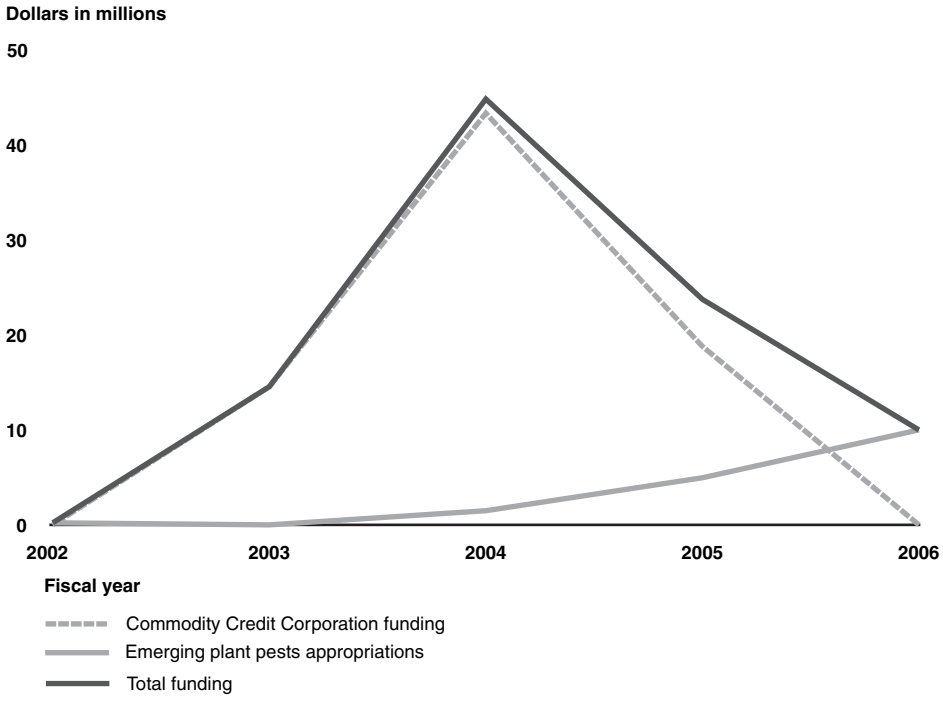

Source: APHIS.

Notes:

For fiscal years 1997 and 1998, funding came from APHIS's contingency fund.

The appropriation in fiscal year 2001 was from APHIS's Miscellaneous Pest line item.

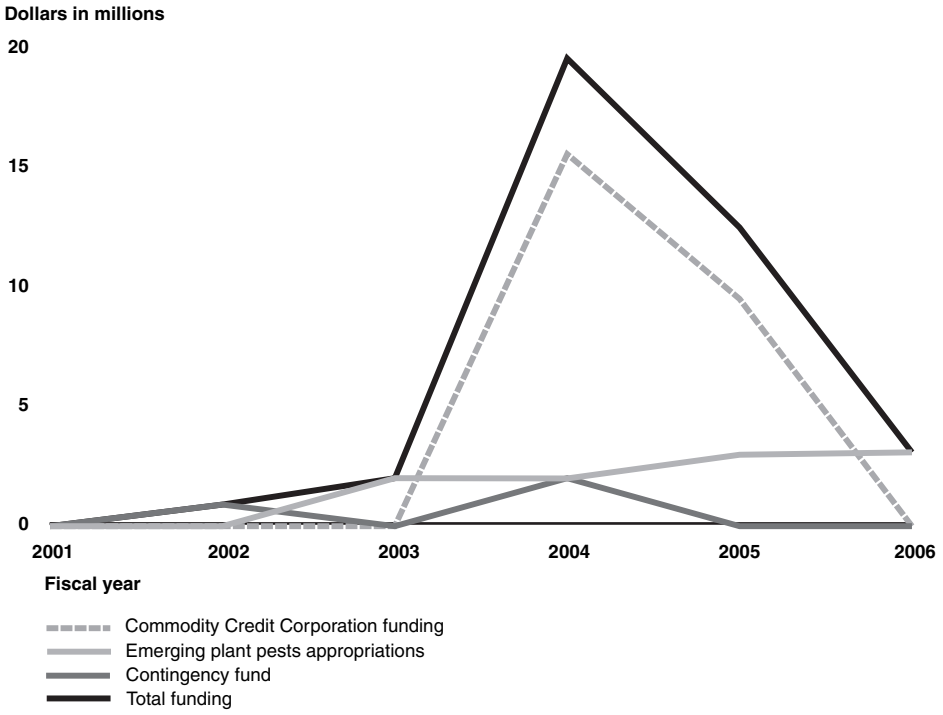
**Figure 13: APHIS Funding for the Emerald Ash Borer Program, by Source, for Fiscal Years 2002-2006**




Source: APHIS.

Note: The Forest Service has also provided funding for emerald ash borer program activities, including tree planting, research, and projects intended to help businesses obtain economic value from ash trees before they become infested. From fiscal years 2002 through 2005, the Forest Service's State and Private Forestry Program and Research and Development Program allocated approximately $15.5 million for these activities. In fiscal year 2006, the Forest Service has about $3.1 million in budget authority for these programs.

**Figure 14: APHIS Funding for the *P. ramorum* Program, by Source, for Fiscal Years 2001-2006**




Source: APHIS.

Notes:

Congress appropriates funds to an APHIS contingency fund that the APHIS administrator has discretion to use for emerging problems.

The Forest Service has provided funding for *P. ramorum* activities since fiscal year 2000. The focus at that time was on research to determine the causal agent of *P. ramorum*. From fiscal years 2000 through 2005, the Forest Service's State and Private Forestry Program and Research and Development Program have provided over $17 million for program activities, including research, risk analyses, and national monitoring and surveying efforts, and eradication efforts in Oregon. The Forest Service also has provided funding for the California Oak Mortality Task Force, a coalition of public and private stakeholders that provides public outreach and education efforts. For fiscal year 2006, the Forest Service has budgeted $2.7 million for continued *P. ramorum* program activities. In addition, other USDA agencies, such as the Agricultural Research Service and the Cooperative State Research, Education, and Extension Service, have provided over $3.5 million since fiscal year 2002 for research and public education and outreach efforts for the program.

States also provide funding for forest pest management actions, although it is generally much smaller than the federal investment. For the emerald ash borer, Indiana, Michigan, and Ohio have provided matching funds totaling about 2 percent of the funds that APHIS has provided from 2003 through 2005. For the Asian longhorned beetle, New York, New Jersey, and Illinois have contributed matching funds totaling about 17 percent of the funds that

APHIS has provided from 1997 through 2006. The *P. ramorum* program has obtained the largest nonfederal contribution as a percentage, with California contributing matching funds totaling about 34 percent of the funds that APHIS provided from 2002 through 2006.

All but 4 of the 37 stakeholders we interviewed believed that it is appropriate that the federal government bear the primary financial responsibility for dealing with these pests. A common comment from stakeholders was that APHIS is the nation's first line of defense in preventing invasive pests from entering the country, and if a pest should enter the country and become established, states should not be expected to bear the primary burden of addressing the consequences. However, stakeholders also believed that the states should bear part of the financial responsibility. Most did not have specific suggestions for what they believed would be an appropriate split between federal and state funding, although those that did have an opinion said that the state share should be anywhere from 0 to 50 percent. Others said that cost share arrangements should be based on the circumstances of a particular pest. In July 2003, APHIS published a proposed rule that would have established criteria for determining the federal share of the financial responsibility relative to states and other cooperators in a plant pest or animal disease emergency. However, the agency did not finalize the rule in accordance with a prohibition on the use of appropriated funds to finalize the proposed rule.[22]

## Federal Funding Constraints Raise Concerns about Achieving Program Goals

Program officials involved with management of the three pests told us that either funding has not been what is needed or that they are concerned about the prospects for maintaining adequate programs because of funding constraints. Without sustained funding, containing the spread of the emerald ash borer and *P. ramorum* will be difficult, and eradicating the Asian longhorned beetle will take longer. In addition, the longer these pests are allowed to persist in the environment, the greater the risk that they may spread to new locations and the more expensive management programs could become.

The Asian longhorned beetle program illustrates the consequences of inadequate and inconsistent funding on the time frames for and total cost of eradication. Specifically, in fiscal year 2002, program funding was cut by about $20 million and remained at close to that level in fiscal year 2003 (as

[22]See Consolidated Appropriations Act, 2004, Pub. L. No. 108-199, §761 (2004). This prohibition has also been included in subsequent appropriations legislation.

shown in fig. 12). This caused program officials to terminate tree climbing and bucket surveys in New York, severely reduce chemical treatments of trees in New York from a planned 143,000 trees to 17,570 actually treated (an 88 percent reduction), eliminate funding for restoration activities in Illinois and New York, and drastically reduce funds for research in fiscal year 2003. Program officials told us that this resulted in their target date for eradication being pushed out from 2009 to 2014. However, this assumes that they will receive about $48 million per year for each of these years. While funding was restored to nearly that level in fiscal year 2005, the fiscal year 2006 appropriation is just under $20 million. Program managers told us that in addition to the risk of additional spread of the beetle during a longer eradication program, they have estimated significant cost savings if the beetle is eradicated sooner. They said that, compared with a $30 million funding level, sustaining funding at the $48 million per year level would (1) allow eradication by 2014 instead of 2020 and (2) save APHIS over $63 million; New York City about $36 million; and the state of New York about $12 million in avoided future costs, such as the disposal of wood debris from infested trees and the enforcement of quarantine restrictions.

It appears that a similar situation is occurring with the emerald ash borer. Stakeholders we interviewed raised concerns that funding for the emerald ash borer program is not adequate to achieve the goal of limiting the infestation to Michigan. In fiscal year 2005, the program received just over one-half of what was estimated to be needed, and the outlook for fiscal year 2006 looks similar; Congress appropriated $10 million to APHIS for the program, but it is unknown whether the Secretary of Agriculture will also transfer CCC funds. The $10 million appropriation is about one-third the amount that the program had estimated it would need. The APHIS national program manager for the emerald ash borer told us that funding shortfalls such as this limit tree cutting in infested sites, which would likely contribute to the artificial and natural spread of the pest. Program officials from Michigan and Ohio confirmed that their states will not be able to remove trees in key infested areas unless funding is increased.

Nearly all stakeholders we interviewed also raised concerns that funding for the *P. ramorum* program has not been adequate to achieve the goal of limiting the infestation in either the natural or nursery environments. Funding for this program has varied significantly over the past several years in response to the resources needed to conduct intensive nursery surveys. For example, funding increased dramatically in fiscal year 2004 in response to the discovery that California nurseries had shipped infected plants to other states. Part of the reason for subsequent funding declines

could be because fewer infested nursery shipments had been detected. The overall funding available from APHIS for fiscal year 2006 has dropped to about $3.1 million, and no CCC funding has yet been made available. This is the lowest level of funding since the nationwide shipment of infested plant materials in 2004. However, program managers have not developed an estimate for funding needed to battle the pathogen. Therefore, it is unclear what impact this funding reduction will have on the program.

In addition to the level of funding, some officials with whom we spoke—who were primarily involved with the emerald ash borer program—discussed problems with the timeliness of when they actually received the funds. CCC funds can be transferred any time during the year, but program officials told us that they frequently received them after the optimal season to carry out certain preventive and control actions, such as tree removal or chemical treatments. For example, the national program manager for the emerald ash borer commented that if funding does not reach the program within the first few months of the fiscal year, it makes it very difficult to plan activities, contract for these activities, and hire and train personnel not knowing if the program will have sufficient funding received in a timely fashion. Another complaint about funding was the impact of the inconsistent amounts the programs receive from year to year. This reduces the ability of the managers to plan in advance for announcing contracts and securing labor.

Finally, the extensive use of CCC funds for ongoing pest management programs has been debated within the federal government. In particular, the Office of Management and Budget (OMB) has expressed concerns with congressional appropriations committees for their not fully funding pest eradication programs, thereby necessitating the transfer of CCC funds.[23] OMB has called the use of CCC funds for anything but unforeseen emergencies, and especially for ongoing eradication programs beyond the 1st or 2nd year, "backdoor financing" that avoids the discipline of the budget process. In contrast, congressional appropriations committees have consistently reiterated that the Secretary should use the authority to transfer CCC funds for animal and plant health emergencies. One reason cited by Congress for continued use of the CCC fund is that the money is available for use until expended—so-called "no-year money"—whereas appropriated funds must be obligated within the fiscal year for which they are appropriated. This makes use of CCC funds more flexible in responding

[23]OMB Statement of Administrative Policy on S. 1427 (Nov. 5, 2003).

to the often dynamic situations in dealing with invasive species.[24] Notably, as of February 2006, USDA had not announced any plans to transfer CCC funds to any of the three pest programs we reviewed for fiscal year 2006.

## Forest Health Monitoring Does Not Adequately Address Urban Forests

USDA conducts a number of monitoring programs that are intended to identify forest health issues, including the presence of invasive species. However, because these programs do not adequately address urban forests, they did not detect the three forest pests we reviewed or other pests. Monitoring in urban areas is important because they are common destination points for internationally traded cargo that is a frequent pathway for pests. Delays in detection and identification allowed the three forest pests we reviewed to become established and spread before control efforts could begin.

### USDA Forest Health Monitoring Programs Cover a Variety of Geographic Areas and Forest Conditions

USDA has monitored the health of the nation's public and private forests for decades. Some programs are focused on broad issues, such as tree species composition and general health conditions, while other programs are focused on identifying specific problems. Key monitoring programs are described below:

- *Forest Health Monitoring Program*: The Forest Service's Forest Health Monitoring Program is designed to determine the status, changes, and trends in indicators of forest condition on an annual basis; it has been conducted since 1990. The program uses data from ground plots and surveys, aerial surveys, and other resources to analyze forest health. In cooperation with state foresters, the agency conducts aerial surveys of more than 700 million acres per year to map tree mortality and defoliation. These surveys provide vital information for use in identifying, evaluating, and responding to the causes of forest health problems. According to the Forest Service, since 2001 the program has expanded its efforts in developing and implementing monitoring systems for undersampled populations (such as urban and riparian forests) and risk-based detection surveys for invasive forest pests such as *P. ramorum*.

[24]For more on the issue of CCC funding, see Congressional Research Service, *Funding Plant and Animal Health Emergencies*: *Transfers from the Commodity Credit Corporation* (July 30, 2004).

- *Forest Inventory and Analysis Program*: The Forest Service's Forest Inventory and Analysis Program—begun in 1930—now conducts a census of conditions on nearly all public and private forest lands in the United States. The program reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates; and in forest land ownership. Similar to the Forest Health Monitoring Program, the Forest Inventory and Analysis Program is implemented in cooperation with state agencies and private landowners. Traditionally, the Forest Inventory and Analysis Program was intended to provide information relevant to the forest products industry. In 1999, the Forest Service merged the plot components of these two programs into a comprehensive monitoring framework that addresses a broad suite of forest health indicators.

- *Nonnative Bark Beetle Survey*: In 2001, the Forest Service began a pilot of the Nonnative Bark Beetle Survey.[25] The program targets 10 nonnative bark beetle species, although all bark beetles captured are identified. The former national coordinator for the program told us that the agency chose to focus on bark beetles for several reasons, including the fact that they are often intercepted at ports of entry. Risk assessments have shown that bark beetles cause problems in both their native range and in new locations, and that, in general, there are effective lures and traps for them. According to the Forest Service, funding for the program has increased from a starting point of $60,000 in fiscal year 2001 to $350,000 in each of fiscal years 2005 and 2006.

  Working with APHIS and state cooperators, the Forest Service has placed traps at more than 300 sites over the course of the program. Traps are typically kept at each site for 1 year. The sites have been in urban forests and forests around ports and wood-handling facilities and were chosen because of their relatively high risk for receiving insects from overseas. According to the Forest Service official who served as the national program coordinator from 2003 through 2005, the agency has shifted the placement of traps away from ports because it realized that cargo containers arriving from overseas are often shipped unopened further inland. Now, the program concentrates its traps near warehouses, landfills or recycling yards (where wooden pallets are handled), nurseries, and urban forests where pests that might be hidden

[25]The Nonnative Bark Beetle Survey also addresses nun moths.

in solid wood packing material are more likely to be released. He also said that APHIS is surveying near ports, so there was no need to duplicate its efforts.

Since 2001, the project has detected six nonnative forest insects for the first time in the United States. According to the former national program coordinator, USDA has not taken management steps for the new finds, with the exception of additional surveying to define the extent of their infestations. He said that while the program has shown that new species can be detected using this method, it has not led directly to any successful management actions. On the contrary, the following two examples drawn from the six new species discoveries provide further evidence of the need for earlier detection and more rapid response.

- In 2002, the bark beetle survey found a new wood-boring species in Georgia, known as *Xyleborus glabratus*. More traps were set out to delimit the extent of the infestation, but few of these beetles were found. According to the former national program coordinator, this species appears to be different from other bark beetles in that it does not respond well to known lures. That fact was not known at the time, however, and, according to the former coordinator, the beetle became a low priority for the Forest Service. However, in 2003, observers noted high mortality in Georgia and South Carolina for a common understory shrub known as red bay (*Persea borbonia*). This mortality was later attributed to a fungus associated with the beetle. Red bay is related to avocado, leading to concern that the beetle and fungus could affect that crop. According to the former coordinator, it is not possible to say whether the beetle could have been eradicated if a rapid response had been implemented after its discovery in 2002. He believed the beetle may have been in the country since the 1990s and was already widespread by the time it was detected. At any rate, he believed that it is now too late for eradication.

- In 2003, the survey detected a beetle in Colorado and Utah known as the banded elm bark beetle (*Scolytus schevyrewi*). APHIS convened a New Pest Advisory Group in July 2003, which recommended conducting additional surveys for the beetle. By the fall of 2003, surveys had found the beetle in 13 states, and an examination of the state insect collection in New Mexico indicated that the pest had been in that state since at least 1998. This pest is known to infest many tree species in Asia, although it has been found only on elm in the United States. Significantly, the beetle could be a carrier of the

pathogen that causes Dutch elm disease. APHIS has not implemented a management program for this species because it is so widespread.

According to the Forest Service's director for forest health protection, the agency is considering expanding the Nonnative Bark Beetle Survey program so that one-third of all states would be participating in any given year. The former national coordinator for the program explained that some high-risk states would participate more often than once every 3 years, while low-risk states might participate once every 5 to 10 years. He estimated that a national program covering one-third of the states and averaging about 16 or 17 sites per state, would cost about $850,000 per year. This amount would cover the cost of supplies for traps, the salaries for surveying crews, the taxonomic expertise needed to identify the insects, and data management. He said that, in his opinion, a national program of that size would still be only "a drop in the bucket" compared with the need. Specifically, he said that there are far more high-risk sites that should be surveyed than would be covered by this program. He also noted that this program would survey for only bark beetles, and that additional funds would be needed to expand to include other insect groups.

- *The Cooperative Agricultural Pest Survey's National Exotic Woodborer/Bark Beetle Survey.* APHIS manages a survey program known as the Cooperative Agricultural Pest Survey. The agency cooperates with state departments of agriculture to survey for a specific list of plant pests, including insects, diseases, and weeds. The focus of the survey is on both agricultural and nonagricultural plant pest species. The list of species that APHIS and the states have agreed to survey for include at least 19 woodborers and bark beetles, including the emerald ash borer, the Asian longhorned beetle, and nine of the species targeted by the Forest Service program previously described. APHIS also encourages survey personnel to record and report detections of other forest pests made while conducting the prescribed woodborer and bark beetle survey. APHIS state plant health directors coordinate with state agencies to select high-risk sites to survey. These sites could include facilities that handle solid wood packing material, nurseries and dealers receiving shipments of foreign bonsai or other living woody plants, urban forests, parks, arboretums, and other high-risk locations. APHIS's survey procedures (1) call for routine reporting of survey data to the National Agricultural Pest Information System and (2) lay out specific steps for reporting new detections.

- *P. ramorum National Nursery Survey* and *National P. ramorum Survey of Forest Environments*. In addition to inspections in regulated states, the *P. ramorum* National Nursery Survey and the National *P. ramorum* Survey of Forest Environments have contributed to the increased detection of infested nursery plant shipments. Started as pilot projects in fiscal year 2002, the *P. ramorum* National Nursery Survey and the National *P. ramorum* Survey of Forest Environments inspect high-risk nurseries that received plants from an infested West Coast nursery and forests adjacent to those nurseries as well as forests where host species are present.[26] In fiscal year 2004, the Forest Service funded the forest surveys in 37 states and in 39 states for fiscal year 2005. Funding for the surveys increased dramatically in fiscal year 2004, following the shipment of thousands of infested plants from a nursery in Southern California. APHIS coordinates the *P. ramorum* National Nursery Survey with state agriculture departments, while the Forest Service works primarily with state forestry or natural resource agencies to conduct the National *P. ramorum* Survey of Forest Environments. Positive detections of the pathogen in nurseries trigger what are known as "trace backs" and "trace forwards," where inspectors attempt to locate either the origin of the infested plant or its destination if it was sold to a customer. In fiscal year 2005, the nursery survey identified 26 positive detections in 6 states, while the forest survey found no positive detections.[27] According to the Forest Service director of forest health monitoring, the forest survey will be fully funded in fiscal year 2006. However, according to APHIS officials, the nursery survey may be limited in fiscal year 2006, due to a lack of funding.

In addition to monitoring forest health issues, the Forest Service developed an early warning system in 2004 that can be used to quickly disseminate information in the event of a major forest pest occurrence.[28] This warning system was established pursuant to a requirement in the Healthy Forest Restoration Act of 2003 to provide a comprehensive early warning system for potential catastrophic environmental threats to forests to (1) increase

[26]The focus of the 2002 pilot, the *P. ramorum* National Nursery Survey, was on nurseries that had received known host plant material from Europe, California, or Oregon within the past few years; nurseries located in areas where native vegetation included host plants; and nurseries that carried listed host plant material.

[27]In 2004, the forest survey did find two infected coast live oaks in Golden Gate Park.

[28]U.S. Department of Agriculture, Forest Service, *The Early Warning System for Forest Health Threats in the United States*.

the likelihood that forest managers will be able to isolate and treat the threat before it gets out of control and (2) prevent epidemics that could be environmentally and economically devastating to forests.[29] This system aims to integrate the various resources, programs, and jurisdictions with relevant authorities and expertise, including several agencies within USDA, the Department of Homeland Security, the Department of the Interior, the National Oceanic and Atmospheric Administration, state agencies, arborists, and others. The warning system does not create any new monitoring or management program; rather, it simply coordinates existing efforts. The Forest Service's Forest Health Protection Program runs the early warning system with assistance from a steering committee comprising representatives from key organizations and agencies. One purpose of the steering committee is to identify steps that are needed to improve the early warning system.

The first step of the early warning system is to identify potential threats before they invade new ecosystems. In its early warning system document, the Forest Service noted several ways in which a variety of agencies' programs identify these threats, including maintaining databases on potential pests that have not arrived; conducting risk assessments to evaluate the likelihood that a specific organism may be introduced and become established; studying potential pests in their native environments so that if they do arrive in this country, more is known about how to manage them; and identifying pathways by which invaders may spread, such as solid wood packing material and live plants. The program steering committee concluded that one way to identify potential threats before they invade is to learn more about how potential invasive species will behave or react when they encounter probable host trees in the United States. The steering committee suggested that one method to do this would be to find or even plant trees native to the United States in other countries and then survey them to find any pests that attack them.

The second step of the early warning system is detection of actual threats. We discussed several detection programs in previous text. The program steering committee identified the need to provide managers responsible for responding to pest outbreaks with improved communication regarding potential pest-caused damages found during regular surveys. The steering committee suggested that the early warning network could link surveillance efforts to the risks of introduction and establishment to

[29]Pub. L. No. 108-148, § 601(c)(2003).

address this need. The steering committee also noted that additional taxonomic expertise is needed to ensure that pests are being adequately identified. These observations are directly relevant to situations such as those created by the three pests we reviewed.

## Surveys for Potentially Harmful Forest Pests Do Not Adequately Cover Urban Areas

Many forest pests, including at least two of the three we reviewed, were first introduced in urbanized environments. However, while some of USDA's monitoring programs may cover these areas, they do not provide adequate coverage. Forest experts with whom we spoke said that, historically, urban forests have not been adequately monitored. In addition, in 1997 and 2004, the National Association of State Foresters passed resolutions stating that there is no systematic inventory and assessment of the nation's urban forest resource. In 1997, the association resolved that criteria and standards be established for a nationwide initiative to periodically gather comprehensive information relating to the inventory and assessment of our urban and community forests. In 2005, the association joined with the Forest Service in convening a task force of forestry stakeholders to (1) evaluate current urban forest inventory efforts, (2) investigate a national continuous urban forest inventory and assessment protocol, and (3) propose an implementing strategy. The task force has not yet produced a report or proposed strategy.

Following the 1997 resolution by the state foresters, the Forest Service initiated a pilot project in 1999 in several states designed to improve urban forest health monitoring. The purpose of the project is to acquire information about the urban forest, while at the same time establishing a nationwide system of urban forest pest detection and forest monitoring and assessment. The project has two components. The first component seeks to extend the sampling grid of the Forest Inventory and Analysis, which has traditionally not sufficiently sampled urban forests. The second component seeks to implement a roadside tree assessment using plots established within public rights-of-way in urban areas.[30] To date, the Forest Service has implemented pilot projects for one or more of these stages in Colorado, Indiana, Maryland, Massachusetts, New Jersey, Tennessee, and Wisconsin. According to the Forest Service's national program manager for forest

[30]The project had a third component that sought to combine the protocols and methods of the first two components into a technology transfer effort for the benefit of local communities. According to the national program manager, the Forest Service is no longer funding that component.

health monitoring, the agency budgeted $850,000 from fiscal years 2001 through 2005, and received a one-to-one match from the states for the pilot. The program manager told us the Forest Service projects a $175,000 budget for fiscal year 2006. Funding has come from both the Urban and Community Forestry Program and the Forest Health Monitoring Program.

Since only seven states were covered by this pilot, systematic monitoring in urban areas is still not adequate. The director of the Urban and Community Forestry Program told us that one way to improve urban monitoring would be to survey Forest Inventory and Analysis plots that are in urban areas but that are not now surveyed because the Forest Service classifies them as "nonforest," even though they may have trees. The Forest Service estimates that extending the Forest Inventory and Analysis to urban sites on a rotating basis would cost about $2.5 million per year. The Urban and Community Forestry Program director said that there are no guarantees that new pests would be found by expanding the inventory, but that there is a strong case to be made for doing so because the potential costs of dealing with pests, such as the emerald ash borer, once they are established are staggering. Another, and perhaps a more likely, benefit of expanded urban monitoring is gathering better information on what trees comprise urban forests. Knowing what tree species are where will help prepare risk assessments related to specific pests. For example, knowing the extent of ash trees in urban settings is necessary to be able to calculate the potential for losses caused by the emerald ash borer.

## Coordination Problems Caused Concerns among Stakeholders, and Communication on the Status of Pest Responses Is Not Adequate

For each of the three pests, while a majority of the 37 stakeholders with whom we spoke told us that appropriate coordination mechanisms are now in place, many raised concerns about appropriate affected parties not being involved in or informed about key decisions early in the response effort. A common theme among the comments was that better early coordination would have strengthened the response efforts. New pest response efforts could avoid such concerns if attention is paid to the lessons learned from the three pest management efforts we reviewed. In addition, we note that USDA's management plans for the three pests do not adequately communicate current information to decision makers and the public about how recent developments, including funding reductions and the extent of the infestations, will affect the prospects for success.

## Stakeholders Generally Believed Appropriate Coordinating Mechanisms Exist, but Suggested Improvements That Could Aid Future Management Efforts

While the majority of the stakeholders we interviewed about each of the three pests believed that appropriate coordinating mechanisms were now in place, a majority also believed that improvements could be made to address problems that were encountered during the pest management efforts.[31] (By coordinating mechanisms, we mean such things as interagency and intergovernmental management teams and panels of federal and nonfederal scientists.) Of the 37 stakeholders we interviewed, 30 stated that the federal and state governments had created appropriate coordinating mechanisms to respond to the three pest infestations. Of the 7 who stated that appropriate federal coordinating mechanisms were not in place, 5 were commenting on the *P. ramorum* program and included stakeholders from federal, state, and nursery organizations. While generally satisfied, the majority of stakeholders also believed that improvements could be made to federal coordinating mechanisms (29 of 37) and state coordinating mechanisms (22 of 37) to address concerns that they identified.[32] Implementing actions to address these concerns could benefit the management of future pest response efforts.

The most commonly suggested area for improvement concerned coordination among state agencies. Three of the Asian longhorned beetle stakeholders, 7 of the emerald ash borer stakeholders, and 8 of the *P. ramorum* stakeholders made comments about state agency coordination. While state agriculture agencies typically have primary responsibility at the state level for addressing invasive pest infestations, the management of those infestations may involve other state agencies, including departments of natural resources, forestry, and the environment. Several stakeholders commented on the need for state departments of agriculture and natural resources to work more closely together. For example, one state department of natural resources official commented that his department could not convince the state department of agriculture

[31]We administered a structured interview to 37 stakeholders—9 involved with the Asian longhorned beetle, 12 with the emerald ash borer, and 16 with *P. ramorum*. The government officials included federal, state, and local officials directly engaged in one of the pest management efforts; nongovernmental officials included academic scientists with expertise in one of the pests and representatives from the nursery industry affected by one of the pests and by quarantine regulations.

[32]Stakeholders who believed that improvements could be made included some who did not believe appropriate mechanisms had been created and some who did. All 16 *P. ramorum* stakeholders, 7 of 12 emerald ash borer stakeholders, and 6 of 9 Asian longhorned beetle stakeholders believed improvements could be made to federal coordinating mechanisms.

to survey for infestations in outlying areas. The result was a delay in the discovery of what turned out to be a large number of well-established outlying infestations. An APHIS state program manager commented that the departments of agriculture and natural resources in his state could have worked together better on a program designed to harvest trees for productive purposes before they fell victim to the pest. Doing so could have helped reduce the spread of the pest. One state official commented that he would like to see more work done by state agencies in addition to the department of agriculture, and that it would be helpful to have one person directing the work of all the state agencies. An APHIS official echoed this by observing that it was not clear which state agency has been in charge in dealing with one of the pests. Two state officials, 2 Forest Service officials, and 2 university research scientists suggested that states need to have a systematic response plan in place before an emergency occurs. Some of these officials said that such plans should identify who would be involved, what their roles and responsibilities would be, and how they would be funded. Having such a plan would facilitate a more rapid response to new infestations.

Eleven of the 37 stakeholders commented that coordination among federal agencies—primarily, coordination between APHIS and the Forest Service—could have been improved during the initial phases of the pest responses. Most of these comments—8 of 11—came from *P. ramorum* stakeholders. Across the three pests, stakeholders attributed coordination concerns in part to the differing missions of the two agencies. For example, 1 state official said that, in the case of the Asian longhorned beetle program, the Forest Service "tends to sit back and watch when the agency should be proactive in working with APHIS in addressing invasive pests." Somewhat in contrast, an APHIS official working on the emerald ash borer commented that the management team had not made good use of the possible contributions of the Forest Service regarding a program intended to harvest and use trees before they became infested. This official also said that the management team could have made better use of the USDA's cooperative extension agents to educate the public about the pest and its potential impact.[33] An academic research scientist commented that APHIS did not become involved with *P. ramorum* until the pathogen showed up in nurseries, but then did not seek input from the Forest Service in the regulatory process.

[33]Cooperative extension agents are part of the Cooperative State Research, Education, and Extension Service.

Two local government stakeholders also raised a concern about the organization of the Asian longhorned beetle program in New York. They commented that APHIS had established three work units in New York City, with one each in Manhattan, Queens, and Brooklyn. According to these stakeholders, the three offices do not consistently record or report data on the surveying operations or tree infestations. The local officials said that they had difficulty obtaining data from these work units for their own analysis. In response to this comment, the APHIS national program manager for the Asian longhorned beetle said that, because of its size and complexity, there are three work units in New York City managed by state and federal supervisors acting as a unified command. The geographic areas those work units cover represent unique challenges that at times require different approaches. The local officials also expressed the opinion that APHIS should have one regional management board for New York and New Jersey. Considering the close proximity of these infestations, the stakeholders suggested that a single regional management team could have sufficed and provided more transparency and consistency in managing the beetle. They noted that multiple management teams sometimes took inconsistent actions that were noticed and questioned by citizens. The APHIS national program manager noted that there are separate management boards consisting of federal, state, and local cooperators overseeing the programs in New York, New Jersey, and Illinois, and that APHIS program managers are represented on all of the boards to ensure coordination and consistency. Within each state, strategic actions are impacted by state and local authorities that may lead to differences in the approach used to execute the eradication protocols in each state.

Ten of the 37 stakeholders commented that improvements are needed in coordination between federal and state agencies. The 10 stakeholders were evenly split between the emerald ash borer and *P. ramorum* programs. Some of their comments reflect the challenge of obtaining a consensus among different levels of government on how to carry out the management program. For example, APHIS officials commented on variations in which state agencies regulate the use of pesticides. Specifically, they noted that they had more success coordinating pesticide use with state departments of agriculture than with a state environmental protection agency. Delays in pesticide application could hamper efforts to slow the spread of the pest. Those same APHIS officials observed that state officials were at times reluctant to use what authority they might have to inspect trees on private property because of concerns over "political fallout." Again, such delays could hamper the program's ability to detect and treat infestations. Another APHIS official complained of not getting strong state support for "routine"

regulatory matters. Two APHIS officials commented that the agency should make better use of its cooperative agreements with states to direct those states' activities. Developing more specific cooperative agreements would require better coordination between the parties and would increase accountability for how federal funds are spent. A state department of agriculture manager told us that closer coordination with his APHIS counterpart could have reduced differences in interpretation of quarantine provisions and, therefore, could have improved enforcement.

Eight of the 37 stakeholders also said that they believed coordination would be improved if a wider range of stakeholders were involved in the management response to the infestation. Of the 8 stakeholders, 4 were speaking about *P. ramorum* coordination, 2 about the emerald ash borer, and 2 about the Asian longhorned beetle. An opinion expressed by some of these stakeholders was that responses to pest infestations are more effective when all affected or potentially affected parties participate in the decision-making process regarding their management. The primary mechanism APHIS uses to bring affected parties together and coordinate an appropriate pest response is to establish a management team comprising federal, state, and local officials as appropriate. Stakeholders for each of the pests in our review noted that key affected parties were not adequately included in this management process. Some of the affected parties that stakeholders believed should be more involved include the following:

- other states that are at risk of receiving pests from the infested states;
- industries that are at risk if the pests are not contained, such as nurseries and maple syrup;
- local officials who can educate their citizens about the pests and the harm that they can cause if left unmanaged, thereby gaining citizen cooperation in addressing the pests; and
- nonprofit groups that are involved in forestry activities and can assist in pest surveys and public education and outreach.

In response to these comments, the national program manager for the emerald ash borer program noted that other states were included in the management team as soon as it became clear that the infestation was not confined to Michigan, and that adjacent states and affected industries were notified of the potential threat.

## The Status, Direction, and Resource Needs of Pest Response Efforts Are Not Clear from Publicly Available Management Plans

Because the success of efforts to control invasive species depends, in some part, on public participation, the National Invasive Species Council's guidelines on early detection and rapid response systems stress the importance of providing timely information to decision makers and the public.[34] The council identified access to the most recently updated scientific and management information as some of the fundamental elements of a rapid response system. While much of this information remains static once a certain level of knowledge on the pest has been reached, specific program information—such as strategic plans, program goals and objectives, status of activities, planned future activities, estimated eradication date, and identified funding needs—are dynamic and should be updated regularly in order to reach decision makers and the public in a timely manner.

The *P. ramorum*, Asian longhorned beetle, and emerald ash borer programs have all issued management plans that are described in the bulleted text below; however, timely updates to plans, including estimated funding needs, and the status of program efforts have not always been available for the three species. For example, plans outlining suppression or eradication goals are outdated or incomplete for the three pests. In addition, the *P. ramorum* management plan does not contain required cost estimates for the implementation of future efforts necessary to control and manage Sudden Oak Death caused by *P. ramorum*.

- In December 2004, Congress required APHIS—subject to the availability of appropriated funds—to develop a national plan for the control and management of Sudden Oak Death caused by *P. ramorum*.[35] USDA was required to address the following three issues in the plan: (1) information on ongoing efforts to identify *P. ramorum* hosts and survey the extent to which Sudden Oak Death exists in the United States; (2) past and current efforts to understand the risk *P. ramorum* poses and the results of control and management efforts regarding Sudden Oak Death; and (3) future efforts considered necessary to control and manage Sudden Oak Death, including cost estimates for the implementation of such efforts. In September 2005, USDA released its

[34]National Invasive Species Council, *General Guidelines for the Establishment and Evaluation of Invasive Species Early Detection and Rapid Response Systems*, *Version 1* (2003).

[35]Pub. L. No. 108-488, 118 Stat. 3964 (2004).

strategic plan for *P. ramorum* that sets a goal of controlling the pathogen by prohibiting its introduction into noninfested regions of the country, not by eradication. The plan outlines a risk management option that identifies preventing the artificial spread of the pathogen through commerce, with regulations and quarantines as the most effective technique to combat *P. ramorum*. The plan also identifies the agencies responsible for identifying hosts, conducting national surveys, and assessing risks—elements of the first two requirements of the law.[36] However, although the plan includes a summary of prior federal and state funding for *P. ramorum*, it does not include an estimate of the cost of anticipated activities. USDA stated in the plan that future resource needs were difficult to project due to the "interaction of complex circumstances" but did not identify in the plan what future scenarios could take place, the activities associated with those scenarios, or their estimated costs.

- The Asian longhorned beetle management plan for Illinois and New York, released in 2000 and available on APHIS's Web site, estimated eventual eradication of the beetle in 2008 for Illinois and 2009 for New York. These program goals were based on a series of multiyear strategies to contain, control, deregulate, and eventually eradicate the beetle, beginning in fiscal year 2001. However, a significant decrease in funding in fiscal year 2002, combined with a similar level of funding in fiscal year 2003, delayed the multiyear strategies for several years in New York, leading APHIS to revise the estimated eradication date for New York to 2014 or 2020, depending on funding levels. As we have previously discussed, the fiscal year 2006 appropriation for the Asian longhorned beetle is significantly lower than the agency believes is necessary to meet either the 2014 or 2020 date. However, APHIS has not updated the plan for the Asian longhorned beetle to reflect this change or to incorporate recently identified infestations in New York City, nor does it contain information on the agency's revised estimate of funding needs. According to the national program manager for the Asian longhorned beetle, APHIS is in the process of updating the strategic plan and anticipates a final version will be available by mid-2006. However, the plan is not likely to include information on projected funding needs.

[36]APHIS has drafted protocols outlining the response to positive *P. ramorum* finds in the forest and wildland environments. Under the draft protocols, it would be at the states' discretion whether or not to undertake eradication efforts.

In 2002, following the identification that year of new infestations in Jersey City, New Jersey, APHIS developed a separate plan calling for eradication in this location by 2008. This APHIS plan—which is not available on the agency's Web site—does not include an estimate of funding needs for the work in New Jersey. Because APHIS has not updated the 2002 plan, it does not reflect the detection in 2004 of an additional large infestation in Middlesex and Union Counties, New Jersey. (APHIS has told us that it has established 2011 as the target eradication date for these two counties.) The passage of time and the changes in the extent of the infestations and actual funding levels have caused the latest agency plans for New Jersey and New York to be significantly out of date. Without a unified plan that reflects those changes, decision makers and the public do not have an accurate picture of the status and future of the Asian longhorned beetle management program.

- APHIS's emerald ash borer program posted on its Web site in May 2005 a management plan that spelled out the goal of removing trees infested with the pest in three strategically placed gateways: one on Michigan's eastern border with Canada, one along Michigan's southern border with Indiana and northern Ohio, and one south of the Mackinac Bridge leading to the Upper Peninsula of Michigan. The immediate objective of this strategy is to eradicate the pest in Indiana and Ohio and keep it contained within the Lower Peninsula of Michigan. The APHIS plan contained an estimate that a long-term eradication program could be completed in Indiana and Ohio by 2016, and in Michigan by 2018, assuming certain levels of funding. The plan included estimates that over $384 million would be needed to achieve the objective, including $43 million in fiscal year 2005 and $34 million in fiscal year 2006. However, two developments have raised doubts about the agency's estimates. One development is that actual funding in fiscal years 2005 and 2006 has not reached the levels APHIS believed were needed, and the states were not able to complete planned eradication projects. The other development is that the program has found additional infestations, including some beyond the gateway areas. Given these circumstances, in addition to the lack of adequate control technologies, none of the emerald ash borer stakeholders we interviewed—including members of the management team—believed that eradication is possible. Despite these conditions, the management team has not issued an updated plan with revised objectives, timetables, or funding needs. One change that the team did make was to remove the timetable and cost estimates from

the publicly available strategic plan, although this does little to convey the government's approach and expectations for the program.

## Science Advisory Panels Have Assisted with the Pest Response Efforts, but There Are Concerns about How They Were Formed and Operated

Program managers believed that the panels comprising federal and nonfederal scientific experts to help the agency respond to each of the three pests we reviewed have been useful. USDA does not have specific procedures for how the panels should operate, and the agency operated the panels for the three pests quite differently. The USDA management programs for the emerald ash borer and the Asian longhorned beetle created science panels that were tasked with giving advice on management approaches. The emerald ash borer team has met at least annually for 4 years, while the Asian longhorned beetle team met once in 1996 but has not met since then. The director of APHIS's emergency pest program told us that the Asian longhorned beetle advisory panel met the objectives of the management team when it operated in 1996, and that the management team did not need it in subsequent years. He also said that the management team has consulted directly with appropriate scientific experts when needed and could call the advisory team back together if necessary. In contrast, the APHIS *P. ramorum* program created a science panel that had the charge of providing information but not recommendations. In June 2004 in Raleigh, North Carolina, APHIS convened a panel of approximately 75 federal and nonfederal scientists and regulators from North America and Europe with expertise in *Phytophthora* species. The APHIS national program manager for *P. ramorum* told us that he believed that the panel was helpful, but that a panel charged with providing advice and recommendations, perhaps under the requirements of FACA, was also needed because of the evolving science concerning the pathogen.[37]

While the panels have generally been helpful, some stakeholders raised concerns about their operation and use. Specifically, 10 of the 37

[37]Pub. L. No. 92-463, 86 Stat. 770 (1972) (classified at 5 U.S.C. app. 2). Under FACA, an "advisory committee" is defined as any committee, board, commission, council, conference, panel, task force, or similar group, or any subcommittee or other subgroup thereof, which is established by statute or reorganization plan, or established or utilized by the President or by one or more agencies, in the interest of obtaining advice or recommendations for the President or one of more federal agencies. The term "advisory committee" does not include (1) any committee composed wholly of full-time federal employees or (2) any committee created by the National Academy of Sciences or the National Academy of Public Administration. Federal advisory committees play an important role in the development of public policy and government regulations by providing advice to policymakers on a wide array of issues.

stakeholders commented that the use of the panels could have been improved. Five stakeholders, collectively addressing all three of the panels, stated they thought improvements were needed in how the science panels communicated with management teams and with others. For example, 1 stakeholder criticized USDA for not explaining why the Asian longhorned beetle advisory panel was used only at the very beginning of the management program. Four stakeholders (including 1 of the 5 just mentioned), also collectively addressing all three panels, thought that more frequent meetings were needed. One panel member, a federal research scientist, told us that a lesson he has learned is that for pests about which little is known, there needs to be significant input and consultation from scientific experts. He believed that in the case of the emerald ash borer, the panel has needed to meet more often than in other pest situations because so little is known about this pest.

USDA did not choose to charter the emerald ash borer and Asian longhorned beetle advisory panels under FACA, and the scope of our work did not include making a legal judgment on whether they should have. However, there are certain principles in FACA that, if included in operational procedures for pest advisory panels, could help to minimize criticism of the sort that we heard. Specifically, the act requires that all committees have a charter, and that each charter contain specific information, including the committee's scope and objectives, a description of duties, the estimated annual operating costs, and the estimated number and frequency of meetings. FACA advisory committee charters generally expire at the end of 2 years, unless renewed by the agency or by Congress. This encourages the agencies to reexamine whether the committees are still needed. FACA also contains general requirements that committees be fairly balanced in terms of points of view represented and the functions to be performed by the committee, and FACA generally requires that committee meetings be open to the public.

## Conclusions

Forest pests have caused substantial damage in the past and continue to pose a serious threat to the nation's environment and economy. We recognize that forest pest managers face a host of challenges—some of which are daunting—that constrain their ability to successfully eradicate new pests. These challenges include the unique biological characteristics of particular species and the lack of existing eradication technologies. However, information derived from past infestations and the three forest pests we reviewed makes it clear that early detection and rapid response to new infestations are critical to improving the likely success of effectively

controlling invasive forest pests. More specifically, it is likely that without broader early detection systems, especially in urban areas because they are at high risk of receiving invasive insects and diseases, future infestations that are costly and difficult to eradicate will occur. We also found that the status of the three pest response efforts was not clearly communicated to the public and other key stakeholders, particularly information regarding the setbacks that the programs will face due to recent funding reductions. Additionally, it was also not clear to us and stakeholders how science advisory panels were used and operated in the pest response efforts. Clear and current communication on these efforts is important since infestations affect many agencies, businesses, and individuals, and the control efforts rely on the actions of many entities beyond just the federal players.

## Recommendations

To improve federal efforts to detect, manage, and eradicate infestations of invasive forest pests, we are recommending that the Secretary of Agriculture take the following three actions:

- Expand current efforts to monitor forest health conditions, particularly in urban and suburban areas that are at high risk of receiving invasive insects and diseases. USDA's monitoring program should incorporate guidance on early detection issued by the National Invasive Species Council in 2003.

- Prepare, publish, and regularly update management plans for pests for which the department has initiated a management program. The plans and their updates should incorporate and describe changes in the extent of infestation; progress to date in control and eradication efforts; schedules for future control and eradication efforts, given known levels of funding; and future long-term funding needs. For the *P. ramorum* program in particular, an updated management plan should include the elements called for by law that were not included in USDA's 2005 plan, such as an estimate of the cost of anticipated activities.

- Implement written procedures that broadly define when and how to operate panels of scientific experts for the purpose of assisting pest management teams, including a discussion on how to determine when such panels should be chartered as advisory committees under FACA.

## Agency Comments and Our Evaluation

We provided a copy of our draft report to USDA. The department provided written comments (see app. VII). Overall, USDA said that the report was comprehensive and well written. However, the department expressed the viewpoint that the tone of the report was overly critical and gave an unfavorable impression of the work done by the agencies to respond to the three forest pests. USDA also offered comments on our recommendations. With respect to the tone of the report, the department emphasized that little was known about these pests before their arrival in the United States, and that federal and state agencies did a reasonable job under those circumstances. We agree with USDA's comments that *P. ramorum* was unknown to science before its arrival and that little was known about the emerald ash borer, and we made those points in the report. We disagree that the Asian longhorned beetle was unknown as a potential threat before its arrival. As we describe in the report, larvae of the beetle or closely related species had been intercepted many times at U.S. ports of entry prior to its detection in 1996. In relation to this point, the APHIS national program manager for the Asian longhorned beetle told us that all larvae similar in appearance to Asian longhorned beetle larvae are invasive and require mitigating action. In general, we agree that the agencies have worked hard to control the three pests and believe that our report describes the difficult tasks that the agencies face in attempting to eradicate them from the environment and accurately portrays the status of those efforts. Nonetheless, the fact of the matter is that 2 of the 3 pests will likely not be eradicated. In summary, we believe the report fairly presents the overall challenges as well as the results of USDA's efforts.

USDA commented that it did not have major concerns about the three recommendations but did not completely agree with them. With regard to the recommendation to increase monitoring of forest health conditions, particularly in urban and suburban areas, USDA noted that the draft report focused only on federal government agencies. The department pointed out that state, university, tribal, business, and nongovernmental organizations have a role to play in combating invasive species. We agree that these entities have a role, and the report does indicate that federal agencies collaborate with nonfederal entities on forest health monitoring. Given that existing Forest Service and APHIS monitoring programs entail collaboration with nonfederal entities, it would not be unexpected that any expansion of these monitoring programs would also involve those partners. As the lead federal agency, USDA has an important leadership role to play in developing and supporting the forest health monitoring capabilities of nonfederal entities to achieve more effective results.

USDA commented that the second recommendation that addresses keeping management plans up to date is "a sound business practice which we support." The department stated its belief that a reasonable job was done in these instances, given the pressures to accomplish work "on the ground." We agree that the program management teams carried a large workload, but continue to believe that more should have been done to keep the public informed about the programs' status and direction. We also continue to believe that these and other pest management programs should regularly update management plans, and that those plans should contain specific information listed in our recommendation. In light of the heavy workload that pest management teams are likely to face when responding to an infestation, the department may wish to consider developing a standardized reporting instrument that would ease the burden on program managers, while still providing essential information to the public and decision makers about such variables as the overall spread of the pest, the location of infestations, the schedule for eradicating those infestations, and funding needs.

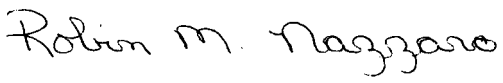
USDA commented that the third recommendation regarding the need for written procedures that broadly define when and how to operate panels of scientific experts seemed reasonable. However, the department said that the draft report incorrectly implied that, in the three situations we reviewed, important people with information to share were not heard. We did not independently assess whether the three science panels included the correct expertise. However, some stakeholders we interviewed believed that the process was not as inclusive or open as it should have been, and we concluded that written procedures for the panels could help avoid that problem in the future. USDA also commented that chartering a committee under FACA would hamper its flexibility in dealing with invasive species issues, and, therefore, it disagreed that panels should be chartered under FACA. In fact, we did not specifically recommend that committees be chartered under FACA, and we agree with USDA that the FACA process may hamper an expeditious scientific response to a new infestation. Nevertheless, panels of nonfederal experts called on to provide advice to USDA may fall under the obligations of FACA, and we continue to believe that the department should develop procedures that clarify when and how scientific panels can be used in pest response efforts and identify under what circumstances a panel should be chartered under FACA.

As agreed with your office, unless you publicly announce the contents of this report earlier, we will plan no further distribution until 30 days from

the report date. At that time, we will send copies of this report to other interested congressional committees and the Secretary of Agriculture. We will also make copies available to others upon request. In addition, the report will be available at no charge on GAO's Web sites at http://www.gao.gov.

If you or your staff have any questions, please call me at (202) 512-3841 or nazzaror@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix VIII.

Sincerely yours,



Robin M. Nazzaro
Director, Natural Resources
and Environment

# Objectives, Scope, and Methodology

This report evaluates the federal response to three invasive forest pests—the Asian longhorned beetle; the emerald ash borer; and *Phytophthora ramorum* (hereafter *P. ramorum*), the pathogen that causes Sudden Oak Death. Specifically, we reviewed (1) the status of efforts to eradicate these three species; (2) factors that have affected the success of the response programs; (3) overall forest health monitoring programs; (4) the coordination of the three pest response efforts among federal and state agencies and other stakeholders, and communication about the response efforts; and (5) the Department of Agriculture's (USDA) use of panels of scientific experts to aid the responses. We also discuss in appendix VI APHIS's use of risk assessments to support decisions for forest pest programs.

We selected a nonprobability sample of these three species because they were discovered in the United States relatively recently; they pose a large potential threat to the nation's forests; and the federal government has established a program to research, control, and manage them.[1] We also deliberately chose both insect and disease pests to learn whether they pose different management challenges. Finally, we took into consideration the fact that the three pests are in different parts of the country. We considered this criterion to be potentially important because states play a major role in responding to pest outbreaks.

To determine what federal entities implement projects to address invasive forest pests and what sources of funding these entities have, we interviewed relevant officials from USDA and the National Invasive Species Council and reviewed forest pest literature and Web sites. Within USDA, we focused our review on the Animal and Plant Health Inspection Service (APHIS) and the Forest Service, the agencies that primarily contribute to the prevention and control of invasive forest pests. We also obtained relevant information on research activities conducted by USDA's Agricultural Research Service and Cooperative State Research, Education, and Extension Service. We recognize that invasive forest pests may affect other federal agencies, such as the Department of the Interior. However, we focused on APHIS and the Forest Service because these two agencies play a larger role in the management of these forest pests.

[1]Results from nonprobability samples cannot be used to make inferences about a population because, in a nonprobability sample, some elements of the population being studied have no chance or an unknown chance of being selected as part of the sample.

To analyze the federal responses to the three pests, we reviewed applicable laws and regulations pertaining to plant protection and quarantines. We also reviewed agency documents pertaining to scientific research, regulations and quarantines, program expenditures, cooperative agreements, strategic plans, and risk assessments, which included estimates of past and potential economic and environmental damage. We interviewed national, regional, and state program managers at APHIS; state agriculture department officials responsible for implementing the response program; Forest Service and state forestry officials; science advisory panel members; and researchers from academia.

We gathered information about invasive forest pest expenditures by federal and nonfederal entities from a variety of sources. These included the structured interviews and documents provided by agency officials in response to our request for funding information. In the instances where officials provided us with information through the interview guide, we asked if their answers were based on a documented estimate. We independently corroborated the data the officials provided in answer to our questions, to the extent possible, using other documentation, such as cooperative agreements with states and appropriations language. We determined that these data were sufficiently reliable for the purposes of this report.

For each of the three pest programs, we contacted officials at federal, state, and local government agencies, as well as at nongovernmental organizations. We did not attempt to identify or contact all federal, state, and local agencies engaged in invasive forest pest management in each example. For the three invasive pests we reviewed, we sought to contact officials representing APHIS and the Forest Service, state agriculture and forestry or natural resources agencies, and local governments as well as scientists and other researchers involved with program efforts. In addition, for the *P. ramorum* program, we also interviewed representatives from the nursery industry; for the emerald ash borer program, we met with individuals in the forest products and firewood industries to gain their opinions on federal quarantine regulations.

We used a structured interview guide to obtain information from federal, state, local, and nongovernmental officials, including 9 stakeholders involved with the Asian longhorned beetle, 12 with the emerald ash borer, and 16 with *P. ramorum*. The federal officials included APHIS and Forest Service employees directly involved in the management programs. The state officials included department of agriculture and department of

forestry or natural resources employees directly involved in the management programs. We administered the structured interview to New York City and Chicago government officials involved in the Asian longhorned beetle program, because of the major role those city governments have had in that program. Nongovernmental officials included representatives from the nursery industry affected by *P. ramorum* and the Asian longhorned beetle, and university scientists with expertise related to one of the forest pests. Table 1 lists the three pests that we reviewed and the number and affiliations of the stakeholders we interviewed with the structured interview guide.

**Table 1: Number of Stakeholders Who Were Administered the GAO Structured Interview, by Pest and Affiliation**

| | Number of stakeholders, by affiliation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Federal agency | | State agency | | | | | |
| Forest pests reviewed | APHIS | Forest Service | Agriculture agency | Forestry or natural resources | Local government agency | University | Nursery industry | Total |
| Asian longhorned beetle | 1 | 1 | 3 | 0 | 2 | 1 | 1 | **9** |
| Emerald ash borer | 4 | 2 | 3 | 2 | 0 | 1 | 0 | **12** |
| *P. ramorum* | 3 | 3 | 4 | 2 | 0 | 2 | 2 | **16** |
| **Total** | **8** | **6** | **10** | **4** | **2** | **4** | **3** | **37** |

Source: GAO.

The structured interview guide asked the officials for their opinions on a variety of topics, including state and federal coordinating mechanisms, quarantines, public education and outreach, management tools and research, funding responsibility, funding needs, risk assessment, potential for eradication, impact to the environment, and recommended contacts. The structured interview guide consisted of 21 questions asking for a "yes," "no," or "uncertain" answer and 29 questions asking for open-ended answers. For some of the "yes" or "no" questions, respondents gave two answers based on their opinion of the overall program as well as their opinion on a more specific issue within the program. For example, in response to a question about the potential for eradication for *P. ramorum*, several officials responded that eradication was not possible for the entire infested area but was possible for a smaller area, such as a less-infested state. At times, in answering one question, a respondent would also provide an answer to a subsequent question. In our analysis, we assigned their answers to the appropriate question. In some instances, respondents did

not give clear answers to specific questions, and we asked additional follow-up questions that were not part of the guide in order to clarify. We also asked the stakeholders to recommend other people to interview. Appendix II contains the questions from the structured interview guide.

We developed our structured interview guide with the assistance of a GAO methodologist. The practical difficulties of asking questions may introduce other types of errors (e.g., differences in how a particular question is interpreted or the sources of information available to respondents can introduce unwanted variability into the responses). We included steps in the development of our interview guides to minimize such errors, including pretesting the content and format of the interview guides with two individuals and making minor changes as appropriate.

In addition to using the structured interview guide, we also interviewed other federal and nonfederal officials in a less formal way. We conducted some of these interviews prior to preparing the interview guides. In other instances, we used an informal interview method because we did not believe that the guides were appropriate for the interviewee. In our report, we present information obtained from the informal interviews, but do so separately from our presentation of information we obtained through the interview guides.

We made site visits to New Jersey, New York, Michigan, and California to observe program activities, such as detection and control efforts and inspections of regulated materials. For example, in Michigan we observed emerald ash borer trap trees and tree removal operations on both public and private land in the gateway between the United States and Canada. We also accompanied state and federal officials as they inspected a sawmill operation for compliance with emerald ash borer quarantine regulations. In California, we observed in a wholesale nursery the use of best management practices to reduce the threat of spreading *P. ramorum* among plants being readied for shipment.

We also discussed APHIS's use of risk assessments to support decisions for invasive species programs. To develop appendix VI on risk analysis, we conducted a computerized literature search and identified and reviewed articles, as well as domestic and international guidelines, relevant to risk analysis for invasive forest pests. To learn about the complex network of roles and responsibilities regarding the risk analysis process and risk-based management within USDA, we studied information on organizational structure provided on APHIS Web sites; conducted interviews with officials

in APHIS's Plant Protection and Quarantine office, USDA's Office of Budget and Program Analysis, and USDA's Economic Research Service; and followed up on the interviews with additional questions through e-mails. In addition, we reviewed published reports evaluating APHIS's roles and responsibilities in this regard. Finally, we used all sources previously mentioned to identify specific risk analysis studies by APHIS for the three pests we reviewed in our report. As reported in appendix VI, we found only two such studies by APHIS that were related to pests of interest.

# Questions from Structured Interview Guide Administered to Stakeholders Involved with the Three Pest Response Programs

The structured interview guide that we administered to stakeholders consisted of the following questions:

## Federal and State Coordination

1. Do you believe that the federal government has created the appropriate coordinating mechanisms to respond to the infestation? (By coordinating mechanisms, we mean such things as interagency and intergovernmental management teams and science advisory panels.)
2. Do you believe that there are improvements that could be made with respect to those federal coordinating mechanisms?
3. If so, what are they?
4. Do you believe that the state government(s) has/have created the appropriate coordinating mechanisms to respond to the infestation? (By coordinating mechanisms, we again mean interagency management teams and advisory panels.)
5. Do you believe that there are improvements that could be made with respect to those state coordinating mechanisms?
6. If so, what are they?
7. Please describe any lessons, either positive or negative, that you have learned from your experiences with these coordinating mechanisms.

## Imposition and Enforcement of Quarantines

8. Do you believe that the state(s) have imposed quarantines for the correct geographic areas to achieve the goal of stopping the artificial spread of the pest?
9. What do you believe should have been done?
10. Do you believe that the state(s) imposed the quarantines in a timely fashion to achieve the goal of stopping the artificial spread of the pest?
11. What do you believe should have been done?
12. Do you believe that the federal government has imposed quarantines for the correct geographic areas to achieve the goal of stopping the artificial spread of the pest?

13. What do you believe should have been done?

14. Do you believe that the federal government imposed the quarantines in a timely fashion to achieve the goal of stopping the artificial spread of the pest?

15. What do you believe should have been done?

16. Do you believe that the quarantines have stopped the artificial spread of the pest?

17. If not, what is most needed to improve the quarantines?

18. Do you have any suggestions for legal or procedural changes that could improve the quarantine process?

19. Please describe your suggestions.

20. Please describe any lessons, either positive or negative, that you have learned from your experiences with the quarantines for the pest.

## Education and Outreach

21. Do you believe that the state and federal efforts to educate the public about this pest have helped stop its spread?

22. If not, why not?

23. What do you believe should have been done?

24. Please describe any lessons, either positive or negative, that you have learned from your experiences with education and outreach for this pest.

## Management Tools and Research

25. Do government agencies have the tools they need to manage the pest? (When we speak of tools, we include understanding the biology of the organism, detection techniques, eradication methods, and other such knowledge or technology.)

26. What additional tools are needed?

27. Is research underway to develop those tools?

28. Please describe any lessons, either positive or negative, that you have learned from your experiences with the technological research for managing the pest.

## Funding Responsibility

29. Do you believe that the federal government should bear the primary financial responsibility for addressing an invasive species problem such as this?

30. Please explain your answer.

31. Do you believe that the states should bear any of the financial responsibility?

32. If so, what do you believe would be a fair cost-sharing arrangement between the federal government and the states to address a situation such as this pest?

33. Do you believe that the resources devoted to controlling this pest have achieved the goal of stopping its spread?

34. What level of funding do you believe is needed per year, regardless of the source, to eradicate the pest?

35. What level of funding do you believe is needed in total, regardless of the source, to eradicate the pest?

36. What is the basis of your answers for Questions 34 and 35?

37. If your answers to Questions 34 and 35 are based on documented estimates, please provide copies or citations.

## Funding Mechanisms

38. Do you believe that any improvements are needed in the mechanisms or processes through which funding is delivered to the states?

39. If so, please provide any suggestions you have for improvements.

## Risk Assessment and Funding Needs

40. Have the federal or state governments conducted risk assessments to estimate the likely costs and benefits associated with managing the pest?

41. If yes, please provide sources or citations.

42. Please describe how the risk assessments have been used in making resource allocation decisions.

43. Please provide any observations you have on how to improve the preparation and use of risk assessments.

## Prospects for Success

44. Do you believe it is possible to eradicate the pest?

45. Do you believe that the federal government should strive to eradicate this pest?

46. Do you believe that the pest can be eradicated from the entire infested area given our current knowledge and level of effort?

47. If not, what do you believe is most necessary to achieve eradication?

48. If you do not believe that eradication is possible, what do you think is the likely outcome?

49. Please offer any other comments you might have regarding the management of this pest.

50. Who do you recommend we should contact to ask these questions? (Additional contacts could, for example, be from your state, from your agency, or from stakeholder groups.)

# Review of Efforts to Control and Eradicate the Asian Longhorned Beetle

Our review of the efforts to control and eradicate the Asian longhorned beetle includes a discussion of the origin and spread of the infestation in the United States and its potential impacts. We also review the roles of federal, state, and local government agencies in addressing infestations and describe the management structures and methods they have used to control and eradicate this forest pest. Finally, we discuss the current status of the Asian longhorned beetle infestation and outline the funds spent to date on controlling and eradicating the pest.

## Origin and Potential Impacts of Asian Longhorned Beetle Infestations

The Asian longhorned beetle is a large, eye-catching, wood-boring beetle that is black with small white spots and long, spotted antennae.[1] It is native to countries in Asia, such as Japan, Korea, and China. The beetle spends most of its life within the inner wood of a variety of hardwood trees tunneling and feeding on the cambium layer, eventually killing the tree. APHIS officials believe that the beetle arrived in the United States sometime in the mid-1980s in solid wood packing material accompanying cargo shipments originating in China and destined for warehouses located throughout the country. While inspections have discovered adult beetles at about 30 warehouses across the country, the only established infestations have been found in a few urban locations. The beetle was first detected in Brooklyn, New York, in August 1996. However, APHIS officials believe that the beetle had been established in Brooklyn for about 10 years prior to its detection. Subsequent infestations were detected in other parts of New York; in Illinois (July 1998) and New Jersey (October 2002); and in Toronto, Canada (September 2003). Many of the sightings leading to the detection of infestations have been by citizens who had been exposed to public outreach efforts regarding the beetle.

Researchers note that the Asian longhorned beetle is a serious threat to hardwood trees in both urban and natural forests, and that it has no known natural predator in the United States.[2] In a 2000 study of the urban forests of nine large U.S. cities, researchers estimated that the beetle could destroy as much as 35 percent of U.S. cities' tree canopy cover and 30 percent of

[1]The Asian longhorned beetle is also known by its scientific name, *Anoplophora glabripennis*.

[2]The various trees that serve as hosts for the Asian longhorned beetle include the following: maple, boxelder, horsechestnut, buckeye, willow, elm, birch, London plane, hackberry, ash, mimosa, poplar, and mountain ash.

their trees (1.2 billion trees), with an estimated loss of value of $669 billion.[3] These estimates do not include the potential adverse impacts on the forest products industry (lumber and furniture), maple syrup production, fall foliage tourism, as well as the impacts from decreased property values; aesthetic damage; and lessened environmental benefits, such as cleaning air and water and providing energy-conserving shade. If the beetle spreads out of its current urban environment, researchers note that it also has the potential to seriously alter the ecological diversity of the natural forests in North America, with additional impacts on wetlands. Researchers estimate that if the beetle enters natural forests, the potential loss could be 71 billion trees, with a value greater than $2 trillion. One researcher noted that the beetle has the potential to cause more damage than Dutch elm disease, chestnut blight, and gypsy moth infestations combined.

## Federal, State, and Local Roles in Controlling and Eradicating the Asian Longhorned Beetle

A number of federal, state, and local agencies are involved in managing and eradicating the Asian longhorned beetle in the United States, with USDA's APHIS Plant Protection and Quarantine (PPQ) group taking the lead. APHIS works with other federal agencies through the use of interagency agreements and with state and local governments through the use of cooperative agreements. Both the interagency and cooperative agreements lay out in detail the roles and responsibilities of each government party as well as other matters. The basic roles of the federal, state, and local governments are described as follows:

- *Federal government*: APHIS's PPQ group works to protect the country from the entry of invasive pests and to manage and eradicate invasive pests once they are established. PPQ is the lead federal agency responsible for surveys, regulatory quarantines, control actions, public awareness efforts, and technology development. USDA's Forest Service undertakes forest restoration, research, and public awareness and has tree climbers who assist in surveys. USDA's Agriculture Research Service engages in research on management tools. Other USDA agencies have also provided personnel to the Asian longhorned beetle program to assist in survey and control activities.

[3]David J. Nowak, Judith E. Pasek, Ronaldo A. Sequeira, Daniel E. Crane, and Victor C. Mastro. "Potential Effect of *Anoplophora glabripennis* (Coleoptera: Cerambycidae) on Urban Trees in the United States." *Journal of Economic Entomology*, vol. 94, no. 1 (2001).

- *State governments*: The Department of Agriculture and Markets in New York and the Departments of Agriculture in Illinois and New Jersey survey, regulate, control, and increase public awareness about the Asian longhorned beetle. The New York Department of Environmental Conservation regulates pesticides and restores forests. The Illinois Department of Agriculture also regulates pesticides. The New Jersey Division of Parks and Forestry restores forests.

- *Local governments*: New York City Department of Parks and Recreation, Forestry and Horticulture conducts data management, debris disposal, and restoration, facilitating the program within the city. The Department of Streets and Sanitation, Bureau of Forestry, conducts data management, tree removal, surveying, and restoration, facilitating the program within Chicago. Municipal and city governments located in Long Island, the suburbs of Chicago, and New Jersey dispose of wood debris and conduct public awareness activities. Some local community organizations also contribute to public awareness activities.

## Management Structures and Methods Used to Control and Eradicate the Asian Longhorned Beetle

Following the August 1996 detection of the Asian longhorned beetle in Brooklyn, an APHIS New Pest Advisory Group met in September 1996 to discuss management options and make recommendations regarding actions that should be taken to address the infestation. The advisory group recommended that APHIS continue to survey for infested trees in Brooklyn, impose a quarantine to prevent the spread of the beetle, convene a science advisory panel, establish a joint federal/state/local operational team, and begin a public outreach campaign in addition to other actions. The following month, APHIS convened a science advisory panel to discuss the beetle infestations and recommend actions that should be taken to control its spread. While recommending actions similar to those set out by the New Pest Advisory Group, the science panel also recommended that APHIS expand its surveys for the Asian longhorned beetle to a national level, pursue research on the beetle's behavior and management tools to control it, and seek complete eradication of the beetle. Following the detection of beetle infestations in each of the three states, APHIS/PPQ established management teams comprising APHIS, state, and local officials to discuss, plan, and carry out an eradication plan.

In April 2000, APHIS officials published APHIS's revised Asian longhorned beetle New Pest Response Guidelines, providing guidance and action steps for eradicating infestations. In September of that same year, following consultation with state and local officials, APHIS released a plan for

eradicating the beetle in New York and Illinois. After detecting infestations in New Jersey in 2002, APHIS released a separate plan for New Jersey that same year. On the basis of various guidelines and plans for addressing the beetle, the management teams' efforts to eradicate it have focused on the following:

- *Overarching strategy*: The strategy of the federal Asian longhorned beetle program is to contain and eventually eradicate the pest from its current urban and suburban locations through a combination of inspections, quarantines, harvesting of infested trees, treating uninfested trees with insecticides, and public education.

- *Surveys*: Surveys serve the following three purposes: (1) detect infestations, (2) determine or delimit the extent of infestations, and (3) evaluate the effectiveness of control strategies employed to achieve eradication. For the Asian longhorned beetle, surveys have consisted of visual inspections of public and private property done from the ground or by tree climbers and with bucket trucks.

- *Quarantines*: State and APHIS officials established what they term "parallel quarantines" where state and APHIS officials met to determine the quarantine boundaries and items to be regulated. The state established a quarantine allowing state officials to use their authority to regulate items that contribute to the spread of the beetle. The federal government followed with a federal quarantine to prevent the interstate spread of the beetle through the movement of infested wood and wood debris. Initial state and federal quarantine boundaries were set, based on current research, as small as possible to lessen their impact on affected parties but large enough to prevent the spread of the beetle. As government officials gained more knowledge about the beetle, a protocol was established for establishing and expanding quarantine boundaries. Because the initial quarantine boundaries were small, government officials expanded the quarantine boundaries to account for infestations that were larger than initially identified, in accordance with the new protocols. Beginning in 2004, APHIS and state officials have been removing quarantines in Illinois and New Jersey as survey results of the infested areas over 3 years have shown no signs of the beetle's presence.

    - *New York:* New York imposed an initial quarantine in December 1996, which was followed by a federal quarantine in March 1997, for areas in the boroughs in Brooklyn and Queens and a small area in

Amityville on Long Island. APHIS expanded the New York quarantines on six other occasions as additional infestations were detected. In total, officials quarantined approximately 132 square miles of infested area, covering portions of the boroughs of Brooklyn and Queens, small areas in Manhattan, and two areas on Long Island.

- *Illinois*: Illinois established an initial quarantine in July 1998 and declared the beetle a nuisance in August 1998.[4] APHIS followed with a federal quarantine in November 1998. Illinois expanded the quarantine 8 times over the next 6 years to account for additional detections of the beetle. Beginning in 2004, APHIS and state officials began reducing some quarantine boundaries in light of 3 consecutive years of negative surveys in those quarantined areas. In total, officials quarantined approximately 35 square miles of infested area.

- *New Jersey*: New Jersey imposed two quarantines, one in October 2002 for an area in Jersey City, and one in August 2004 for portions of Middlesex and Union Counties. APHIS followed with federal quarantines in May 2003 for Hudson County (including Jersey City) and in January 2005 for Middlesex and Union Counties. APHIS removed the quarantine for Hudson County in October 2005. In total, state officials quarantined approximately 20.5 square miles covering a small area of Jersey City and Hoboken in Hudson County and parts of four smaller cities adjacent to one another in Middlesex and Union Counties.

- *Public education and outreach*: According to APHIS, state, and local officials, one of the critical components in detecting and eradicating the Asian longhorned beetle was an aggressive program of public education and outreach directed at parties directly affected by the quarantines, local officials, local plant organizations, and citizens. Several detections of the beetle infestations were a result of citizens seeing and reporting the pest following a public outreach effort or event. For example, within 2 hours of a radio show about the beetle, a New Jersey resident called in a sighting of the pest, which led to the detection of an infestation.

- *Removal of infested trees*: Since the beetle has no known natural predators in the United States and state and local laws restrict the use of

[4]The date of the declaration is the final date following a public hearing as required by state law.

insecticides in urban areas, the only way to prevent the spread of the beetle has been to cut down, chip, and burn infested trees. Government agencies have contracted with private companies to remove and dispose of the trees. As of the end of 2004, government officials had removed and destroyed over 8,000 infested trees. New York City established a free curbside pick-up program to remove residential wood debris within the quarantined zones to prevent the spread of the beetle. In Illinois and New Jersey, government agencies established disposal sites and wood grinders to handle wood debris gathered by both commercial entities and residents within the quarantined areas.

- *Chemical treatment of noninfested host trees*: For trees that are susceptible, but not yet infested, APHIS and state agencies have contracted with tree companies to treat the trees with an insecticide that will kill the beetle in the early stages of its life cycle while it is still inside the tree or as an adult feeding on the leaves and twigs. Over 600,000 noninfested host trees have been chemically treated to kill the beetle during its larvae life stage to prevent the beetle from spreading.

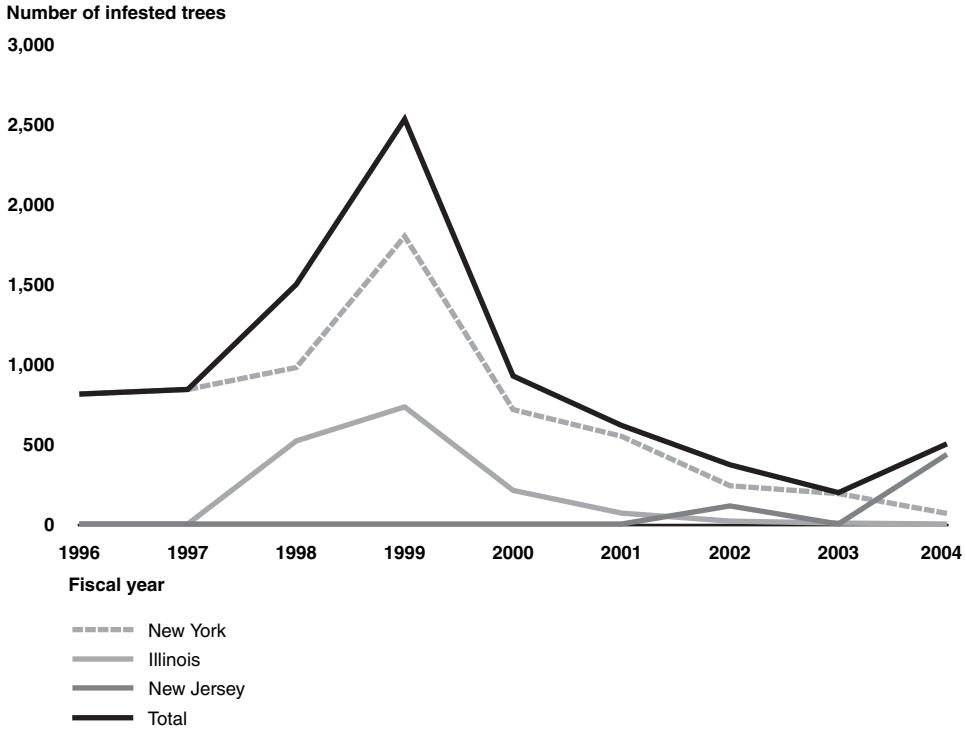
- *Replantings*: The Forest Service, in cooperation with state and city forestry agencies, has provided residents with the option of replacing infested trees removed from their properties with a tree species that is not a host for the beetle.

- *Research*: Research to date by government and university scientists has focused on the biology and dispersal of the beetle (used to establish survey and quarantine boundaries), quality assurance studies of survey methods that led to the use of bucket trucks and tree climbers, and the development of a trunk injection chemical treatment to augment tree removal. Research on lures and traps for the beetle has not yet proven successful. Ongoing research into controlling and eradicating methods include the following: rearing large numbers of beetles for research purposes; effective exclusion technologies to detect and eliminate the beetle from foreign cargo entering the country; testing an acoustical detection device; a uniform data management system; a system for injecting insecticide into the soil to supplement tree trunk injection; and alternatives to chemical treatments, such as biological control agents.

## Status of Asian Longhorned Beetle Infestation

Starting in 2000, the data indicated a downward trend in the number of infested trees identified each year, except for New Jersey where a large infestation was detected in 2004. Figure 15 shows the distribution over time of the infested trees identified among New York, Illinois, and New Jersey.

**Figure 15: Number of Asian Longhorned Beetle-Infested Trees Identified in New York, Illinois, and New Jersey**




Source: APHIS.

The quarantines in combination with solid management teams and aggressive public outreach and education have resulted in the beetle slowly being eradicated in the infested states. APHIS and Illinois have removed all but one of the Illinois quarantines and plan to remove the last in the spring of 2006. APHIS and Illinois state officials expect to complete the management program in 2008. APHIS and New Jersey state officials have removed the quarantined area in Hudson County and expect to remove the other quarantines in the next several years. APHIS and New Jersey officials expect to complete the management program in 2011. Although

government officials expected complete eradication in New York by 2009, that date has been moved to perhaps as late as 2020 due to the detection of new, but small infestations; the sheer size of the infestations; the difficulty of working in the New York urban environment; and inadequate funding. All but one of the government officials involved in the Asian longhorned beetle program that we interviewed believed that it will be completely eradicated if adequate and consistent funding is provided to complete the program.

## Funding for Asian Longhorned Beetle Eradication Efforts

In its initial response to the Asian longhorned beetle detections, APHIS drew money from its contingency funds to pay for research and surveys to determine the extent of the infestations. Several years into the program, APHIS began including part of its funding needs in its appropriations requests. APHIS has received $229 million in fiscal years 1996 through 2005 on the beetle eradication program, using a mix of APHIS contingency funds, Commodity Credit Corporation (CCC) transfers, and other appropriations. APHIS has estimated that, in total, $578 million will be needed to eradicate the beetle. As previously noted, a federal funding shortfall in fiscal year 2002 resulted in the cancellation of tree removal and insecticide treatment contracts. Because insecticide treatments need to be performed for 3 years to be effective, the shortage of funding had a significant effect on the treatment schedule. Specifically, it caused APHIS and New York state officials to extend the eradication goal in New York from 2009 to 2014 or 2020, depending on future funding levels. However, for fiscal year 2006, Congress appropriated $20 million for the beetle program, an amount that raises doubts about the program's ability to meet even the 2020 date, unless USDA uses its emergency authority to transfer funds from CCC or other available USDA appropriations.

As of fiscal year 2006, over $249 million has been provided for the eradication of the beetle since it was first detected. Table 2 provides detail on federal funding toward eradication of the Asian longhorned beetle.

**Table 2: APHIS Budget Authority for the Asian Longhorned Beetle for Fiscal Years 1997 through 2006**

Dollars in millions

| | Funding source | | |
|---|---|---|---|
| Fiscal year | Commodity Credit Corporation funds | Emerging plant pests appropriations | Total |
| 1997[a] | $0.0 | $0.8 | **$0.8** |
| 1998[a] | 0.0 | 1.3 | **1.3** |
| 1999 | 6.9 | 0.0 | **6.9** |
| 2000 | 14.1 | 2.1 | **16.2** |
| 2001[b] | 49.6 | 2.1 | **51.7** |
| 2002 | 14.6 | 16.9 | **31.5** |
| 2003 | 7.0 | 26.2 | **33.2** |
| 2004 | 12.9 | 30.0 | **42.9** |
| 2005 | 14.6 | 30.0 | **44.6** |
| 2006 | 0.0 | 20.0 | **20.0** |
| **Total** | **$119.7** | **$129.5** | **$249.2** |

Source: APHIS.

[a]APHIS funded fiscal years 1997 and 1998 from its contingency fund.

[b]APHIS funded fiscal year 2001 from its Miscellaneous Pest fund.

The state of New York has provided over $12 million toward personnel costs for state employees devoted to the Asian longhorned beetle eradication program, management of tree removal contracts, tree replanting, and implementation of state quarantines. New York City provided $18 million toward tree replanting, public outreach, and a woody debris disposal program for private residents within the quarantined area. Additionally, a few municipalities within infested areas have paid for services such as traffic control during tree removal.

# Review of Efforts to Control and Eradicate the Emerald Ash Borer

Our review of the efforts to control and eradicate the emerald ash borer includes a discussion of the origin and spread of the infestation in the United States and its potential impacts. We also review the roles of federal, state, and local government agencies in addressing infestations and describe the management structures and methods they have used to control and eradicate this forest pest. Finally, we discuss the current status of the emerald ash borer infestation and outline the funds spent to date on controlling and eradicating the pest.

## Origin and Potential Impacts of Emerald Ash Borer Infestations

Emerald ash borers are metallic green beetles small enough to fit on a penny.[1] They are native to China and other countries in eastern Asia. The beetle spends most of its life in tunnels it creates in the outer layer—known as the cambium—of ash trees. The tunnels cut off the flow of water and nutrients through the cambium and eventually kill the tree, usually within 2 to 4 years. Scientists believe that ash borers arrived in the Detroit metropolitan area of southeastern Michigan by the early 1990s in solid wood packing material accompanying products shipped from Asia. Ash trees had displayed severe decline for several years in Michigan. However, observers attributed the mortality to other causes, including a native borer and a disease known as "ash yellows." It was not until June 2002 that government and university officials realized that a nonnative insect was the cause.

Armed with information about a new identification in Michigan, Canadian officials confirmed in August 2002, that the ash borer was also in Windsor, Ontario. The insect was found in Ohio in February 2003, and in Indiana in April 2004, but may have been in those states for several years. In 2003, small infestations caused by the illegal movement of nursery stock from Michigan were also found in Maryland and Virginia. Many of the infestations in states other than Michigan were caused by people accidentally moving the beetle in infested firewood, logs, or nursery trees. In addition, because ash borer populations are able to spread an estimated 5 to10 miles per year on their own, they are naturally moving into Ohio and Canada from southeastern Michigan.

The emerald ash borer is thought to have caused the death of approximately 15 million ash trees, primarily in Michigan. There are 16

[1]The emerald ash borer is also known by the scientific name *Agrilus planipennis* Fairmaire.

species of ash trees in North America, and all are believed to be vulnerable to the borer. According to Forest Service data, there are approximately 850 million ash trees in Michigan, 279 million in Ohio, and 147 million in Indiana, not counting those planted in communities, residential yards, or along public rights-of-way. The Forest Service estimates that there are approximately 8 billion ash trees in forests across the country.

Ash trees have been widely planted by homeowners and city governments, often to replace elm trees lost to Dutch elm disease. APHIS estimated that the total value of urban ash trees in the United States was between $20 and $60 billion. The Forest Service estimated that if not contained and eradicated, the borer could cause approximately $7 billion in additional costs to state and local governments, as well as landowners, for removing and replacing dead and dying ash trees in urban and suburban areas over the next 25 years.[2] In addition to being a popular ornamental tree, ash lumber is used to make furniture, tool handles, flooring, and sports equipment. USDA estimated that the value of ash timber grown in the eastern United States is $25.1 billion. Ash trees also (1) serve an ecological role by providing habitat and food for wildlife and (2) provide other environmental functions, such as producing oxygen and providing energy-conserving shade.

## Federal, State, and Local Roles in Controlling and Eradicating the Emerald Ash Borer

- *Federal government*: As with the Asian longhorned beetle program, USDA's APHIS/PPQ group has the lead for managing the emerald ash borer. APHIS surveys for the pest; regulates its movement; and conducts control, public awareness, and technology development activities. The Forest Service conducts restoration and research, and has assisted with surveying. USDA's Agricultural Research Service has also conducted research on the ash borer.

- *State governments*: The departments of agriculture in Michigan and Ohio and the department of natural resources in Indiana are the state agencies managing the emerald ash borer control program at the state level. APHIS has entered into cooperative agreements with these agencies through which it funds survey, regulatory, control, and public awareness activities.

[2]The Forest Service is in the process of refining this estimate.

- *Local governments*: Municipal agencies, such as departments of public works or forestry, remove dead and dying ash trees from public land. This has been a large task primarily in the core-infested area of Michigan, where APHIS and the state have not carried out large tree removal projects. The Forest Service has funded local governments' replanting efforts to replace ash trees.

## Management Structures and Methods Used to Control and Eradicate the Emerald Ash Borer

USDA and Michigan, Ohio, and Indiana have formed several organizational bodies to address the emerald ash borer problem. In July and August 2002, APHIS convened two New Pest Advisory Group teleconferences for the emerald ash borer.[3] The advisory group noted that eradicating the beetle was not a viable option because it was too widespread. The group also noted that a decision to eradicate would only make sense if Canada also decided to eradicate. Instead, it recommended taking steps to slow the ash borer's spread while conducting research on management techniques.

In 2002, APHIS formed an emerald ash borer management team to implement the control program. The team consists of representatives from APHIS; the Forest Service; the departments of agriculture from Michigan, Indiana, and Ohio; and universities in the three states. APHIS and the Forest Service also developed and cochair a tristate committee made up of the state plant pest regulatory officials and state foresters. The primary purpose of the committee is to help ensure that state foresters have a "seat at the table" and to identify where the state forests can play an active role to contain and eradicate the pest.

APHIS also formed a science advisory panel to examine the ash borer's threat in more detail, and to make recommendations to the management team.[4] The panel met in October 2002, October 2003, January 2004, December 2004, January 2005, and December 2005 and provided recommendations to the federal management team after each meeting. Throughout this period, the panel has stressed the need for aggressive

[3]The group included representatives from APHIS, the Forest Service, USDA's Agricultural Research Service, the Michigan Department of Agriculture, Michigan State University, the National Plant Board, and the Oregon Department of Agriculture. (Oregon was represented by an expert on similar beetles.)

[4]As of December 2005, the panel consisted of two APHIS employees, one Forest Service employee, two university professors, one state employee, three Canadian government employees, and one retired Forest Service employee.

measures to control the pest. For example, in October 2002, the panel stated its belief that urgent action was critical if the insect populations were to be contained, reduced, and ultimately eradicated with cooperation from Canada. The panel also recognized that the effort would be long and complicated, requiring substantial commitment for success. The alternative would be the potential loss of North American ash as landscape and forest trees.

Additionally, each of the three affected states has formed a task force to support state emerald ash borer management programs. The teams typically comprise representatives from the state department of agriculture, the state department of natural resources, universities, and relevant USDA agencies. The state management programs design and carry out regulatory and control activities in consultation with USDA. While the states have their own authorities to take steps to address the ash borer, USDA provides funding for those activities through cooperative agreements. These agreements spell out the financial support that USDA is to provide and the activities that the states have agreed to conduct.

Finally, the following methods have been or are being used in efforts to control and eradicate the emerald ash borer.

- *Overarching strategy*: The current goal of the APHIS emerald ash borer program is to eradicate the pest in Ohio and Indiana and keep it contained within the Lower Peninsula of Michigan. As APHIS and the Science Advisory Board learned more about the extent of infestation, the government response has evolved to what is known as the "gateway approach." Drawing upon the geography of Michigan, APHIS identified three gateways to defend: (1) the boundary between southern Michigan and northern Ohio and Indiana; (2) the Straits of Mackinac between the Lower and Upper Peninsulas of Michigan; and (3) the St. Clair River separating the eastern portion of Michigan and the southwestern portion of Ontario, Canada. However, the emerald ash borer has spread outside of the Lower Peninsula of Michigan and into each of the three gateways, and in some cases beyond. The strategy calls for focused attention on the gateways to keep more ash borers from spreading beyond them and to push current infestations back toward them. This approach is being implemented in a variety of ways, including surveying, regulatory enforcement, eradication, and public education. In the meantime, the strategy calls for little work—such as surveying or eradication—in the core-infested area of southeastern Michigan.

- *Surveys*: Following the ash borer's identification in 2002, the federal and state governments have conducted a wide range of detection and surveying activities to determine the extent of infestation. The Science Advisory Panel recommended that Indiana and Ohio survey in a band running 50 miles south of Michigan, while Michigan needed to survey throughout the state except for in the 20 southeastern counties already known to be infested. APHIS, the Forest Service, and the states use two basic techniques to survey for ash borers. Visual surveys consist of looking for symptoms of infested trees, including thinning crowns, dead branches, cracked bark, new sprouts from the base of the tree, and exit holes. Visual surveys were also enhanced by the use of tree climbers or bucket trucks to examine tree crowns. Agencies are also visually inspecting sites considered to be at high risk of infestation, including nurseries, campgrounds, firewood dealers, and sawmills. For example, Michigan reported that in 2004, it conducted 1,032 "high-risk" inspections of businesses and other entities and surveyed 1,068 public and private campgrounds in the Upper Peninsula alone.

  The second method of surveying is to use "trap trees." Healthy trees are girdled, meaning that bark is stripped from a section of the tree trunk. The girdling is thought to stress the tree and cause it to emit chemical signals that might attract the insect. After a period of time, the tree is cut down and debarked to determine whether borers have infested it. The Ash Borer Science Advisory Panel recommended varying the density of trap trees from 4 per township to as many as 36 per township, with the larger number placed in the gateways. Townships vary in size, but 36 square miles is the norm. Therefore, even the most densely surveyed townships may have only 1 trap tree per square mile. In 2005, Michigan set 10,500 trap trees, while Indiana and Ohio set 1,500 and 1,400, respectively. Other states have also added the emerald ash borer to the list of pests that they survey for as part of their APHIS-funded Cooperative Agricultural Pest Survey. The Canadian government also conducts surveys in Ontario.

  Federal and state officials with whom we spoke do not consider either surveying technique to be very effective. For most of the year, the ash borer is hidden inside the tree, and exit holes are inconspicuous. Furthermore, government agencies are not certain that trap trees actually attract ash borers any more than ungirdled ash trees do. A major shortcoming of the ash borer program is that scientists have not developed a lure for the insect that would help find the leading edge of infestation and new outliers.

- *Quarantines*: Michigan, Ohio, Indiana, and USDA have imposed a series of quarantines over an expanding area in an attempt to stop or reduce the artificial movement of the emerald ash borer into new locations. In general, the quarantines have regulated ash trees, ash lumber, ash logs, and hardwood firewood. Under state quarantines, a person or business may move regulated items, such as firewood or trees, inside a quarantine area but not outside that area unless the material is certified to be uninfested. Federal quarantines regulate the movement of the same types of materials across state lines. USDA and state regulatory officials are in charge of enforcing the quarantines. This enforcement includes identifying businesses, such as nurseries, sawmills, and firewood dealers, that handle regulated products. Businesses that want to ship regulated products outside of the quarantined area generally must first obtain approval, via a certificate or limited permit, from the state or federal government. These businesses are subject to regular inspections. A major objective of the quarantines is to stop people from moving firewood, because residents commonly take firewood to summer homes or campsites in uninfested parts of the states. State and federal regulatory officials have set up so-called "firewood blitzes" during which they check motorists at highway rest stops to make sure that they are not carrying firewood in violation of the quarantine. Michigan has also assigned inspectors to watch for firewood being moved across the Mackinac Bridge to the Upper Peninsula. A major element of the quarantines is public education. Stakeholders from all three states emphasized the importance of educating the public about the dangers of moving firewood, a message that the states have publicized using highway billboards, press releases, radio public service announcements, and mass mailings. While program officials with whom we spoke believed that their efforts have reduced the movement of potentially infested material, they concede that it is not possible to prevent all such movement, particularly of firewood. They believed that firewood is the most likely means by which ash borers will be moved to new locations. Quarantines imposed in Michigan, Ohio, and Indiana and by USDA are discussed in the following text:

  - *Michigan*: Michigan issued its first quarantine regulations in July 2002, regulating the movement of ash-related items in 5 counties in the Detroit area. Michigan added a 6th county in October 2002. As surveys found that the infestation was more widespread than originally believed, Michigan quarantined 7 more counties in August 2003, and another 7 in December 2004. As it added entire counties to the quarantine, the state also added so-called "outlier" locations to

the quarantine. These are portions of counties where surveyors have found small infestations. As of January 2006, there were 21 entire counties and 31 outlier locations under quarantine, with quarantines pending in other outlying locations. Additionally, in July 2004, Michigan revised its internal quarantine to prohibit the sale and/or transportation of ash nursery stock into, within, or out of the state's Lower Peninsula. On May 20, 2005, Michigan issued a regulation banning the movement of untreated nonconiferous (hardwood) firewood[5] out of the state's Lower Peninsula—regardless of whether the wood came from a quarantined area—and allowing the movement of ash logs and ash lumber with bark out of the Lower Peninsula only under a compliance agreement with the state department of agriculture.

- *Ohio*: In September 2003, Ohio issued the first of a series of quarantines for ash and related products. As of November 2005, Ohio had quarantines in place in portions of 11 counties. Ohio also prohibits the movement of regulated materials into the state from Michigan.

- *Indiana*: In April 2004, Indiana issued the first of a series of quarantines for ash and related products. The state began by regulating one township in Steuben County. Subsequent amendments throughout 2004 and 2005 have added new townships to the list of quarantined areas. As of January 2006, Indiana had quarantined 9 townships in 4 counties.

- *USDA*: The federal government's first emerald ash borer quarantine took effect on October 8, 2003, and covered 13 Michigan counties. USDA stated that federal regulations were necessary to prevent the spread of the ash borer to other states. On January 5, 2005, USDA amended its federal quarantine, effective December 28, 2004, to add areas in Michigan, Indiana, and Ohio, noting that recent surveys had revealed infestations outside the 13-county quarantined area in Michigan. USDA added more areas in Michigan, Ohio, and Indiana to the list of quarantined areas, effective February 25, 2005, and even more areas effective October 25, 2005.

[5]Ash is a hardwood. All hardwoods are regulated as a precaution because of the difficulty of distinguishing ash firewood from some other species of hardwood, such as oak or maple.

- *Removal of infested or potentially infested trees*: The primary method for controlling emerald ash borer is to cut, chip, and burn infested or potentially infested trees. To date, government agencies have cut hundreds of thousands of trees in the three states.[6] However, the management team and Science Advisory Panel have agreed that the priority for tree removal is in the gateway areas and outlying areas, rather than in the core-infested area of southeastern Michigan.

  The Science Advisory Panel currently recommends tree removal projects that strive to cut all ash trees within a 0.5 mile radius of a tree known to be infested in an outlying area. The highest priorities are those outlying areas in or near one of the gateways.[7] However, the management program has not been able to complete eradication projects in all of the gateway infestations because of inadequate funding. As a result, these infestations are likely to continue to pose a risk to those gateways.

  Michigan has recently completed or begun removing trees at 3 of the 15 infested sites in the northern and southern gateway areas. According to the state's program manager, the state will complete the work at these sites by May 1, 2006. He also said that the state could have completed work at the other 12 sites in the two gateways by May 1, 2006, if adequate funds were available. May is a significant target date because that is about the time adult ash borers emerge from the trees. To prevent their emergence and possible flight to new locations, trees should be removed by then. Michigan completed a 0.5-mile eradication in 2005 at 1 site outside of the gateways; this was a site in the Upper Peninsula beyond the northern gateway. As of December 2005, Ohio had delineated 11 infested sites but had been able to complete the 0.5-mile eradication at only 6 of them. Because of funding shortages, the state only planned eradication cuts in 2 counties (Delaware and Auglaize). Those infestations were the furthest south from the leading edge of

[6]This is a huge number of trees. However, to put the number in perspective, note that the trees include saplings that can be less than 1 inch in diameter.

[7]Infested sites slated for eradication are not all equal. To define a site, surveyors map a ½ mile radius around a single infested tree. If that is the only infested tree found in the area, the eradication zone will be about 8/10 of a square mile. If multiple trees in the area are infested, the size of the eradication zone becomes larger. For example, one eradication zone in Indiana is about 10 square miles in size. The number of ash trees that need to be cut in each area may vary greatly, thereby affecting the time and expense of the eradication project.

infestation, and the state hoped to complete them by the end of March 2006. If additional funds are available, the state will focus on the furthest east infestations in Erie and Lorain Counties. This would still leave numerous infestations in Defiance, Fulton, Hancock, Lucas, Ottawa, and Wood counties. As of December 2005, Indiana had been able to complete 0.5 mile eradication projects at 2 of the 8 infested sites within the southern gateway, according to the State Entomologist. At that time, he told us that additional eradication activities were planned for 2006.[8] However, on January 25, 2006, the Indiana Department of Natural Resources announced that the state will no longer require nor fund the removal of trees in an infested area. A department press release quoted the State Entomologist as saying "the removal of ash trees surrounding an infested area has not proved to be an effective approach to controlling the emerald ash borer because of the near impossibility in detecting a new infestation."

While APHIS and Michigan have worked to harvest trees in outlying areas, they also created locations where homeowners and local governments in the core-infested counties could bring dead ash trees for disposal. To help handle the volume of woody debris, by 2004 Michigan had operations at 8 sites in quarantine areas to grind and dispose of ash material. The Michigan Department of Agriculture reported that the facilities have disposed of over 300,000 tons of ash. The facilities were supported with federal funding, which originally enabled the state to offer the service to municipalities and property owners at no charge. However, due to funding constraints in 2005, the 7 sites still in operation began to charge fees that varied depending upon the type of material.

- *Research*: All of the officials with whom we spoke regarding the emerald ash borer noted that government agencies do not have adequate tools with which to manage the pest. Over the years since the program began, APHIS, the Forest Service, the Agricultural Research Service, and universities have conducted approximately 50 research projects to support emerald ash borer management. In December 2004, the Science Advisory Panel identified several research areas needing continued or additional attention, including: (1) survey and detection tools; (2) control techniques, including insecticidal control; (3) emerald ash

[8]On January 20, 2006, the department reported the detection of an infestation in Hamilton County. The department estimated it had been there for 7 years.

borer behavior and biology; (4) host range and host resistance; and (5) treatment techniques for ash logs and firewood.

Research on the use of insecticides indicates that there are treatments that can be effective at protecting healthy ash trees from being attacked by the ash borer. However, these treatments are expensive to apply. While it may be feasible for individual landowners to use the treatments to protect individual trees, these insecticides cannot be practicably used on a large scale in a forest environment and do not appear to have a significant benefit for trees already infested. Research on biological controls indicates that there may be Asian parasites that could be introduced to prey upon emerald ash borer. Stakeholders we spoke with believe that successful management of the ash borer will depend upon discovery of a biological control that can be used widely and inexpensively across the landscape. Typically, it takes many years for such technologies to be developed and approved for use.

- *Restoration efforts*: While little can be done directly to restore forested areas affected by the ash borer, the Forest Service has allocated funds to help local communities replace trees killed by the pest. For example, in 2004, Michigan used Forest Service funds to provide more than $855,000 in grants to communities within the quarantined counties to plant about 10,700 trees to replace ash trees that had been removed. The state also provided 10 grants totaling more than $200,000 to communities located in outlier areas to plant more than 3,500 trees. In 2005, the state awarded another 80 grants to communities—primarily in the quarantined areas—to pay for the planting of approximately 13,000 trees. These trees are small in size and number in comparison to the dead trees removed.

## Status of Infestation

The emerald ash borer now infests an estimated 40,000 square miles in three states plus Ontario, Canada. Government surveyors continue to find new infestations, including some that scientists estimate began several years ago. While program managers believe that quarantines have helped to slow the artificial spread of the pest, most do not believe that quarantines have completely stopped the public from moving the pest. Movement in firewood is a particular concern. In addition, populations of the pest are able to naturally spread on their own. Considering these circumstances and the lack of cost-effective management tools, program officials with whom we spoke were not optimistic that the infestation can be eradicated. In December 2005, the ash borer Science Advisory Panel concluded that

current resources available to the program are inadequate to achieve the long- or short-term goals of the program.

## Funding for Emerald Ash Borer Control and Eradication Efforts

From fiscal years 2002 through 2006, the federal government has allocated about $107 million for the emerald ash borer program. The primary source of funding for the emerald ash borer program has been USDA APHIS, which has had budget authority of over $93 million from fiscal years 2002 through 2006 (see table 3). The Forest Service has been the other major source of federal funding, with budget authority of close to $19 million during that time period (see table 4). The Secretary of Agriculture has allocated funds to the program from the emergency CCC and congressionally appropriated pest management and forest management programs. Funds support work done by the states as well as by federal employees assigned to work on the program.

**Table 3: APHIS Budget Authority for the Emerald Ash Borer Program, by Funding Source and Fiscal Year**

Dollars in millions

| | Funding source | | |
|---|---|---|---|
| Fiscal year | Commodity Credit Corporation funds | Other appropriated funds | Total |
| 2002 | $0.0 | $0.2 | **$0.2** |
| 2003 | 14.6 | 0.0 | **14.6** |
| 2004 | 43.4 | 1.5 | **44.9** |
| 2005 | 18.8 | 5.0 | **23.8** |
| 2006 | 0.0 | 10.0 | **10.0** |
| **Total** | **$76.8** | **$16.7** | **$93.5** |

Source: APHIS.

**Table 4: Forest Service Budget Authority for Emerald Ash Borer Activities, by Funding Source and Fiscal Year**

Dollars in millions

| | Funding source | | | |
|---|---|---|---|---|
| Fiscal year | Commodity Credit Corporation appropriations | State and private forestry appropriations | Research and development appropriations | Total |
| 2002 | $0.00 | $0.04 | $0.00 | **$0.04** |
| 2003 | 2.80 | 0.95 | 0.70 | **4.45** |
| 2004 | **0.00** | 4.59 | 0.80 | **5.39** |
| 2005 | 0.00 | 4.49 | 1.13 | **5.62** |
| 2006 (anticipated) | 0.00 | 1.90 | 1.25 | **3.15** |
| **Total** | **$2.80** | **$11.97** | **$3.88** | **$18.65** |

Source: Forest Service.

APHIS issued a strategic plan in 2005 that projected $383,750,000 would be needed from fiscal years 2005 through 2018 to eradicate emerald ash borer. Of that total, $162,900,000 would be needed in Michigan, $87,250,000 in Ohio, and $31,050,000 in Indiana. However, actual funding levels in fiscal years 2005 and 2006 have been considerably lower than what APHIS believed was needed—$23.8 and $10.0 million versus $43 and $34 million, respectively—raising doubts about those long-term estimates.

# Review of Efforts to Control and Eradicate *P. ramorum*

Our review of the efforts to control and eradicate *Phytophthora ramorum* (*P. ramorum*) includes a discussion of the origin and spread of the infestation in the United States and its potential impacts. We also review the roles of federal, state, and local government agencies in addressing infestations and describe the management structures and methods they have used to control and eradicate this plant pathogen. Finally, we discuss the current status of the *P. ramorum* infestation and outline the funds spent to date on controlling and eradicating the pathogen.

## Origin and Potential Impacts of *P. ramorum*

*P. ramorum* is a recently introduced plant pathogen of unknown origin currently found in natural and nursery environments in North America and Europe. It is unclear how the pathogen arrived in the United States. The pathogen is the causal agent of the plant disease known as Sudden Oak Death and has caused the death of tens of thousands of tanoak and true oak trees throughout central coastal California.[1] *P. ramorum* has also infected thousands of shrubs and herbaceous plants in natural and nursery environments. The pathogen can spread via spores that move through water, moist soil, wind-blown rain, and the movement of infected plant materials. Moisture seems to be an important factor for the pathogen's survival and spread, and the natural infestation appears along the path of the coastal fog belt in California. In addition, detecting infected plants can be difficult due to the variability of symptoms by species. The large range of hosts and the varying symptoms have added to the difficulty in managing *P. ramorum*.

In the mid-1990s, hikers noticed the apparent sudden death of tanoaks in the populated, wildland-urban interface environments of Marin, Santa Cruz, and Monterey counties in California. Despite the public reporting of observed tree mortalities, no action was taken to determine the cause until coast live oaks began to show signs of decline in 1997. By the end of 2001, the infestation had spread to 9 California counties and was found on 40 acres in Curry County, Oregon.[2] Since that time, the pathogen has continued to spread in California's natural environment and now infests 14 central counties.

[1]The tanoak, *Lithocarpus densiflorus*, is not a member of the oak genus.

[2]According to the Oregon Department of Forestry, there is no evidence of the pathogen spreading from California to Oregon.

The Forest Service constructed a preliminary risk map of the United States in 2002, to determine the highest risk natural areas for potential *P. ramorum* infestations on the basis of potential pathways, susceptible plant species, and weather conditions favorable to the spread and survival of the pathogen. (See fig. 9 in the letter of this report.) The map indicates that the Appalachian Mountains and the coastal areas of California, Oregon, and Washington are at the greatest risk of possible infestation. The map suggests areas of lower risk, based on moisture and temperature, among other factors, that may serve as a barrier to *P. ramorum*'s natural spread between the western and eastern United States. The risk map also demonstrates the threat posed by the artificial spread of the pathogen to the oak forests of the eastern United States. The first detection of the pathogen on a nursery plant—a rhododendron—occurred in January 2001, in a California nursery surrounded by a heavily *P. ramorum*-infested forest. However, the discovery did not raise much concern within the nursery industry or the scientific community in California since the pathogen was still perceived to be primarily a threat to the natural landscape. This was despite the presence of a different population and mating type of *P. ramorum* infesting European nurseries and garden centers. In March 2004, the APHIS *P. ramorum* National Nursery Survey discovered the pathogen on camellias in a large nursery in Los Angeles County, California, an area considered to be low risk for the spread of *P. ramorum*. Agency officials determined that the nursery had shipped potentially infected plants to over 1,200 establishments in 39 states. By the end of 2004, APHIS confirmed *P. ramorum* at 176 sites in 22 states, and over 1 million nursery plants were destroyed as a result of the detections.

The long-term environmental impacts of *P. ramorum* are not well quantified. Government agencies estimate that *P. ramorum* has killed tens of thousands of trees in California and hundreds in Oregon, although the true number of mortalities is unknown. The extent of *P. ramorum* infestation in the natural environment is oftentimes difficult to determine since the distribution of mortality within the landscape is patchy. Also, secondary pests often infect *P. ramorum*-infected trees, making diagnosis difficult. However, in some areas, mortality can be as high as 85 percent. The Forest Service is conducting an analysis to determine the number of tree mortalities, but the results are still pending. Oak species are important for forest and woodland biodiversity, and tree mortality resulting from *P. ramorum* can lead to the loss of food and habitat for wildlife, increase the risk of fire, and cause soil erosion.

The economic impacts associated with *P. ramorum* affect several stakeholder groups, including the forest and horticultural industries. The oak hardwood forest is the largest forest type in the United States and is an important commodity in the timber products industry. The Forest Service has estimated the potential threat to commercial timber production could potentially exceed $30 billion dollars if *P. ramorum* were to become established in the eastern deciduous forests. California's timberlands alone are valued at over $500 million for forest products. Furthermore, live oaks play a more important role in the local ecology as one of the key drought tolerant species and are widely prevalent as a landscape tree, adding to property values in upscale communities. In addition to the timber industry, the potential impact of the pathogen to the U.S. nursery industry is high. Since the pathogen was detected in nurseries in 2002, damage to the nursery industry has been estimated to be between $3 and $17 million, including costs associated with inventory management, green waste disposal, and insurance. This estimate does not, however, include lost sales.

Despite affecting an area with a population of more than 7 million people, the true social impact of *P. ramorum* has yet to be determined. Affected stakeholders include homeowners, Native American tribe members, arborists, and firefighters. For example, the Kashia tribe, currently the only Native American tribe with *P. ramorum* on their lands, has historically used the tanoak acorn as one of the main staples in their diet. Tanoak acorns and other host plants are also used in ceremonial dress and baskets. The sociocultural impact of the loss of tanoak trees on this community is difficult to quantify. Likewise, it is equally difficult to quantify the impact of the loss of coast live oaks to neighborhoods in which they are a primary ornamental species.

## Federal, State, and Local Roles in Efforts to Control and Eradicate *P. ramorum*

At the federal level, APHIS regulates the interstate movement of host and associated host plants and other regulated articles from quarantined areas in California and Oregon. In addition to funding inspections in regulated states, APHIS has also coordinated inspections at nurseries in states across the country. To date, the Forest Service's primary activities have included sponsoring extramural research projects and coordinating surveys of forested areas.

State agriculture departments in California and Oregon regulate the intrastate movement of regulated articles, monitor quarantines, and undertake eradication efforts that take place within their own state.

Through cooperative agreements with APHIS, regulated states also inspect nurseries that ship hosts and associated host plants interstate. In California, the state agriculture department contracts with the county agriculture inspectors to inspect interstate shipments and conduct annual nursery inspections. Other state agriculture departments participate in the *P. ramorum* National Nursery Survey by sampling high-risk nurseries in their state. In addition, state forestry and natural resource departments inspect forests for the National *P. ramorum* Survey of Forest Environments in partnership with the Forest Service.

In contrast to California's control program, Oregon is attempting to eradicate the pathogen from a small portion of Curry County with assistance from the Forest Service. Aerial surveys first detected symptoms of the pathogen in July 2001, and subsequent extensive ground surveys of the area determined the infestation to be limited to 40 acres within a 9-square mile area. Oregon and the Forest Service established an eradication program that clearcut and burned host trees and plants in the infested area. As of December 2005, the program had identified 51 infested sites in Oregon covering a total of 88 acres and increased the quarantine area to 22 square miles in early 2006.

## Efforts to Control and Eradicate *P. ramorum*

- *Overarching strategy*: Because there is no cure, minimizing the artificial spread of *P. ramorum* is the primary management action in California. Based on the widespread natural area currently infested by *P. ramorum* along the central California coast, containment of the pathogen through quarantine regulation is the only feasible alternative since the current level of infestation is too widespread to attempt large eradication efforts. However, in areas where the infestation is not considered to be widespread, more aggressive, slow-the-spread or eradication efforts can be implemented. For example, in addition to the eradication effort in Curry County, Oregon, the Forest Service is coordinating a slow-the-spread project in Humboldt County, California, where the infestation is relatively small. These efforts include early detection and monitoring of the area, selectively removing host plants to limit pathogen spread, eradicating hot spots, and using various fungicides to inhibit sporulation of *P. ramorum* on tanoaks. For nurseries with confirmed positive detections, APHIS's regulatory protocol is to destroy all host and associated plats and plant parts within a specific block area. However, this destruction does not ensure eradication and several nurseries have had subsequent outbreaks. APHIS is revising the protocol in an effort to prevent these reoccurrences.

- *Surveys*: APHIS and the Forest Service have joined with state agencies across the country to survey for *P. ramorum* in nurseries and forest environments. APHIS coordinates the *P. ramorum* National Nursery Surveys with state agriculture departments. The agency's goal is to survey high-risk nurseries in all 50 states to determine whether the pathogen has been spread artificially through infected nursery stock. Any positive detection of the pathogen in nurseries would trigger further investigations to determine the movement of potentially infected plants between nurseries and customers. The Forest Service has conducted aerial and ground surveys in California and Oregon to identify infestations, and is coordinating the National *P. ramorum* Survey of Forest Environments with state forestry agencies to inspect forests near nurseries that have received plants from areas that are considered high-risk.

- *Quarantines*: Although Oregon and California took action to prevent the pathogen's artificial spread through intra- and interstate quarantines and regulations beginning in 2001, the federal government was slower to enact regulations. In February 2002, APHIS issued an interim rule quarantining 10 counties in California and part of Curry County, Oregon, and regulating nurseries that operated within the quarantined counties that shipped host or associated host plants or other regulated articles outside of the area. At that time, knowledge of the pathogen's life cycle was limited, and it was believed that areas in Southern California would be inhospitable due to the dryness and heat. In March 2004, it came as a surprise when the *P. ramorum* National Nursery Survey confirmed detections of the pathogen in a Southern California nursery well over 400 miles from the nearest known infested forest. Shipments from this nursery were traced to over 1,200 establishments in 39 states. Within 1 month, 15 states imposed their own quarantines on nursery products and some states banned outright all California nursery stock shipments. California nurseries were estimated to have suffered $4.3 million in lost sales for March 2004.

  APHIS responded to the positive nursery detections by issuing an emergency order extending the quarantine to 2 additional California counties on April 9, 2004, requiring all California nurseries shipping host and associated articles interstate from nonquarantined counties to be visually inspected and tested before shipping occurred. However, after meetings with the National Plant Board and the National Association of State Departments of Agriculture, APHIS amended the emergency order on April 22, 2004, to require California nurseries in the nonquarantined

counties that shipped *P. ramorum* hosts and associated articles interstate to be inspected by a regulatory official, sampled, and tested for the disease before shipping.

Despite the federal quarantines and order, some states continued to quarantine nursery products from California. Five states requested a Special Needs Exemption from the federal regulations in July 2004, but APHIS denied those requests.[3] In addition, California and the nursery industry requested that APHIS take measures against the states that were imposing quarantines more stringent than the federal government's. APHIS, however, did not take action against these states. In July 2004, the California Association of Nurseries and Garden Centers filed a suit against the Commissioner of the Kentucky Department of Agriculture and others claiming the state violated the Supremacy Clause of the United States Constitution and the federal Plant Protection Act by regulating California nursery stock for *P. ramorum* in a manner that is inconsistent with and exceeds federal regulation. The lawsuit was settled the same month and the court entered a consent order under which the Kentucky defendants agreed to a permanent injunction prohibiting implementation or enforcement of any regulations, orders, policies, or quarantines for *P. ramorum* that are inconsistent with or in excess of USDA's regulation of the pathogen.

Also in July 2004, APHIS conducted a review of its *P. ramorum* management program to analyze current USDA policy, the regulatory responses, and the status of *P. ramorum* in the United States. In a memorandum to the APHIS Administrator, the PPQ Deputy Administrator wrote that while eradication in the natural environment is likely not viable because that pathogen is too widespread, quarantine regulations should continue. Another outcome was the decision to expand the federal order when needed on the basis of each situation's specific risk of spreading *P. ramorum* in interstate trade.

After much deliberation with stakeholders, APHIS issued an emergency federal order on December 21, 2004, that went into effect on January 10, 2005, replacing the earlier emergency order. The order—which expires in January 2008—requires all nurseries in California, as well as Oregon

[3]Under the Plant Protection Act, a state may not regulate pests more stringently than USDA, unless the state has requested and the Secretary of Agriculture has made a finding of "special need" based on sound scientific data or a thorough risk assessment.

and Washington, that ship host and associated plant nursery stock interstate to have their nursery stock inspected, sampled, tested, and certified free of *P. ramorum*. In addition, nurseries in a quarantined area that ship nonhost plants interstate must undergo an annual visual inspection. APHIS will decide what further actions need to be taken to control *P. ramorum* when the emergency order expires in 2008.

## Status of the *P. ramorum* Infestation

At this time, there is no known cure for plants infected with *P. ramorum*. Although a number of fungicides are being tested, there is no chemical treatment available to eliminate *P. ramorum* when the pathogen is well-established in the natural environment or on nursery stock. Without a cure, minimizing the artificial spread of *P. ramorum* is the primary management action. Currently, *P. ramorum* is known to infect species in more than 55 plant genera. The complete list of hosts is unknown and continues to grow as additional infected species are identified. As of October 2005, the *P. ramorum* National Nursery Survey had identified 25 positive detections in nurseries in 2005. Changes in the federal order, effective January 2005, have increased nursery inspections and by the end of 2005, APHIS found 99 confirmed positive detections of *P. ramorum* associated with nursery plants in 7 states, a decline from 2004. Key stakeholders with whom we spoke do not believe the pathogen can be eradicated from the natural environment in California. However, the infestation in Oregon has been contained to a small portion of Curry County, and many of the stakeholders with whom we spoke are optimistic about controlling and eventually eradicating its spread in Oregon and the nursery environment.

## Funding of Efforts to Control and Eradicate *P. ramorum*

Several federal and state agencies contribute funding and resources to the *P. ramorum* program. APHIS provides funding in the form of annual cooperative agreements to regulated states for management activities, such as inspecting, sampling, and testing nursery plants. The Forest Service has provided infrastructure support and funding to the California Oak Mortality Task Force[4] for public outreach since 2000. The agency has also provided funds to Oregon for eradication activities in Curry County. Additional contributions to *P. ramorum* management by other USDA agencies, such

[4]The California Oak Mortality Task Force is a coalition of research and educational institutions, public agencies, nonprofit organizations, and private interests. Its stated objectives include assisting communities affected and threatened by *P. ramorum* and providing information and education to interested parties.

as the Agricultural Research Service and the Cooperative State Research, Education, and Extension Service, include providing training and educational materials to diagnose infected plants in the landscape environment, improving diagnostics, and developing fungicides. Table 5 outlines the funds spent by various USDA agencies to control *P. ramorum* between fiscal years 2000 and 2005.

**Table 5: Summary of USDA funding for *P. ramorum*, Fiscal Years 2000 Through 2005**

Dollars in millions

| | Funding, by USDA agency | | | | |
|---|---|---|---|---|---|
| **Fiscal year** | **Forest Service** | **Animal and Plant Health Inspection Service** | **Agricultural Research Service** | **Cooperative State Research, Education, and Extension Service** | **Total** |
| 2000 | $0.12 | $0.00 | $0.00 | $0.00 | **$0.12** |
| 2001 | 4.20 | 0.00 | 0.00 | 0.00 | **4.20** |
| 2002 | 0.97 | 0.90 | 0.00 | 0.00 | **1.87** |
| 2003 | 3.70 | 2.00 | 0.62 | 0.30 | **6.62** |
| 2004 | 3.70 | 19.50 | 1.30 | 0.30 | **24.80** |
| 2005 | 4.40 | 12.40 | 1.00 | 0.12 | **17.92** |
| **Total** | **$17.09** | **$34.8** | **$2.92** | **$0.72** | **$55.53** |

Source: USDA.

# Risk Analysis as a Tool to Address Invasive Forest Pests

The PPQ organization within APHIS is the primary federal agency responsible for protection of the nation's public and private forests from invasive forest pests, while providing for movement of agriculture and other commodities across the United States and its borders. In 1999, President Clinton signed Executive Order 13112 on invasive species. The order established the National Invasive Species Council, in part, to coordinate the federal government's efforts to manage risks associated with invasive pests. The order also called for a scientific process to evaluate risks associated with the introduction and spread of invasive pests and to develop a risk-based process for control and management of invasive pests. Furthermore, under the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS), the United States must be able to justify protection measures against invasive pests on the basis of scientific principles and a risk assessment and protection measures must not be applied in a manner that would constitute a disguised restriction on international trade. Consequently, risk analysis is important as it constitutes key evidence for member countries demonstrating that the measures they have adopted are to ensure human, animal, or plant protection, rather than to create arbitrary barriers to trade. To this end, APHIS develops and employs risk analysis as an essential tool in meeting its responsibilities for detection, control, as well as development of appropriate programs aimed at management of invasive pests.

Although PPQ is the primary agency that assesses the risks that invasive plant pests pose to the United States' economy and environment, a large number of offices within USDA and APHIS are engaged in activities related to risk analysis. The Center for Plant Health Science and Technology (CPHST), in particular the Plant Epidemiology and Risk Analysis Laboratory group in the CPHST division of PPQ, is the scientific support organization that assesses the risks that invasive plant pests pose to the United States' economy. Risk Analysis Systems, a component of the Policy and Program Development (PPD) office within APHIS is devoted to basic investigations associated with risk analysis, data collection, quantitative methods, and other analytical support activities required for APHIS programs. The office of Policy Analysis and Development, also in PPD, provides economic analysis for rulemaking and cost-benefit analysis required for a USDA "major proposed regulation," the primary purpose of which is to regulate issues of human health, human safety, or the

environment.[1] Finally, the Office of Risk Assessment and Cost-Benefit Analysis, under the office of USDA's Chief Economist, is to ensure that regulatory analyses include a risk assessment and cost-benefit analysis that are performed consistently and use reasonably obtained and sound scientific, economic, technical, and other data.

In this appendix, we briefly give an overview of APHIS's responsibility for conducting risk analysis for detection, control, and regulation of invasive forest pests. We also define the essential component of risk analysis—risk assessment and risk management. Finally, we discuss what risk assessment was done by APHIS for the three pests investigated in this report.

## Pest Risk Assessment Is an Essential Element of Risk Analysis

Pest risk assessment is the essential first component of risk analysis; risk management and communication are the other components. In general, pest risk assessment involves estimating the likelihood of the introduction, establishment, and spread of invasive pests. Risk assessment also involves estimation of economic and environmental consequences associated with the spread and establishment of invasive pests. Risk management, however, involves identification and selection of appropriate risk management options; risk communication involves documentation and conveyance of this information to interested parties.

In general, the protocol and terminology used by APHIS in conducting its risk assessments are developed pursuant to the international standards as established by the SPS and the International Plant Protection Convention (IPPC). Although SPS establishes the baseline requirement for the use of risk assessments, IPPC is the key organization for providing the detailed guidelines to be followed by member countries when conducting these assessments. IPPC guidelines are published by the Secretariat under a number of International Standards for Phytosanitary Measures (ISPM)—such as ISPM No. 11, which provides detailed guidance for risk analysis for quarantine pests.[2] Under this standard, the process for risk assessment for quarantine pests involves a number of specific steps that could include,

[1]A "major regulation" is any regulation that the Secretary of Agriculture estimates is likely to have an annual economic impact on the U.S. economy of $100 million in 1994 dollars.

[2]IPPC defines a "quarantine pest" as a pest of potential economic importance to the area the pest endangers but not yet present there, or present but not widely distributed and being officially controlled.

(1) identification of the pest or pathway risk for introduction of the pest, (2) estimation of the likelihood of pest entry, (3) estimation of the likelihood for establishment and spread, (4) estimation of economic and environmental consequences, and (5) integrating this and other information about risks into an overall conclusion about risk that will be useful to decision makers.

Resources and data permitting, pest risk assessments can be conducted quantitatively where various likelihoods are quantified and integrated. Individual risk factors are combined, resulting in an overall conclusion about the pest risk. That is, the threat of establishment of the invasive pest and the economic and environmental impacts of the pest invasion. However, when data for quantitative evaluation are lacking, risk assessments are based on a more subjective assignment of the risk values and on qualitative scales, such as high, medium, or low risks. Such qualitative presentations usually omit the details that are included in the more rigorous quantitative risk assessments.[3]

In general, in the absence of reliable data, APHIS relies, to a great extent, on qualitative analysis to assess the threat of invasive pests.[4] For example, APHIS used a qualitative assessment to assess the risk for entry, establishment, and consequence of establishment of the Asian longhorned beetle associated with solid wood packing material imported from China. Three risk factors—entry, establishment, and consequences—were all rated "high." APHIS then combined these individual risk factors to arrive at one overall high-risk rating for the pest.

[3]A more rigorous analysis could, for example, assign ranges and probability distributions to introduction, rate of spread, or effectiveness of controls being applied to invasive pests and using probability models make projections as to what might happen.

[4]The study, *Economic and Policy Implications of Wind-Borne Entry of Asian Soybean Rust into the United States*, is one example of a more rigorous analysis of invasive pests. It was conducted by the Economic Research Service in collaboration with other USDA offices. The study which was completed in 2004, explicitly introduces probabilities to quantify the likelihood of various occurrences and specifies various geographic scenarios of rust outbreak extent and yield loss to estimate a range of economic impacts on agriculture producers and consumers.

## Risk Assessment Is a Tool for Risk Management

The ultimate value of risk assessment is the extent to which it is used by risk managers to target activities, allocate resources, justify regulations, and improve the quality of their management decisions. In particular, risk assessment can be used to prioritize pest threats, targeting limited resources commensurate with the risk of pest threats, and to mitigation and control programs that most effectively address the most significant threats and produce the most impact for the resources invested. APHIS conducts risk assessments to be used for import and export and for emergency and regulatory programs. It also could integrate risk-based information in several aspects of its invasive pest management decision making.

APHIS conducts risk assessments to assess the potential threat of introducing new and of exotic plant pests into the United States when permits are requested for importation of plants or plant products.[5] Such risk assessment begins by determining the likelihood of a harmful pest becoming established in the United States and the magnitude of potential adverse consequences. When this risk is deemed unacceptable, the assessment could lead to identifying risk mitigation options and eventually to decisions to authorize, prohibit, or allow importation under specific conditions, depending on the risk and potential adverse effects of the pest. Furthermore, for invasive pests that have previously entered the United States, risk assessments can be conducted to estimate the likelihood and potential damage of further spread across the country and to support decision makers' allocation of resources to different control and eradication measures.

Risk assessment can also become a component of economic analysis required for rulemaking to regulate invasive pests. The Policy Analysis and Development office provides economic impact and cost-benefit analysis. When available, risk assessment can be used as an additional input for conducting regulatory impact analysis and is a component of information forwarded to decision makers, along with economic analysis.

[5]More specifically, risk assessment associated with trade includes commodity risk assessment for plants and plant products proposed for import; pathway risk assessment associated with baggage, packing materials, and mail; and export risk assessment to support market access for the United States exports.

Finally, risk assessment can be a valuable tool used by decision makers in budget development, resource allocation, and prioritization programs and strategies to control the threat of invasive pests.

## APHIS Has Conducted Risk Assessments for *P. ramorum* and the Asian Longhorned Beetle

The risk assessments for the pests we reviewed were focused on showing that the pest problem is potentially significant and warrants a management response. We did not see analysis of the costs and benefits of taking specific management actions within specific time frames.

The risk analysis for the pathogen *P. ramorum* was conducted and published in May 2005 by APHIS's Plant Epidemiology and Risk Analysis Laboratory. The analysis was aimed at assessing the risk associated with the importation and domestic spread of the pathogen. Such risk assessment would make possible the promulgation of regulations and present mitigation measures to prevent the movement and spread of the pest to noninfested areas of the United States. The assessment was conducted pursuant to relevant international standards published by IPPC and APHIS guidelines for pest risk assessments.[6]

In this risk analysis, a qualitative scale was used to rate all individual risk factors for *P. ramorum*. This led to an overall pest risk potential for this pest—to spread, infect, and cause potential economic and environmental consequences—of a "high" rating. In particular, as there are many areas in the United States with potential hosts and climates favorable to the pest, the rating for the Host-Climate Interaction Factor was judged to be "high." Similarly, given that many host plants are susceptible to infection by this pest, and that a number of other factors, both natural and human-assisted, can aid the dispersal of the pest to areas with suitable hosts and climate conditions, the risk rating for Host Range and Dispersal Potential factors were judged to be "high." As a result of a "high-" risk rating in these and other risk elements, the overall risk potential for the pest was assessed as "high."

APHIS has not published similar detailed risk assessment studies for the emerald ash borer or the Asian longhorned beetle. However, in 1998, APHIS published a risk assessment report for the Asian longhorned beetle, as a part of a study examining the risks associated with solid wood packing

[6]USDA, APHIS, PPQ, Permits and Risk Assessment Commodity Risk Analysis Branch, *Guidelines for Pathway-Initiated Pest Risk Assessments*, *Version 5.02* (October 2000).

material imported from China into the United States. According to this study, because of widespread detection of the pest in the United States, favorable climate, and a wide variety of hardwood tree hosts, both the risk of entry through this pathway and establishment of the Asian longhorned beetle in the United States were rated as "high." Furthermore, because many studies had suggested that the beetle could severely affect the forest resources and forest-related industries in the United States, the risk for potential consequences was also rated "high," leading to a "high" overall risk potential for infection from the Asian longhorned beetle in the United States.

Finally, APHIS has not conducted an economic risk assessment for the emerald ash borer. The Forest Service generated some preliminary estimates of the damages that the ash borer could cause across the country, including the impacts on the ash timber industry and ash trees in residential areas. APHIS cited these estimates in support of its decision to impose quarantine regulations. The Forest Service is in the process of revising its analysis of the potential impact of ash mortality in urban areas; it expects to complete this analysis in early 2006.

# Comments from the Department of Agriculture

United States Department of Agriculture

Office of the Secretary
Washington, D.C. 20250

MAR 29 2006

Ms. Robin Nazzaro
Director
Natural Resources and Environment
United States Government Accountability Office
441 G Street, NW
Washington, D.C. 20548-0001

Dear Ms. Nazzaro:

Thank you for the opportunity to review the draft Government Accountability Office (GAO) report GAO-06-353, entitled "AGRICULTURE INVASIVE SPECIES: Lessons Learned from Three Recent Infestations May Aid in Managing Future Efforts." We find the report to be comprehensive and well-written.

Although we do not have major concerns regarding the three recommendations in the report, we do not completely agree with them. Accordingly, we offer following comments.

The beginning and ending sections of the report seem appropriate, but intervening sections give an unfavorable impression of the job done by the agencies. Various agencies worked hard against these invasive species with some success. For example, the Asian long-horned beetle (ALB) is nearly eradicated from Chicago, and Sudden Oak Death (SOD) does not seem to be present in the forests of the eastern United States. On the other hand, the emerald ash borer (EAB) now seems well established in the United States. ALB and EAB were not on any list of potential or existing invasive species, and we could not have predicted they would enter the United States. Phythophora ramorum, the organism responsible for the plant disease known as sudden oak death (SOD), is a new pest previously unknown to science. Given these considerations, we believe that the coalition of Federal and State agencies and private collaborators did a reasonable job in combating these pests. We recognize that improvements can be made, but we disagree with the generally critical tone of the report. It is our view that decisions were made in a short time frame, in the heat of the crisis, and most of them were the correct decisions.

Recommendation 1, to increase urban monitoring, focuses only on Federal government agencies. The effort to combat invasive species necessarily requires a partnership among personnel in Federal, State, university, tribal, business and non-governmental organizations. GAO did not examine the roles of these partners, their responsibilities, or the outcomes of their efforts. We suggest including all affected organizations in recommended actions.

An Equal Opportunity Employer

Recommendation 2, keeping management plans updated, is a sound business practice which we support. We believe a reasonable job was done in this regard, given the workload and the fact that there was the need to allocate resources to get the job done on-the-ground—which left little time to update management plans.

Recommendation 3, put more rigor into how science panels are formed, seems reasonable. It implies, however, that people who had important information to share were not heard. We believe there were ample opportunities for all interested parties to be heard either directly or through representatives. The use of a Federal Advisory Committee Act-chartered committee would hamper our flexibility in dealing with these invasive species issues, and we do not support implementing this recommendation at the Department of Agriculture.

Thank you for providing us the opportunity to review the report and provide our comments. We look forward to seeing the final report.

Sincerely,

Mike Johanns
Secretary

# GAO Contact and Staff Acknowledgments

## GAO Contact

Robin Nazzaro, (202) 512-3841

## Staff Acknowledgments

In addition to the individual named above, Trish McClure, Assistant Director; Ross Campbell; John Delicath; Dewi Djunaidy; Les Mahagan; Mehrzad Nadji; Jena Sinkfield; and Amy Webbink made major contributions to this report. Important contributions were also made by Laura Gatz; Gerry Laudermilk; Charlotte Moore; Judy Pagano; and Jay Scott.

## GAO's Mission

The Government Accountability Office, the audit, evaluation and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

## Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday, GAO posts newly released reports, testimony, and correspondence on its Web site. To have GAO e-mail you a list of newly posted products every afternoon, go to www.gao.gov and select "Subscribe to Updates."

## Order by Mail or Phone

The first copy of each printed report is free. Additional copies are $2 each. A check or money order should be made out to the Superintendent of Documents. GAO also accepts VISA and Mastercard. Orders for 100 or more copies mailed to a single address are discounted 25 percent. Orders should be sent to:

U.S. Government Accountability Office
441 G Street NW, Room LM
Washington, D.C. 20548

To order by Phone: Voice: (202) 512-6000
TDD: (202) 512-2537
Fax: (202) 512-6061

## To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

## Congressional Relations

Gloria Jarmon, Managing Director, JarmonG@gao.gov (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, D.C. 20548

## Public Affairs

Paul Anderson, Managing Director, AndersonP1@gao.gov (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, D.C. 20548

PRINTED ON RECYCLED PAPER