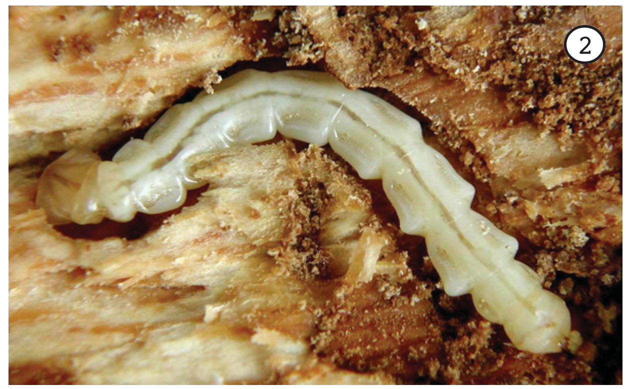
Fading Forests III

American Forests

What Choice Will We Make?



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Credits for images on the cover

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Photograph 1 is of Thousand Cankers Disease on black walnut in Knoxville, Tennessee and was taken by Nathan Waters, Tennessee Division of Forestry, and is in the public domain.

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Credit for the graphs

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Key Points and Strategic Actions

Background/Introduction:

Trees and forests are essential to the American way of life. They provide shade and shelter, jobs and products, and clean air and water. From tree-lined neighborhood streets to national parks, Americans count on trees to provide benefits today and for generations to come. Today many of North America's trees and forests are being destroyed by non-native insects and diseases. These invaders are removing entire species of trees from our forests and neighborhoods threatening air, water, economies, and the quality of life in our communities.

We Americans import a wide variety of goods from abroad. Our domestic economy also depends on free movement of goods within our borders.

This free movement of goods carries with it a high cost – movement of species of animals, plants, and microbes to new environments, where a small percentage of them become highly damaging invaders. Among the most damaging of invasive species are insects and disease pathogens that kill trees. These forest pests enter primarily through a few pathways: various kinds of wood, especially incoming crates, pallets, and other forms of packaging made of wood; imported plants; and, in some cases, as hitchhikers on ship superstructures. The pests are moved across the country in wood – including firewood and wood for woodworking or processing; and living plants.

In the past dozen years, 28 new tree-killing pests have been detected in the country. Several of these threaten to cause immense devastation; these include polyphagous shot hole borer, thousand cankers disease, and goldspotted oak borer. The pathogen *`ohi`a* rust attacks the most widespread tree species in Hawai`i, although fortunately the specific strain introduced to the Islands causes less damage to *`ohi`a* than do other strains of the pathogen.

As noted in Chapter 2 of the report, Aukema *et al*. (2011) estimated that municipalities and homeowners spend $2.7 billion annually on removing trees killed by non-native pests. Homeowners lose another $1.5

billion in property values. The value of timber threatened by such pests was estimated to be $152 million. These estimated costs, while substantial, nevertheless underestimate the full range of costs because they do not include ecological impacts arising from the death of entire tree taxa and impacts from a significant number of pests, including all the pathogens and thousand cankers disease.

Once introduced, pests impose continuing, often rising, impacts over time. For example, white pine blister rust, introduced 100 years ago, continues to spread to new geographic areas and new vulnerable pines. These non-native insects and pathogens can essentially eradicate species from throughout their ranges. The USDA Forest Service' Forest Health Enterprise Team's 2012 report projects mortality across 90% of the basal area of redbay within 15 years.[1] Some of the species at risk are the foundation of ecologically unique species assemblies, such as the "high-five" pine species in the mountains of the West; hemlock groves in the Appalachians; and tanbark as the only hardwood/hard mast species in the predominantly coniferous forests of northern California.

Options for Protecting Our Forests

As the report notes in Chapter 7, science has identified solutions which can be implemented if government authorities and trading companies act sufficiently boldly and quickly.

Actions Intended To Prevent Introductions of Additional Pests

- ***Wood Packaging***: as many as 13,000 infested containers *per* year might be entering the United States. To curtail introductions *via* this pathway, the following actions could be carried out;
    1) APHIS and Customs and Border Protection could strengthen enforcement of regulations requiring treatment of incoming wood packaging.
    2) APHIS could adopt a regulation requiring foreign suppliers to switch to non-wood packaging;
        - USDA and international lending bodies could provide funding to assist developing country suppliers to make this switch
        - In the meantime, U.S. companies that import goods from abroad could require their suppliers to make that switch
    2) U.S. companies could put in place programs of active pest surveillance at key points of their own supply chain, such as at warehouses and distribution centers.
    3) Consortia of citizens, academics, and phytosanitary authorities could implement intensive surveillance at locations where imports "come to rest" in the country, *e.g.*, cities and suburbs where imported goods are sold or purchased in large volumes
- ***Living plants (plants for planting):*** The approach rate of pests in plant imports of all types is unknown. One study found an approach rate of 12 percent in certain plant types. Extrapolating that approach rate to all imports of cuttings and whole plants would suggest that at least 113 million pest-infested or pathogen-infected plants arrive in the United States each year. To curtail introductions *via* this pathway, the following actions could be carried out:
    1) APHIS could quickly adopt amendments to the Q-37 regulations under which the agency can require foreign suppliers to adopt programs that identify and mitigate practices that facilitate pest or pathogen infestations. APHIS could promptly begin negotiating sufficiently rigorous programs with countries that supply the most risky plant category – whole plants (with or without roots);

---

[1] Krist, F.J. Jr., J.R. Ellenwood, M.E. Woods, A.J. McMahan, J.P. Cowardin, D.E. Ryerson, F.J. Sapio, M.O. Zweifler, S.A. Romero. 2014. FHTET 2013 – 2027 National Insect & and Disease FOREST RISK ASSESSMENT. FHTET-14-01 January 2014. Available at: http://www.fs.fed.us/foresthealth/technology/pdfs/2012_RiskMap_Report_web.pdf

2) importers (plant wholesalers & retailers; plant enthusiasts) could avoid importing whole plants; instead, they could import cuttings or seeds;
3) APHIS could apply the same stringent regulations now required for fruit trees and grapevines to imports of horticultural shrubs. Under this new program, cuttings would be imported into certified facilities where they would be monitored closely for infestation while grown and propagated to supply the retail market.

Actions Intended to Prevent Pests' Spread from Introduction Sites to other vulnerable areas:

- ***Firewood:***
    1) The U.S. government and firewood producers could establish a certification program for firewood moving interstate:
        - APHIS could adopt regulations requiring dealers moving firewood interstate to comply with labeling and treatment requirements;
        - USDA Agriculture Marketing Service could finalize "process certified" agreement with firewood producers which will be the foundation for firewood certification;
        - Businesses could join the certification system;
    2) National Park Service and USDA Forest Service could adopt regulations prohibiting visitors from bringing their own firewood to campgrounds on these federal lands.

Actions Intended to Prevent Both New Introductions and Pest Spread:

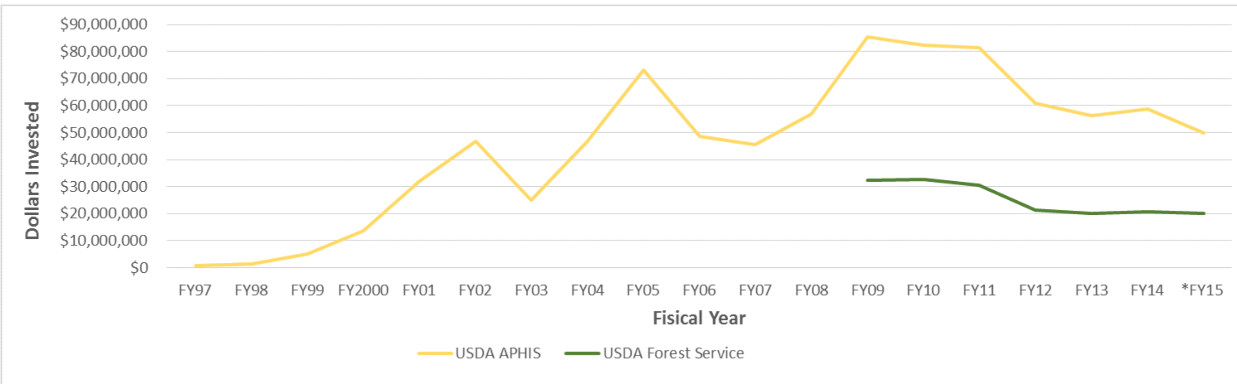
- Congress could create a program under which businesses implementing a hazard identification and mitigation program would qualify for indemnification for pest-related costs or losses. The system would have the following components:
    a) importers pay a small fee to help fund pest-prevention measures (for example, a fee of $1 *per* container would raise $25 million; fees could be levied on other types of imports, also, to be complete).
    b) importers implement hazard identification and mitigation programs to minimize pest risk; the programs would be subject to third-party audits to ensure compliance.
    c) importers on whose premises pests are found would be indemnified for costs or losses as long as that importer had been certified as implementing the hazard mitigation program.

- Congress could appropriate adequate funding for
    1) border enforcement by Customs and Border Protection and APHIS
    2) surveillance at high-risk locations by APHIS and USDA Forest Service; could be supplemented by states, businesses, and volunteers
    3) response to newly detected pests by APHIS and USDA Forest Service; could be supplemented by states and businesses
    4) research into pathways of introduction, detection and control methods, etc. by APHIS, USDA Forest Service, Agriculture Research Service; could be supplemented by states and universities
    5) implementation of control measures, including denying permission to ship interstate to those companies that have repeated pest problems; fines; etc. by APHIS; could be supplemented by states

6) outreach to firewood users, woodworkers/turners, gardeners, others who move wood, plants, or other articles that can transport tree-killing pests by APHIS, USDA Forest Service, National Institute for Food and Agriculture; could be supplemented by states, universities, and non-governmental entities

7) research into biocontrol, resistance breeding, *etc*. Programs targetting new pests could be initiated as soon as the new pest/host situation is identified. These programs would be maintained over the decades required to achieve success. This research could be conducted by APHIS, USDA Forest Service, Agriculture Research Service; and could be supplemented by states, universities, trade associations, other stakeholders, and non-governmental organizations.

Since the beginning of the 21st Century, more than 30 new tree-killing pests have been detected in the country – but U.S. government programs have not expanded to meet this challenge.



Federal agencies, including APHIS and the USDA Forest Service, the states, and the full range of stakeholders (including agricultural interests, forest scientists and managers, conservation organizations, and representatives of cities and suburbs) could work together to develop an effective system to address tree-pest introductions that occur under the following situations, and which currently lack effective responses:

- Who can act when a resource is threatened by a pest when the state where the pest is found declines to act? APHIS usually won't act until the pest is in more than one state, and/or the state acts. Furthermore, APHIS controls only interstate movement, so it cannot protect resources in the individual state. What actions might such non-governmental entities undertake?
- How can we resolve situations in which states or stakeholders believe APHIS' response is insufficient? APHIS has yet to approve a single state's petition for recognition of a "special needs" exemption from federal preemption of more stringent actions.

Preamble

The transformation of American forests by nonnative insects and pathogens began almost two hundred years ago. Today, that transformation continues and is accelerating. In the interim, thousands of Americans who care passionately about the threat to forests from nonnative pests have tried to prevent, counter, and control the influx of these alien invaders. Many scientists have devoted their careers to documenting the threat, defining its components, and devising solutions. The science has now evolved from studies of individual species or trade pathways to analyses of cumulative impacts. These new approaches should have greater effect on policy.

These efforts have resulted in significant policy successes, such as the 1912 Plant Quarantine Act and Plant Protection Act of 2000, along with several recent international phytosanitary standards. As of autumn 2013, we seem on the verge of important progress in understanding and, to a lesser extent, improved implementation.

- The Department of Homeland Security's Customs and Border Protection (CBP) is acting aggressively to counter introductions of Asian gyspy moths on incoming ships and has adopted more sophisticated measures to target shippers with poor records of infested wood packaging. The CBP has also tried several outreach efforts to engage companies in improving management of wood packaging.
- The USDA Animal and Plant Health Inspection Service (APHIS) has revised its regulations for sudden oak death (*Phytophthora ramorum*) so that detection of the pathogen in water, soil, or pots – as well as on plants – triggers regulatory action.
- A national association of firewood dealers has nearly completed preparations for a certification program.
- Private nurseries and state departments of agriculture should soon begin testing a system of voluntary best practices to reduce the risk that pests will be present in plants shipped in interstate trade.
- Scientists are using new approaches to understand pathways of pest movement:
    - Several studies to determine the efficacy of ISPM#15-mandated treatments for wood packaging, including laboratory testing of the treatments and growing out larvae found in wood packaging to determine the species;
    - Analysis of trade data to identify metropolitan areas that receive the largest volumes of imported wood packaging and living plants; and the most likely sources of firewood being transported to each state.

However, policy has not kept up with the rising threats from ever-growing trade volumes from new source countries and faster modes of transport. As a result, American forests are now riddled with permanently established non-native pests and additional introductions are certain. In the welter of natural resources interests and perspectives competing for attention and rectification, this compelling story of forest transformation has somehow failed to persuade decision-makers in government, corporations, the media, and environmental organizations to give this issue the support it needs to halt this threat on a landscape level.

It is evident to us that what the country is lacking, and what is now needed, are champions at the national level. Champions that will successfully translate the passion of American citizens for their forests and the increasing body of work by technical experts into effective policy. A modern George Perkins Marsh to frame the issues in language that both policy makers and the American public can understand. A new John Muir to fire opinion-makers' imaginations. A steadfast Gifford Pinchot, Stephen Mather or Charles Marlatt to set assertive goals for government agencies and win administrative approval to act. A John Lacey or Stewart Udall to press for bold new legislation. Ideally, a Theodore Roosevelt-like figure to pound the bully pulpit to enact the visions put forward by experts.

Fading Forests III is the last publication of a trilogy on pests, policy, and forest health that we began over 20 years ago. This publication, however, is not intended to be a requiem. Instead, we hope that Fading Forests III will be received as a call to greater effort, focused on a limited agenda of actions that can ensure our forests' future.

Our society has chosen to build our economy on free trade and private enterprise. Our challenge is to find new phytosanitary and restoration strategies that work effectively in this economic context. Forests and Americans who love them will not be the only beneficiaries. Nonnative species threaten the full range of agricultural and horticultural crops, from citrus to soybeans, from wine grapes to boxwood. Since the same phytosanitary programs apply to all plant pest issues, progress can be greatest if those of us working to improve protection for forests and other natural systems build alliances with people concerned about threats to agriculture.

The grim situation in our forests outlined in Fading Forests III show that American citizens are now truly at a fork in the forest path. Their choice is relatively simple: work toward enacting a comprehensive policy/biological program that ranges from prevention to restoration or be prepared to live with altered forests that not only look different, but also will provide different values than current forests.

We ask: what do Americans want for the future? Trade? Forests? Or both? Consider the words of Secretary of Interior Stewart Udall, "Is a society a success if it creates conditions that …… make a wasteland of its finest landscapes?" Consider whether it is worth reinvigorating the Nation's invasive species programs, finding new allies and trying new approaches that can protect our forests, while minimizing impact to trade and American lifestyles? Walk outside and look at the elm or ash towering over your house or the California live oak shading your street. Visit a National Park or National Forest….

And you will know the right path to take.

Chapter 1
American Forests at Risk

"We are coming to recognize as never before the right of the Nation to guard its own future in the essential matter of natural resources. In the past we have admitted the right of the individual to injure the future of the Republic for his own present profit…. The time has come for a change."

President Theodore Roosevelt, 1908

With these remarks, President Theodore Roosevelt opened the Conference of the Governors of the United States, and placed the protection of the Nation's natural resources foremost in politicians' minds. He gave notice that the needs of future generations would prevail over the exploitation practiced by private industry, then and before.

Americans have tended to view their widespread forests as abundant, inexhaustible and – occasionally – an impediment to progress.[1 2] By the end of the 19th Century, forests were being rapidly consumed. Americans responded to this obvious depletion by establishing and managing public lands, and protecting endangered wildlife populations and habitat. Forward-thinking politicians like Congressman, later Ambassador, George Perkins Marsh and Representative John Lacey (R-IA); public servants like Gifford Pinchot, the first chief of the U.S. Forest Service, and Steven Mather, the first director of the National Park Service; and citizens like George Bird Grinnell, founder of the first Audubon Society and long-term editor of *Forest and Stream*, and John Muir, founder of the Sierra Club, all raised the national consciousness on how natural resources were being mismanaged, and proposed workable solutions. As a result, forest use became more balanced between profit and sustainability.

Today's Turning Point

A century after the first crisis was averted, North American forests are again at a turning point. This time, our ever-increasing reliance on foreign imports threatens forests and the values they provide. Nonnative insects and pathogens from other countries, so-called "exotic forest pests," are being introduced into our forests at an alarming rate. Our natural resources face an immediate battle, not only to prevent further entry by foreign forest pests, but also to combat those already present.

In general, American forests are fairly resilient to disturbance and will eventually rebound from many individual threats. This is true even in the case of severe abuse. In the Copper Basin area of southeastern Tennessee, for example, smelter fumes essentially poisoned the local landscape. This resulted in a barren area that could be seen from space. Now, though, this area is slowly recovering, as it is re-colonized by various plants and trees.

In contrast, today's forested ecosystems face not one, but a myriad of threats. These may interact, with sometimes devastating results. Such threats include climate change; alterations in the characteristics of fires and when and where they occur; forest fragmentation; and ever-increasing numbers of exotic insects and diseases. These threats, in combination with urban sprawl from human population growth, will increase demand for the values that forests provide. But there will be less land available, with more problems.

Among these threats, damage caused by exotic forest pests is unique. Such pests are able to diminish or remove tree species throughout their ranges. As the number of woody species declines, the forest, as a whole, loses resilience – its capacity to absorb disturbances without undergoing fundamental change. Forests become more vulnerable to each additional threat and impacts snowball. In these situations, species loss becomes irreversible and the forest is permanently altered on the landscape level. This affects a wide variety of values cherished by the American public.

In this era of mass media and electronic communication, it is almost inconceivable that the rapid and widespread transformation of American forests is occurring without the attention paid to other environmental issues, e.g., "fracking" for natural gas production. Sadly, we are neglecting our forests, as exotic pests kill or debilitate the trees and shrubs native to North America. These pests, along with a long list of non-native trees, vines, shrubs, and wildlife, are transforming our native forests into exotic landscapes.

The Setting for This Report: Experience and Frustration

The authors have worked separately in the exotic pest arena for more than 25 years, and together since 1991. Individually, each has produced various policy-related (Campbell) and biology-oriented (Schlarbaum) publications. Together, they wrote *Fading Forests: North American Trees and the Threat of Exotic Pests* (1994),[3] and *Fading Forests II: Trading Away North America's Natural Heritage* (2002).[4] These are integrated policy and biology documents, focusing on exotic forest insects and pathogens.

The 1994 report summarized the 16 major exotic forest pests attacking North American forests. It discussed the U.S. Department of Agriculture's (USDA) risk assessment process and highlighted the flaws in trade policy that could – and did – reduce protection against importing potential pests. *Fading Forests II* was a more in-depth policy analysis of the exotic forest pest problem. It suggested how to mitigate this growing problem, and to provide a more complete response to established pests.

In this third report, the authors summarize what has happened since publication of *Fading Forests* in 1994, concentrating on changes since *Fading Forests II* was published in 2002. There is evidence of worsening problems: more foreign pests attacking more tree species, with too few new policy solutions, and a diminishing infrastructure that makes sustainable response improbable.

This report includes:

- An overview of the largest-scale forces that are shaping forests, e.g., international trade and climate change (Chapter 1);
- A brief summary of the value of North American forests to the general public, and the costs that pests impose (Chapter 2);
- A description, in detail, of the policy issues that stand in the way of better forest protection by federal and state officials (Chapter 3);
- An assessment of the major and minor pathways by which exotic forest pests are introduced into the United States (Chapter 4), and then spread within the country (Chapter 5);

- Consideration of restoration measures for damaged forests (Chapter 6); and
- An exploration of additional measures needed to address this urgent and growing problem – and options for realizing them (Chapter 7).

THE ONSLAUGHT OF EXOTIC FOREST PESTS

Despite extensive deforestation over the last three centuries, forested landscapes still cover nearly 50 percent of the United States and Canada, combined.[5] These landscapes have developed in response to widely varying climatic and other factors. As a result, ten types of forests grow in the United States and Canada (Figure 1, Box 2). Altogether, North American forests are comprised of 1,165 different native tree species.[6] With this diversity, newly introduced insects and pathogens often find woody hosts to fit their needs.

Box 1. The Richness of U.S. and Canadian Forests[7]

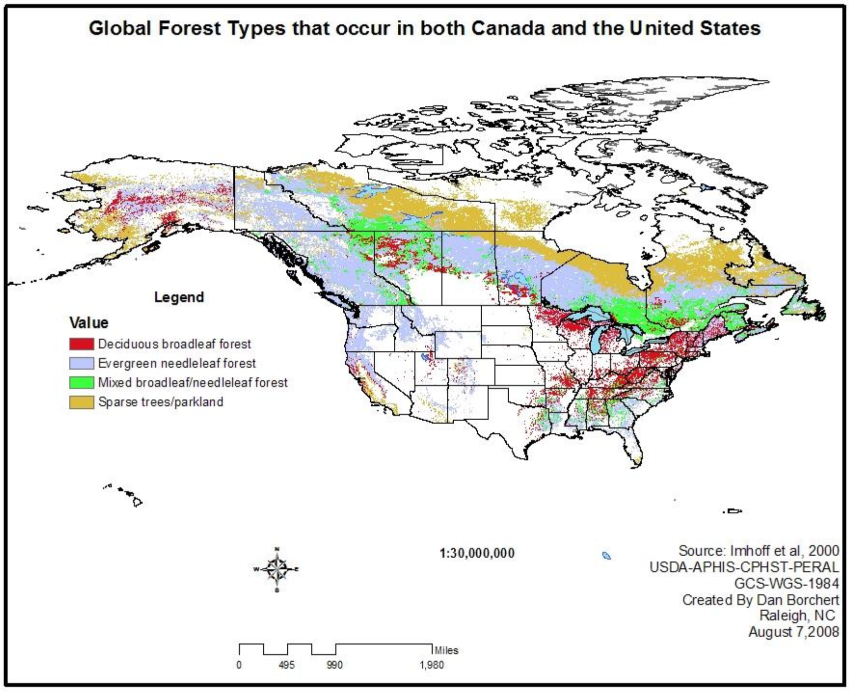
Four forest types are shared between Canada and the United States:

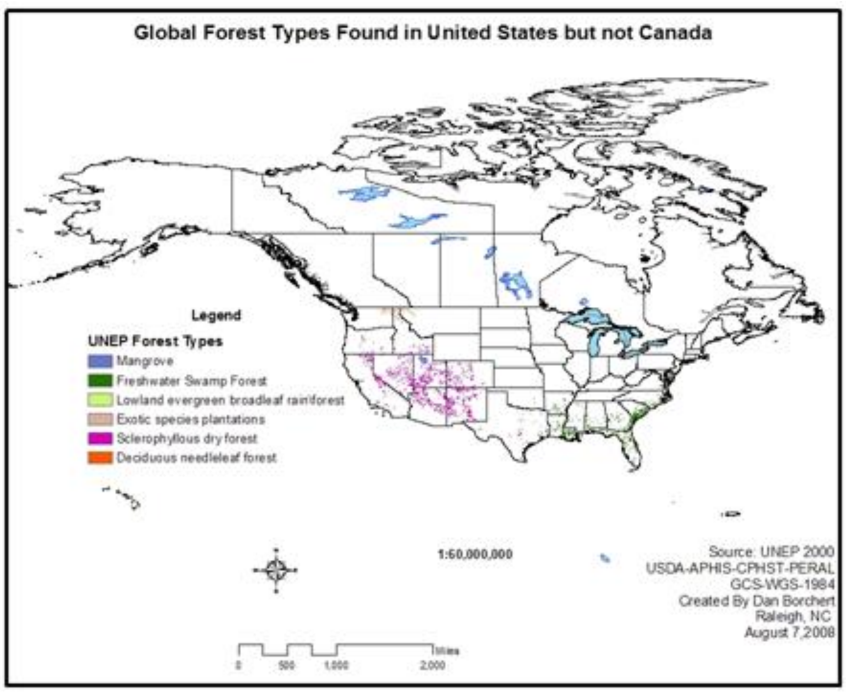
- Evergreen needle leaf forests – the most abundant forest type, covering 4 million km^2 combined;
- Sparse trees/parkland, covering 2 million km^2;
- Mixed broadleaf / needle leaf forests, covering 1.2 million km^2; and
- Deciduous broadleaf forests, covering 1.2 million km^2.

The United States alone (including Hawaii and Alaska) has six additional forest types that cumulatively occupy a combined area of 0.365 million km^2:

- Sclerophyllous dry forests;
- Freshwater swamp forests;
- Deciduous needle leaf forests;
- Mangrove forests; and
- Two tropical forest types.

Figure 1. Distribution of Forest Types

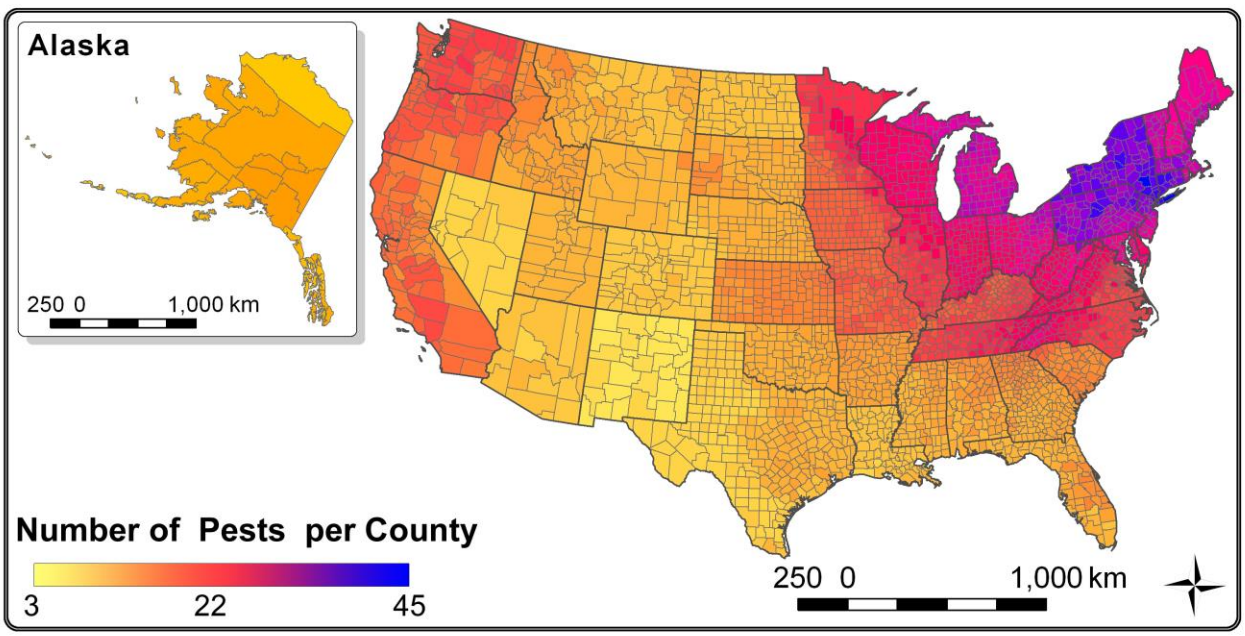




Both maps are from United States Department of Agriculture, Animal and Plant Health Inspection Service. August 2009. Risk analysis for the movement of Solid Wood Packaging Material (WPM) from Canada into the United States.

Damage to our forests from exotic pests is an old story – but we add new pages every year. *Phytophthora* root rot disease[a] on American chestnut was reported as early as the 1830s.[8] More than two dozen species of tree-killing pests – all new to the country – have been reported just since 2003. By the first decade of the 21st Century, the number of non-native insects and pathogens damaging our forests had risen to at least 475[9] (Figure 2). Sixty-two of the insects, and all of the 17 pathogens, were judged to have "high impact,"[10] with both economic and ecological ramifications. Similarly, more than 181 exotic insects that feed on woody plants are established in Canada.[11] (See Chapter 2 for the resulting costs.)

Figure 2. Number of Damaging Non-native Pests



Map is from Liebhold, A.M., D.G. McCullough, L.M. Blackburn, S.J. Frankel, B. Von Holle, J.E. Aukema. 2013. A highly aggregated geographical distribution of forest pest invasions in the USA. Diversity and Distributions. (2013) 1-9

Now, there is an exotic pest threat to nearly every dominant tree species in the eastern deciduous broadleaf forest – a major landscape component in 20 states.[12] [13] Some pests are relatively new introductions, e.g., the emerald ash borer. Others have been in this country for a long time, yet are still affecting their host species. Given time, as more pests are imported, host plants will face multiple exotic pests. This is already true of the beloved American chestnut, which is attacked now by six exotic pests (Box 2).

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[a] Latin and common names for insects are available at http://www.entsoc.org/pubs/common_names, a publication of the Entomological Society of America. Similar information for plant diseases is provided by the American Phytopathological Society, at http://www.apsnet.org/publications/commonnames/Pages/default.aspx. See the U.S. Department of Agriculture's PLANTS Database for names of tree hosts, at http://plants.usda.gov/java/.

Box 2. American Chestnut Under Siege

Initially, an exotic disease (*Phytophthora* root rot) removed American chestnut trees from bottomlands and poorly drained soils in the Southeast in the 1800s. In New England, chestnuts were impacted by rapidly expanding populations of the European gypsy moth, which had been imported intentionally in 1869.

Subsequently, another pathogen, the exotic chestnut blight fungus, was imported on Asian chestnuts.[14] It attacked upland chestnut stands and reduced the once-dominant tree to short-lived sprouts. Chestnut gall wasp was the next exotic pest to affect chestnut. This pest was introduced on smuggled budwood of Japanese chestnut in the 1970s, and has rapidly spread north and west.[15] It rarely kills trees, but can predispose them to secondary pest attack. In 1974, the Asian ambrosia beetle was first detected in the United States; it was found to cause mortality in a Chinese chestnut planting[16] and has been noted to attack American chestnuts in forest settings.[17]

Finally, specially bred trees,[b] planted in a forest to test their resistance to chestnut blight, have been attacked by the Asiatic oak weevil.[18] The adult weevil defoliates the tree, while its juvenile form feeds on the roots. This insect, contrary to its name, prefers chestnut and may become a significant problem in restoration efforts.

There are breeding programs to make American chestnuts resistant to *Phytophthora* root-rot, chestnut blight, and chestnut gall wasp. However, no breeding program addresses all three. Various strategies are used to control gypsy moths, except when there is an epidemic, and populations become uncontrollable. However, there is no practical solution for protecting chestnut from Asian ambrosia beetles and Asiatic oak weevils.[19]

With each new pest, efforts to restore American chestnut to U.S. forests have become more difficult.

U.S. PEST PREVENTION POLICY: LOSING THE BATTLE

The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is charged with preventing foreign pests' entry into the United States. Also, it is responsible for stopping pests' spread once they arrive. The agency faces several challenges in suppressing pests' movement arising from a pro-trade political climate, inadequate funding, ambiguous legal authority, and uncertain support by USDA's leadership.

APHIS has made greater progress in working with international bodies than in preventing pest from spreading within the country. That is, the agency has adopted new measures aimed at curtailing introduction of pests with imported goods. Regrettably, too many policy issues remain unchanged – or have worsened – over the past decade. As a result, pest detections continue to rise (Box 3). Some of these have since spread across major parts of the country.

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[b] Produced by the American Chestnut Foundation's breeding program, these trees are bred to have 15/16 of their genes from American chestnut, and 1/16 from Chinese chestnut, which are resistant to blight.

Box 3. Non-Native Pests Detected Since Fading Forests II

Since 2003, at least 19 new species of bark- and wood-boring insects have been reported for the first time in the continental United States.[20] These include:

- Redbay ambrosia beetle (vector of laurel wilt disease);
- Goldspotted oak borer;
- Walnut twig beetle and thousand cankers disease; and
- Soapberry borer.

Other new tree-killing pests are:

- Red palm mite;
- Red palm weevil;
- South American palm weevil;
- Polyphagous shot hole borer; and

On Pacific islands, new pests include:

- \`Ohi\`a rust;
- Cycad scale;
- cycad blue butterfly;
- Erythrina gall wasp;
- Pisonia scale.

During this same decade, three or possibly four additional introductions of the Asian longhorned beetle has been detected – in Worcester, Massachusetts; Clermont County, Ohio; Mississauga, Ontario; and possibly Long Island, New York.

If we are to protect American forests, we need to minimize the likelihood that rising international trade will result in the introduction of even more non-native pests. This means immediately correcting problems in laws, regulations, implementation strategies, and funding. An added incentive for action is ensuring that forests are as healthy as possible now, before they suffer further impacts from climate change.

THE ROOT OF THE PROBLEM: INTERNATIONAL TRADE

Our consumer-driven economy has relied increasingly on imports in recent decades. Their rising volume has provided numerous opportunities for non-native species to reach our shores. Some of the unintended consequences of global trade have received attention from political leaders, *e.g.*, displacement of manufacturing jobs. However, the introduction of invasive species has not yet achieved that level of attention.

Data on actual pest introductions are limited. Also, existing information is complicated by the weaknesses that plague detection efforts, themselves. The available data – surprisingly – do not support the widespread belief that plant pest introductions are rising as fast as the volume of imports. A comprehensive analysis of forest pest introductions found that the rate has remained steady since 1860 – at approximately 2.5 new kinds of pests detected each year.[21]

The apparent absence of rising rates of pest introductions, however, does not justify indifference to the risks of trade. A portion of newly detected forest pests are considered "high-impact," and the rate of <u>these</u>

introductions has increased. From 1860 to the early 1990s, about 0.5 new, damaging species were found per year – or one every 2.1 to 2.4 years. From 1990 to 2006, though, the rate averaged 1.2 per year, nearly three times that in the previous 130 years.[22] Also, detection of a pest usually lags several years behind its actual date of introduction. Therefore any measure of the current rate is almost certainly low. Finally, the recent recession has suppressed import volume, thus possibly delaying, rather than eliminating, the latest set of introductions.

The risk of importing damaging forest pests through international trade is associated with three interlocking factors: 1) increasing volume of imports; 2) the rising use of shipping containers containing crates, pallets, and other forms of packaging made from wood; and 3) opening of trade with countries that have historically exported little or nothing to the United States.

Import volumes

U.S. imports, excluding petroleum products, more than doubled between 1994, when World Trade Organization agreements went into effect, and 2008.[23] While the recent financial crisis has decreased the volume of trade, the overall trend remains upward.[24] Imports are often packaged in crates or pallets made from solid wood, a proven pathway for pest introductions. Imports of living plants, another proven introduction pathway, have risen even more rapidly – by 33 percent per decade over the last 43 yrs.[25] Imports climbed to more than 3.15 billion plants in 2007, before somewhat decreasing, due to the recession.[26]

Container Ships

The risk of pest introduction has been exacerbated by the switch to container ships, as well as the increase in size, speed, and number of ships in the global cargo-carrying fleet. In 1973, container ships carried 4 million units,[c] or containers, of cargo. By 2007, an estimated 141 million units were in use.[27] The United States received nearly 25 million containers in fiscal year 2013.[28] Depending on their contents, each container provides multiple opportunities for an exotic species to be transported to a new country.[29]

Photo by National Oceanic and Atmospheric Administration National Ocean Service
Via Flickr and Wikimedia Commons

[c] Container "units" are not fully standardized. Usually one unit is termed a "twenty-foot equivalent unit," or TEU, because shipping containers are twenty feet long. Width and height vary, but are often 8 and 8.5 feet, respectively.

New Trade Partners

A number of countries, particularly Asian ones, opened to trade recently. For example, U.S. trade with mainland China began in 1979, after the two countries re-established diplomatic relations.[30] The value of U.S. imports from China accelerated rapidly, totaling $15.2 billion by 1990. Two of the most damaging introduced insects, the Asian longhorned beetle (primary host – maple species) and the emerald ash borer (primary host – ash species), became established in America by 1992, only about a dozen years after trade with China began. Now, China is the largest source of U.S. imports, valued at $425.6 billion, in 2012.[31]

Although Mexico and Central American countries are not new trading partners, recent exotic pest introductions have turned attention to these southern neighbors. Three pests, native there and to small regions of American border states, are spreading. In the process, they are causing widespread mortality of U.S. trees without previous exposure. They are Thousand Cankers Disease transported by the walnut twig beetle (primary hosts – black walnut and butternut), goldspotted oak borer (primary host – some California oak species), and soapberry borer (primary host – soapberry).

The high level of trade between the United States and Canada also presents a risk. An estimated 387 million solid wood pallets are used annually to move goods from Canada to the United States; an additional 30 million pallets are imported as a commodity.[32] These imports are distributed throughout the United States, raising the concern that Eurasian species, established in limited areas in Canada, might be moved to uninfested areas in the United States – or vice versa. (The risk to Canada is probably even higher, given that more goods move from the U.S. to Canada and the large areas of the United Staes infested by various woodboring insects.)

U.S. FORESTS IN A TIME OF CLIMATE CHANGE

Climate change is already affecting our nation's valuable natural resources, including forests. For example, spring is coming earlier.[33] In northeastern forests, temperatures are warmer and precipitation is greater.[34] In the West, both single wildfires and annual fire seasons are lasting longer, and large fires occur more often.[35 36]

As the levels of carbon dioxide and other greenhouse gases in the atmosphere continue to rise, they drive a series of changes that further alter weather patterns and the distribution of moisture. The latter are major factors in determining the distribution of vegetation. Shifts in vegetation, in turn, change the distribution of insects and pathogens, and their interactions with plant hosts.[37]

For instance, the hemlock wooly adelgid, an aphid-like pest, has decimated many eastern hemlock populations since the mid-1980s. Hemlock "could functionally disappear from eastern forests in the next several decades," because trees have no resistance to the pest, they rarely recover, and there are as yet no effective controls.[38] The hemlock woolly adelgid cannot survive below certain temperatures, though, so northernmost tree populations are protected at present. However, as winters warm, this pest's range is projected to expand extensively throughout the Northeast.[39 40]

The severity of seasonal fires is expected to increase over most of North America. This indirect effect of climate change may alter the distribution and migration of species even more than its direct influences.[41]

America's forested lands will respond to climate change much as they responded to continental glaciation events over the last 2.5 million years – through contractions and expansions of their ranges. However, forests do not respond to environmental change as a whole. Instead, species (including pests) respond individually. Because species' responses are unknown now, it is impossible to generalize broadly about future pest impacts.[42] [43] [44] It is conceivable, though, that trees already under stress from exotic pests may not respond well to further stress caused by alterations in climate.[45]

Even with climate change, the vulnerability of some U.S. ecosystems may be primarily due to the severity of a variety of non-climate stressors, including non-native species.[46] For example, southern populations of butternut have become severely fragmented by the exotic butternut canker disease. They will be further impacted by Thousand Cankers Disease. Many populations have been reduced to ten or fewer trees, and some groups exhibit inbreeding depression, a build-up of deleterious genes, *e.g*., albinism. Additional stress from climate change could tip these small groups into local extinction. Without the burden of disease, butternut populations would more readily adjust to changing climate, *e.g.*, by slowly shifting their distribution to places with more favorable conditions.

Inbreeding depression in butternut as evidenced by a high proportion of albinism in germinating seedlings.
Photograph by Scott E. Schlarbaum,
The University of Tennessee, and is in the public domain.

Recent studies have shown that rising temperatures have a positive relationship with both establishment of non-native species[47] and abundance of native insects on native trees.[48] These results remained significant, even when several other factors, such as rising import volumes, were controlled. These findings support concerns that climate change, *per se*, might exacerbate invasion of our forests by non-native pests.

Rising atmospheric carbon dioxide levels themselves have significant impacts on plants, associated pathogens, and plant-eating (called phytophagous) insects. These are distinct from changes resulting from new temperature or precipitation patterns.[49] [50] Such changes will further scramble both the structure of future ecosystems, and our attempts to predict their evolution.

In contrast to climate change, impacts from exotic forest pests occur relatively rapidly. The American chestnut was devastated by chestnut blight in less than fifty years. On a landscape scale, exotic pests have already significantly changed American forests. These changes are real and observable now. Unless exotic forest pests are appropriately addressed, future American forests will be very different from today's, regardless of climate change, urban sprawl, or other landscape-changing events.

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Chapter 2
Forest Values and the Costs of Foreign Pests

Forests have historically been a treasured and integral part of our national heritage and way of life – whether in wild, rural, suburban, or urban settings. Every American derives some value from forested land, whether it be from: employment; use of commodities like wood and paper; acquiring food; enjoyment of natural areas and their beauty; historical and cultural connections; the relief urban trees provide us and our homes from noise, concrete, metal and glass; comfort to our spirits; higher land, property, and rental value[1]; or the critical benefits that nature provides,[2] known as "ecosystem services."

Some of these values can easily be quantified in monetary terms, such as timber. Others are more elusive to measure economically. Nevertheless, they are prized. Polls by the Nature Conservancy show that Americans are devoted to forests and neighborhood trees. In both 2005 and 2010, between 93 percent and 95 percent of those polled said that trees are important to the character or quality of their neighborhoods, and provide a sense of peace and tranquility.[3]

Several studies have shown that contact with the natural environment, including trees, is associated with better health. The most recent study found that counties with significant loss of trees, due to invasion by the emerald ash borer, also saw a rise in death rates from heart attack and lower respiratory tract disease. The authors suggested that the association might have been caused by increased stress.[4]

MONETARY AND NON-MONETARY VALUE OF FORESTS

The most obvious benefit forests supply is wood products, and associated economic activity. In 2011, the U.S. forest products industry harvested almost 13 million cubic feet (roundwood equivalent) of timber.[5]

Translated to dollar amounts, this industry accounts for approximately five percent of the total U.S. manufacturing Gross Domestic Product. Companies produce about $190 billion annually and employ nearly 900,000 people – exceeding employment levels in each of the automotive, chemicals, and plastics industries.[6] In Canada, forest products represent three percent of the country's Gross Domestic Product, as well as three percent of employment.[7]

Supporting Biological Diversity

Forests support much of North America's wildlife and plant diversity. For example, they maintain pollinator communities, and protect aquatic resources, such as fisheries.

Americans have set aside 193 million acres in 155 national forests and 20 national grasslands. Although these comprise less than a quarter of the total U.S. forested area, they provide:

- Habitat for 429 federally-listed threatened and endangered species;
- 80 percent of the elk, mountain goat, and bighorn sheep habitat in the lower 48 states;
- 28 million acres of wild turkey habitat;
- Habitat for more than 250 species of migratory birds; and
- Some of the best remaining habitat for grizzly bear, lynx, and many reptile, amphibian, and rare plant species.[8]

Providing Ecosystem Services

Forests provide a host of ecosystem services upon which everyone depends. For example, forests protect water supplies. This role was one of the founding tenets for the USDA Division of Forestry when it was formed in 1881. Now, about 60 million people get their drinking water from sources that originate on national forest land.[9] Also, forests regulate the timing and flow of surface and groundwater to streams, rivers, reservoirs, and bays. They improve water quality, lower stream temperatures, control stormwater runoff, and prevent flooding.

Urban trees, especially, protect air quality and remove pollutants. They lower summer air temperatures, and reduce wind speed – saving energy used for heating and cooling. In Auburn, Alabama, a residence half covered with dense shade would use 19.3% less electricity than one without it.[10] Urban trees also reduce storm-water runoff, an expensive problem for cities to manage. This function was valued at $496,000 per year in just one city: Bismarck, North Dakota.[11]

Ash tree in Arlington, Virginia; photo by F.T. Campbell

According to one study, the cost of replacing urban forests[a] in the United States would be $2.4 trillion.[12] Urban forests also have functional value, that is, they store carbon in their wood – valued at $50 billion; and take up carbon each year (sequestration) – valued at $2 billion.[13]

Forests, like urban trees, store large amounts of carbon in soil, and in live and dead wood. In the United States alone, forest lands store an estimated 44 billion metric tons of carbon. This amount is in constant

[a] Replacement cost, or "compensatory value," considers an individual tree's value only as a physical, or structural, asset.

flux as plant growth increases it, harvesting and mortality decreases it.[14] As a result, forests play an important and active role in controlling the concentration of carbon dioxide in the atmosphere globally.

Recreation

Forests provide enjoyment to millions of hikers, campers, hunters, anglers, birders and other recreational users. Outdoor recreation, much of which takes places in our nation's forests, accounts for $646 billion in spending each year. Recreational activities fund 6.1 million jobs and provide $80 billion in federal, state and local tax revenue.[15] Recreation is a growing role for our forests. The outdoor recreation industry grew about 5 percent per year, between 2005 and 2011 – at a time when many industries declined.[16]

THE ECONOMIC COSTS OF EXOTIC FOREST PEST PROBLEMS

The monetary costs of exotic forest pest problems are passed on to the American public, primarily through the costs of managing dead and dying trees in urban and suburban areas.[17] Trees, once regarded as financial assets, become substantial safety and economic liabilities as they die. Both private property and public areas are affected. To a much lesser extent, pests add to the cost of wood products.

Also, we pay for preventing and controlling exotic pests, and reforesting and restoring public forests, through our taxes. These costs are borne by federal, state, and local governments.

When the public hears about forest pests, they tend to think about ecological impacts, or costs to the wood products industry. The costs imposed on homeowners and local governments are often overlooked. Yet the cost of local tree treatment, removal, and replacement is at least ten times that of federal programs to suppress pests, or prevent their spread. Municipal governments and private property owners are most affected. They are neither adequately considered in most analyses, nor are they included in venues where relevant decisions are made.[18]

Costs of Insect Invasions

Wood-boring insects impose the highest costs. Estimates include $1.7 billion per year, in local government expenditures, for tree removal and replacement. Plus, there is an estimated $1.5 billion per year in losses to property owners, for removing trees and reductions in residential property value.[19] The $92 million per year in federal expenditures for containing or eradicating wood-boring pests, while less, is still substantial. It has been nearly 18 years since the first Asian longhorned beetle outbreak was detected in 1996. In this time, USDA APHIS and its Canadian counterpart have spent more than $800 million trying to eradicate this woodborer, and to contain another, the emerald ash borer.[20] [21]

Box 1. "Feeding Guilds"

Scientists can group insects into broad categories, or "guilds," based on how or where they feed. Pests within a guild share some biological traits, and usually cause similar types of plant damage. Different guilds are associated with different pathways of introduction, and their impacts vary, from one to another. Fundamental information on exotic forest pests, like that in articles by Aukema and colleagues,[22] [23] is sorted into these same categories.

Woodborers live beneath bark and feed on living tissue, *e.g.*, phloem (the tissues that transport nutrients throughout the tree), or cambium (the cells that add diameter to the stem as it grows), or on the wood itself. "Bark beetles" are in this category. They feed on, or immediately under, the bark.

Sap feeders suck up the sugary sap that is produced in foliage, and transported throughout the tree in phloem beneath the bark. These insects feed on various parts of the tree, and include aphids, whiteflies, scale insects, gall-forming adelgids, and psyllids.

Foliage feeders are insects that damage the leaves and crown of trees, by feeding, externally or internally, on leaf or needle tissue or, sometimes, on small shoots. Many are larvae, an immature form of some insects.

Also, it can be helpful to group insects with their relatives, but at a taxonomic rank higher than genus and species. Entomologists often use a shorthand form of the scientific family name for this. Unusual-sounding names for insect groups often fall into this category. For example, adelgids belong to the insect family Adelgidae; psyllids are in the taxonomic family Psyllidae. Many of the woodboring beetles fall into two families; the "buprestids" (Buprestidae) and "cerambycids" (Cerambycidae).

Relatively few species of woodborers have been introduced into the United States, compared to insects in other feeding guilds. However, a high proportion of exotic woodborers (20 percent) are damaging. A 32 percent chance exists that another, highly destructive, borer species will invade the United States in the next 10 years.[24]

Introductions of sap-feeding and foliage-feeding insects have been much more numerous. These do not generally damage wood, but they can cause trees to die. Sap feeders are estimated to cause the least loss in timber value, and federal agencies are expected to spend the fewest dollars on their control or management ($14 million annually). They do, though, cause substantial losses in real estate values – approximately $260 million per year.[25]

Foliage feeders' costs also are low, in terms of timber value. But federal spending is higher for foliage feeders than for any other feeding guild: $110 million per year. Also, they are estimated to cause $410 million per year in lost property value.[26]

Higher Costs in the Future

Introduction of new pests, along with the spread of those already here, will create more severe problems – and higher costs – in the future. Homeowners and other property owners will bear many of these. Costs to state and local government are likely to rise, as well. The federal government has the option to ignore new introductions – and thus avoid expenditures. Doing so, however, just shifts unavoidable expenses to others.

For example, Thousand Cankers Disease of black walnut now exists in scattered populations throughout the West. Also, it has spread to five eastern states: North Carolina, Ohio, Pennsylvania, Tennessee, and Virginia. Black walnut's native range includes major portions of at least 20 more eastern states, and the disease is expected to spread gradually to them.[27] As it spreads, costs to owners of managed forests and the wood products industry will accelerate dramatically. Black walnut is the most valuable tree in the country for veneer and lumber production. In 2002, the value of growing stock was estimated to be more than one-half of a trillion dollars ($539 billion).[28]

Some costly forest pests have not become established, or spread widely, in eastern forests, *e.g.*, the Asian longhorned beetle and Sudden Oak Death. These, or other invaders, could also have severe impacts on timber species.[29]

Overall, net forest worth will decrease for landowners who are trying to manage diverse forests. Destruction of dominant tree species will impose costs on the forest products industry, resulting in higher prices and a more limited selection of products. Tourism will probably also be affected, further undermining rural economies.

Disruption of the ecosystem services that forests provide also poses a growing threat to rural and urban economies. For instance, finding substitute methods for protecting water supplies is expensive. An analysis of 27 U.S. water suppliers showed that treatment costs increased, from $297,110 to $923,450 per year, when the forest cover of their watersheds shrank from 60 percent to 10 percent. A number of U.S. cities, facing potential costs in hundreds of million dollars for constructing and operating new water filtration plants, invested, instead, in better protecting their watersheds.[30]

THE ECOLOGICAL IMPACTS OF FOREIGN PESTS

The ecological impacts of non-native insects and pathogens on forests are complex, and likely to become increasingly severe. This is due not only to the addition of more introduced pests, but also to interaction with other multiple stresses: disturbed habitats; increased ozone levels; climate change; encroachment by growing human populations; and damage from indigenous and exotic forest pests already present.[31]

Ecological impacts are discussed thoroughly in a number of publications. See, for example, USDA's 2000 risk assessment for importing wood packaging;[32] the 2006 case study, "Forest Ecosystem Responses to Exotic Pests and Pathogens in Eastern North America;"[33] Kenis, *et al*.'s survey of insects' effects;[34] and Loo's survey of the impacts of fungi.[35] Reliable and measurable data on exotic insects' ecological effects only became available in the 1990s, so we can expect to learn much more in the future.

While experts describe impacts as forest "destruction" and "transformation," the harm may be invisible to the public. The impact of most foreign pests is on one, or a few, host tree species. The resulting effects can be diluted by the many undamaged trees of other species that grow in the same forests, i.e., a few trees are dead, but most are living. The remaining forest trees and shrubs, including those in the canopy as well as the understory, quickly fill voids left by dead trees. This makes the landscape "green" again, and most people associate "green" landscapes with good forest health. However, this masks the fact that the affected tree species are missing and that overall forest structure and function have been altered, sometimes severely.

PREVENTION SAVES MONEY

Preventing the movement of pests to new areas can provide substantial benefits, even fairly late in their spread. Kovacs, *et al*.[36] studied the economic impacts on communities expected to be invaded by the emerald ash borer, from 2009 to 2019. They estimated the discounted cost of ash trees' treatment, removal, and replacement on developed land at $10.7 billion. Likewise, efforts to prevent establishment of new outlying, or satellite, populations has a substantial economic benefit. Successfully preventing the formation of such populations of emerald ash borer (like those in Missouri and West Virginia) would have resulted in benefits that exceeded the cost of the program, even as late as 2005. These costs could total more than $1 billion by 2020.[37]

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Chapter 3
The Urgent Need for Policy Improvements

Exotic forest pests are usually viewed by the general public and policy makers as biological problems to be solved with scientific solutions. In reality, solutions are more complex. They require a combination of biologically-based actions and the political will to make policy changes, especially when decisions involve sizable industries within the United States, and those engaged in international trade. It is vital that this technical/political combination become the norm. Addressing issues in just one area will not resolve the problem and, indeed, may make it worse.

The biology of an organism and its affected environment certainly contribute to exotic invasions. However, an introduced organism's economic and ecological impacts are enabled by American society's failure to adapt plant health policies to the reality of global and domestic trade. Trade is overwhelming longstanding policies, programs, systems, and practices intended to ensure that the products, packaging, and conveyances being moved are free of damaging pests. Until there is a united front among government agencies, economic entities engaged in trade, and the buying public to identify and implement more effective measures, pests will continue to enter the United States and impact the landscape.

Key policy issues remain unresolved:

1. International and interstate policies on trade
   A number of authors have concluded that the legislative mandate Congress provided to the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is a significant problem. It gives a higher priority to facilitating international and domestic trade than to preventing pests from first entering the country and moving within it after introduction. The current mandate reflects a compromise between competing interests, which can be altered if there is sufficient support for different priorities.

2. Preventing spread of non-native insects and pathogens
   While APHIS has extensive legal authority to counter pests' spread within the country, the agency's regulations have tended to emphasize facilitating interstate commerce (see Chapter 5 and the article by Porter and Robertson[1]) rather than maximize protection against pest spread.

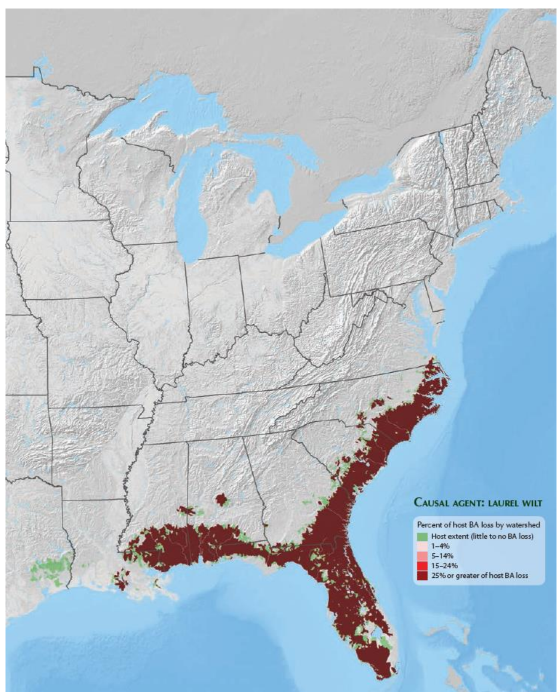
   State-imposed regulations afford some protection, especially when federal agencies are slow or unwilling to act. Unfortunately, relationships between APHIS and the states can become quite complex. They are also sometimes contentious, especially when it comes to devising management strategies that restrict movement of a commodity.

3. Addressing key pathways
   Increasing visual inspections for pests have been shown to be ineffective in curtailing the introduction and movement of pests *via* several of the most important pathways by which forest pests move, *e.g.*, with nursery stock and wood packaging. Regulations that require measures to ensure the "cleanliness" of the pathways, themselves, will be more effective, but only if they receive sufficient political support from stakeholders to be adopted.

4. Control of new and previously established pests.
   APHIS plans to rely less on intercepting pests at the U.S. border and more on detecting pests early and then responding rapidly. The agency is taking steps to improve early detection components of its programs. However, early detection is not easy. Furthermore, state and federal efforts to control pests quickly are insufficient now, and their continued funding is not assured. It is not clear how APHIS will pay for the improvements it envisions.

5. Lack of resources for forest restoration.
   Forest restoration is a key component for preventing or limiting the transformation of forest ecosystems. However, resources are seriously deficient. Tree improvement programs need bolstering. Germplasm for trees attacked by exotic pests needs to be conserved in a better organized and more coordinated fashion.

These five policy issues are detailed below. Also, chapters on preventing introductions into the United States (Chapter 4) and on preventing pests' spread within the country (Chapter 5) examine policies that apply primarily or exclusively to particular pathways.



Laurel wilt is expected to eradicate more than 90 percent of
Redbay populations throughout the species' range in just 15 years
Forest Health Technology Enterprise Team 2013 – 2027
National Insect & and Disease FOREST RISK ASSESSMENT
Krist, F.J. Jr., J.R. Ellenwood, M.E. Woods, A.J. McMahan, J.P. Cowardin, D.E. Ryerson, F.J. Sapio, M.O. Zweifler, S.A. Romero
FHTET-14-01
http://www.fs.fed.us/foresthealth/technology/nidrm.shtml

1. INTERNATIONAL POLICIES ON TRADE

The United States' capitalist economy is characterized by private or corporate ownership of capital and goods; by investments that are determined by private decisions; and by prices, production, and distribution of goods determined mainly by competition in a free market.

Although these economic activities can affect the environment and society as a whole, these impacts are not integrated into corporate decision-making. Instead, these impacts are considered by the business community as "externalities," including those due to the inadvertent import of foreign forest pests. The lack of concern by corporations and businesses is understandable, as they are not obligated to pay for damage, control, etc. from an imported forest pest.

Over the past decade, neither Congress, nor federal agencies, has fully accounted for foreign pest impacts when making trade policy, even though the United States has actively sought trade agreements and treaties over the last 30 years. While agricultural agreements have explicitly included phytosantiary components, the World Trade Organization's underlying treaties hamper efforts to protect against exotic invasions. [http://treeimprovement.utk.edu/FFII.htm] Under these measures, the federal government has to prove that an insect or pathogen will cause harm, before it can take steps to prevent its entry. This places the burden of proof, which can be difficult and costly, onto APHIS and thereby the American taxpayer, not the foreign supplier of some product to be imported.

Contrary to our expectations [http://treeimprovement.utk.edu/FFII.htm], the international phytosanitary, or plant health, community has acted fairly quickly to develop and implement new measures to address plant health concerns. New regulations governing solid wood packing material (SWPM) (ISPM#15) [https://www.ippc.int/core-activities/standards-setting/ispms] were first accepted by the world-wide phytosanitary community in 2002, less than four years after they were proposed. An international standard governing the movement of live plants (including nursery stock; ISPM#36) [https://www.ippc.int/core-activities/standards-setting/ispms] was adopted in 2013 after six years.

Legislating Contradictions: The Plant Protection Act

APHIS' legislative mandate makes the agency responsible for two contradictory goals: APHIS must protect the United States from plant pests while simultaneously facilitating trade among states, as well as between the United States and other countries.

The agency's authority derives from section (3) of the Plant Protection Act of 2000.[a] It states:

> "[I]t is the responsibility of the Secretary [of Agriculture] to facilitate . . . interstate commerce in . . . commodities that pose a risk of harboring plant pests or noxious weeds in ways that will reduce, to the extent practicable, as determined by the Secretary, the risk of dissemination of plant pests and noxious weeds .…"

The wording regarding "reduce" and "to the extent practicable" gives APHIS flexibility. However, these phrases combine to weaken the protection the act provides. A report by Porter and Robertson,[2] from the Environmental Law Institute faults the statutory language of the Act, as well as the practices that APHIS has adopted to implement it.

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[a] 7 U.S.C. §7701, *et seq.* (2000)

The contradiction reflects a balancing of the many interests at play when the statute was adopted and which continue to influence its implementation. It is our view that stronger involvement in the policy-making process by stakeholders who want to increase protection for forests can shift the agency's relative emphasis from "pro-trade" to "protection of forests."

2. PREVENTING SPREAD OF INSECTS AND PATHOGENS

The APHIS mandate to facilitate trade also applies to interstate commerce. In addition, the constitutional and legal presumption of free commerce within the country is backed by vocal and powerful interest groups.

As a result, APHIS has sometimes exercised the flexibility provided by statute to favor trade considerations. For example, APHIS has not barred from continuing to ship interstate those nurseries which have repeatedly been infested with the *Phytophthora ramorum* pathogen. As a result, infected plants were moved from the West to infect nurseries in at least 27 eastern states. Now, water-borne spores of the pathogen are repeatedly detected in several eastern streams.[3] More than 100 species of trees, shrubs, and herbaceous plants are hosts for the aggressive pathogen (see case study in Chapter 5).

APHIS maintains domestic quarantines and other restrictions on pest movement for a surprisingly short list of forest pests. These include only seven exotic insects and diseases of tress:

- European gypsy moth
- Asian longhorned beetle;
- Emerald ash borer;
- Common pine shoot beetle;
- Japanese beetle;
- Light brown apple moth
- Sudden oak death

APHIS' Authority to Regulate Pathways

APHIS has the legal authority (under Sections 7112 and 7114 of the Plant Protection Act) to regulate general pathways of spread within the country. However, the agency has been slow to take such action.

For example, APHIS is still developing regulations governing labels on firewood, a well-documented pathway for movement of numerous pests, six years after it was asked to do so by state phytosantiary and forestry officials. Also, APHIS has decided that it lacks sufficient data to justify regulating wood packaging in domestic commerce. Certain kinds of data will naturally be incomplete, or difficult to obtain, especially if pests are new, little-known, or hard to find. Requiring such information undermines the efficacy of any pathway-based strategy intended to limit pests' spread. Dr. Kenneth Rauscher, then head of the Michigan Department of Agriculture's pest program, explained at an emerald ash borer "summit" in March 2008, that effective regulations to manage pathways must be implemented ahead of a known pest's infestation. The current procedure – imposing a quarantine on only those areas known to be infested – usually means that the pest is "one jump ahead," and has already spread to additional areas.

Due partly to APHIS' self-imposed constraints, curtailing the spread of pests requires coordination of actions taken by multiple partners. States, various industries on a (semi) voluntary basis, individuals, and associations all are involved. Although this approach has potential, progress has been predictably slow or limited. Success would be greater if there were national measures to provide overarching requirements.

State Policies to Prevent Pests' Spread

Under the Commerce Clause of the U.S. Constitution and the Plant Protection Act,[4] states are free to adopt their own measures when there is no federal regulation. For example, they may restrict movement of potentially pest-infested articles from outside their borders into their state. Several states, most notably California, have used these powers assertively to inspect for specified agricultural pests before they are allowed into the state. For a variety of reasons, probably often related to funding constraints, APHIS has chosen not to regulate a growing number of exotic forest pests, including the goldspotted oak borer, `ohi`a rust, thousand cankers disease, and polyphagous shot hole borer. This puts the burden of protecting themselves onto the states.

Some argue that at least the first two of these pests are native to small parts of the United States, so they should not be deemed exotic pests, subject to applicable federal regulation. APHIS, however, agrees that the federal Plant Protection Act does not limit its authority to address pests native to the country.

Stand-alone state-imposed regulations do afford some protection. However, preventing the spread of pests by state regulation, alone, raises its own set of issues. First, states act independently. Their cumulative regulatory actions are unlikely to apply a consistent approach across landscapes. Second, even states that do regulate a pest or pathway remain vulnerable if a neighboring state adopts weaker regulations, or chooses not to regulate at all. Furthermore, shippers are confused by the many, and usually varied, requirements from state to state.

When APHIS has already regulated a pest, or is preparing to do so, relationships between the agency and the states can become quite complex and, sometimes, contentious. According to one study,[5] some conflicts might be an inevitable and unavoidable part of the constitutional system, at least as long as APHIS' mandate in the Plant Protection Act remains contradictory.

One source of conflict might arise when a state takes a pest threat more seriously than does APHIS. States that are currently free of a pest are motivated to prevent its introduction by adopting quarantines and other measures that are more stringent than current or pending federal rules. One example is the continuing conflict over how to regulate plants that are hosts of the sudden oak death pathogen, described in Porter and Robertson.[6]

In adopting the Plant Protection Act in 2000, the Congress included a provision allowing a state to request a "special needs exemption," in order to adopt measures stronger than APHIS'. This provision was probably intended to help manage state-federal tensions (as well as the pests themselves).[7]

In some cases, regulating a pathway can compensate for the lack of a species-specific program. Firewood is the most likely pathway by which goldspotted oak borer is spread and it is the focus of an elaborate nationwide program engaging many players, including APHIS (see chapter 5). For other pests – thousand cankers disease of walnut, *Puccinia* or `ohi`a rust, and *Sirex* woodwasp – the most likely pathways of transport are not regulated by either APHIS or the states.

APHIS' Support for State Pest Programs: the FRSMP Program

States often want APHIS' assistance in preventing introduction of pests into their jurisdictions. This is particularly true regarding pests that may arrive via imports from abroad, which the states have no legal authority to regulate.

Partially in response to states' needs, APHIS created a program it calls the "Federally Recognized State Managed Phytosanitary Program," or FRSMP. According to APHIS, this is designed to provide federal assistance to states.[8] A state petitions APHIS to designate a pest eligible for the program. Once APHIS accepts a petition, the agency will train its staff at ports of entry to disallow shipments to the participating state if they contain the pest. Also, APHIS will strengthen inspections at critical points of interstate movement, to interdict contaminated shipments that are destined for that state.

Despite promising this additional support, APHIS has been using FRSMP as an alternative to its own efforts, freeing APHIS from managing pests it considers to be of only regional concern.[9] In late 2010, APHIS began formally ending programs for specified pests, with the agreement of the National Plant Board. As of September 2013, 63 programs had been dropped.[10] (See Appendix III for a list of these pests.) In this time of shrinking budgets, APHIS' leaders appear to be divesting the agency of some traditional programs that the agency and its state counterparts agree are of less importance.

"Special Needs" Exemptions

When APHIS has established a federal quarantine for a pest, states normally are prohibited, by law, from requiring additional or inconsistent measures. This provision has concerned states, fearing they would be vulnerable if APHIS' rules are too weak to prevent the pest's spread.

In response, states persuaded Congress to include a "special needs" exemption in the Plant Protection Act of 2000.[b] The provision allows states to adopt regulations more stringent than an existing federal rule. First, though, they must demonstrate to the Secretary of Agriculture – with sound scientific data or a thorough risk assessment – that the state has a "special need" for additional prohibitions or restrictions. In 2008, APHIS adopted regulations[11] to clarify the process that states must follow, in applying for such an exemption.

There has been one analysis of APHIS' implementation of this provision. The authors concluded that APHIS has not allowed states to adopt limited, more stringent, regulations to supplement "leaky" federal quarantines – thus allowing pests to spread.[12] Fifteen states have filed at least seven individual and joint petitions for a special needs exemption since 2000.[c] They aimed to regulate pests associated with the movement of living plants (such as nursery stock, as distinct from fruits or vegetables). Five applications concerned the pathogen that causes sudden oak death. Two petitions addressed the light brown apple moth, an insect with a wide host range, established in parts of California. As of December 2011, APHIS had denied approval for six of these petitions; one request had received no response after 19 months.[13] The flurry of petitions led APHIS to negotiate with the states that resulted in adoption of a requirement that the West Coast states give recipient states advance notice of shipments of *P. ramorum* hosts – so that they can be prepared to inspect them thoroughly when they arrive.[14] Meanwhile, both pests have spread substantially, despite federal quarantines.

In rejecting these requests, APHIS has always cited perceived gaps in the specific petitions. However,

[b] 7 U.S.C. 7756

[c] APHIS did not disclose information on at least one additional petition to analysts, so the data are incomplete.

during the 2006-2008 rulemaking process, the agency received several formal public comments raising concerns about states' regulations impeding interstate commerce. APHIS' response indicated that it shared this concern. For example, two commenters wrote that the proposed rule would promote economic protectionism. The agency responded by reasserting that it would base its decision on the best available science and the requirement that it allow states to take only the least restrictive action (presumably, but not stated, needed to achieve the desired level of protection). Regardless of these concerns, each of the seven state petitions should have passed muster under the Commerce Clause, as there was no evidence that they were attempting to protect in-state producers.[15]

In its final rule, APHIS clarified that it would not grant a special needs request based solely on economic factors (such as potential losses to those who wished to send products to that state). Furthermore, APHIS restricted any exemption to an effective period of only two years. After that, the applicant would have to request a renewal, submitting all the information required for an initial request, along with justification for its continuation.[16] APHIS did not limit states' actions as much as some had asked, however. The agency refused to require that a petitioning state show that its stricter protections would not come at the expense of neighboring states.[17]

Porter and Robertson analyzed the criteria for approving states' requests in several measures – the Plant Protection Act, the federal rules adopted by APHIS, and the federal quarantines on sudden oak death and the light brown apple moth. The authors concluded that the quarantines governing both pests were intended to control the pests. That is, the rules were not intended to prevent the pests' dissemination, despite saying so in the federal quarantine regulations. According to Porter and Robertson's interpretation, the Plant Protection Act allows APHIS to preempt states' rules only if APHIS is acting to prevent the dissemination of a plant pest within the United States. Also, the authors suggested that APHIS would be well-served by a more flexible approach to granting states permission to adopt more restrictive quarantines, especially when an uninfested state seeks to prevent the pests' introduction.

However, APHIS has not taken this approach. The agency's focus is on limiting short-term impacts on the interstate horticultural trade,[d] rather than on protecting ecosystems and agriculture. This has left the East open to immense damage by sudden oak death *via* movement of nursery stock from the West Coast.[18]

Porter and Robertson[19] recommended that:

- APHIS should not impose a substantive evaluation on whether petitions are "complete." Rather, the agency should make this decision quickly, at a minimal threshold;
- APHIS should not require that the "particularly vulnerable" resources that it seeks to protect be unique to that state;
- APHIS should clarify the threshold level of vulnerability that must be demonstrated for those resources; and
- APHIS should specify, or Congress should enact, time limits for APHIS' decisions. The need for preventive quarantines is time-sensitive and should be implemented before the pest is spread into a state.

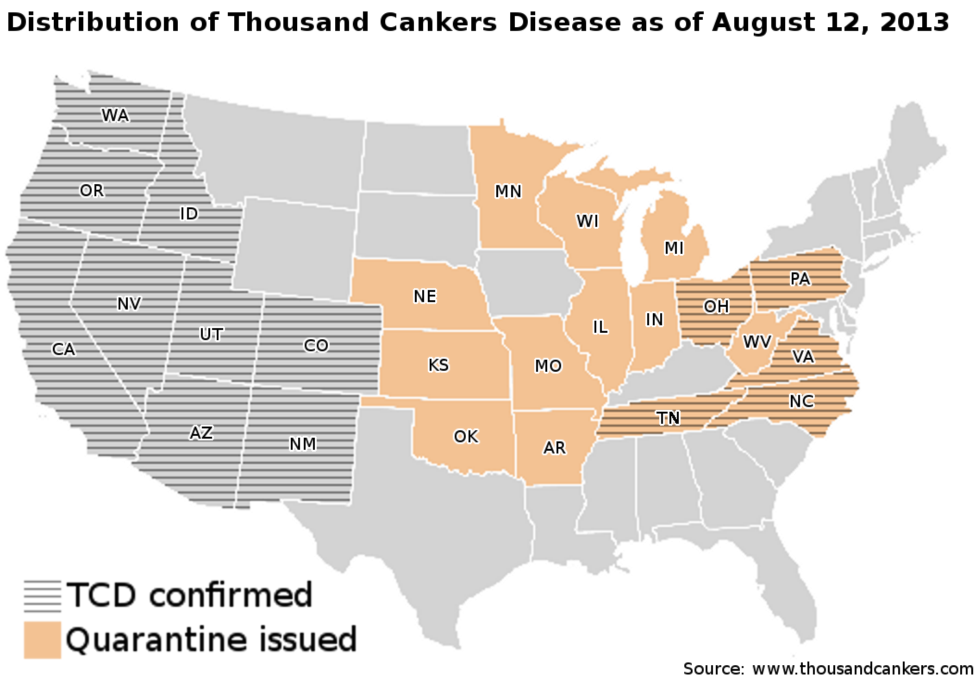
[d] This statement was taken from the Porter & Robertson study; Bob earlier approved my repeating their statements, since Environmental Law Institute is a credible source.

Coordinated State Quarantines

Despite the federal-state conflicts over how stringent some APHIS regulations should be and the disappointing record in administering the special needs provision, Porter and Robertson[20] concluded that a federal quarantine is still worthwhile, even when it is not sufficiently stringent to meet a state's goal of preventing a pest's entry.

Some states disagree, and actively oppose federal quarantines for certain pests. For example, Missouri and other states have adopted their own regulations governing thousand cankers disease of walnut. They have explicitly said that they do not want their efforts to be hampered by insufficient federal regulation.[21] Instead, these states have coordinated their efforts. As of the end of January 2014, 16 states regulate this disease (Figure 1).

Figure 1. Sixteen States with Regulations on Thousand Cankers Disease



Source: Anonymous. 2013. U.S. distribution map. Distribution of thousand cankers disease as of August 12, 2013. Online at http://www.thousandcankers.com/media/images/TCD_Confirmed_State_Map_2_2013.png. Accessed February 3, 2014.

Together, these states represent an impressive proportion of the host species' (black walnut and butternut) native range. However, some states within that range have not adopted any regulations. This exposes the entire region to an increased risk from the disease, can easily spread from an unregulated state, to an adjacent, regulated one.

The variety of regulatory responses to thousand cankers disease illustrates the weakness of relying solely on state efforts. Collectively, they are unlikely to provide landscape-level protection for all states. Clearly, a more effective, comprehensive and coordinated, federal-state program is needed to prevent pests' spread.

3. ADDRESSING KEY PATHWAYS

The most important international and federal regulators have all concluded that increased inspection of incoming goods will not more effectively limit the introduction and spread of exotic forest pests via several principal pathways.[22] The principal difficulties with inspection are, first, the relatively small percentage of goods that can be inspected and, second, the cryptic nature of many pests and pathogens.

Instead of inspections, APHIS' leadership has been relying increasingly on measures that address important pathways of pest introduction and movement, *e.g.*, nursery stock and wood packaging. Pathway-based measures address multiple pests at once, rather than attempting to manage individual pest species. Also, pathway approaches have the advantage of being compatible with trade agreements. These approaches can also help curtail introductions of unknown pests. Some parties to trade agreements object to this interpretation, since trade agreements require that pests' status as "quarantine pests" must be validated by risk assessment.

APHIS' revision of regulations governing imports of plants uses a pathway strategy, as we advocated in 2002 in Fading Forests II.[23] Implementation by APHIS has been relatively slow, with important rules still not in place as of January 2014. This is due, in part, to legal requirements for rulemaking. Furthermore, the agency has experienced long delays in obtaining approval by USDA leaders for steps intended to implement the new regulatory approach. For example, USDA officials took more than six years to approve APHIS' authority to temporarily prohibit imports of certain plants while the Agency determined what, if any, procedures would allow such imports to proceed safely.

4. CONTROL OF NEW AND ESTABLISHED PESTS

APHIS plans to rely more heavily on early detection of, and rapid response to, exotic pests. The agency is taking steps to improve such efforts. For example, APHIS is exploring how to engage private individuals and non-governmental groups in early detection. The need to have more people watching for more pests was made obvious by several recent outbreaks. The large, apparently long-established, population of Asian longhorned beetles in Worcester, Massachusetts, was not reported until 2008, ten or more years after it became established.[24] Then, it was a homeowner who first found the pest.

Section 10201 of the 2008 Farm Bill has provided higher and more stable funding for both early detection and rapid response. (It is not subject to fluctuating annual appropriations.) Funding has been at $50 million per year, since Fiscal Year 2011. Fortunately, the versions of the Farm Bill adopted by the House and Senate in 2013 continue the early detection and rapid response program.

Why Early Detection and Rapid Response Fail

APHIS will need to solve serious problems, if its focus on early pest detection is to succeed. There are so many foreign insects that could potentially be introduced that trying to develop detection tools tailored to each is not likely to be productive. The presence and spread of many newly introduced woodborers, for example, can be detected only after scientists have spent years developing traps and lures. Detection of pathogens often occurs only after they have become established and caused noticeable levels of disease. A further difficulty is that many pathogens are completely unknown, or their native ranges have not been determined. This lack of knowledge makes it difficult to decide whether a newly discovered species is native to the region but formerly overlooked; or exotic.[25]

Most disturbing, however, is the continued pattern of insufficient response, once a pest outbreak is found. While APHIS' shrinking budget is a principal cause of this shortfall, there are other causes:

- Procedural Issues
    - Detections usually occur years after the initial introduction, allowing a pest to become too widespread for small-scale and quick eradication;
    - Officials tend to act against a new pest after its ability to cause harm is demonstrated, even when a scientific risk assessment has predicted significant damage; and
    - Some populations of pests are overlooked, because there is no national infrastructure for monitoring them.
- The Size of the Problem
    - State and federal agencies are already overwhelmed by the demands of existing programs that target the established pests causing major damage to prominent forest trees;
    - More pests are detected each year – ones new to the United States, or to a state; and
    - Each pest requires an individualized program. Detection and control methods generally cannot be transferred from one pest to another, because of biological differences.
- Policy Issues
    - State and federal agencies focus on short-term response to a host of other forest problems, *e.g.*, forest fires;
    - Federal programs give priority to addressing other natural resource issues, *e.g.*, climate change;
    - Funding for addressing current pests is inadequate, yet declining; and
    - There is no prospect of additional funds to address newly detected and established pests, with declining state and federal budgets.

Between 2002 and 2010, APHIS became quite aggressive in its efforts to prevent or contain pests that threaten primarily native habitats and urban or suburban areas, as distinct from major agricultural crops. In Fiscal Year 2010, nearly half of APHIS' budget for "emerging plant pests" was allocated to recently introduced, high-profile tree pests, *i.e.*, the Asian longhorned beetle, emerald ash borer, and sudden oak death.

Changes in the structure of APHIS' budget make year-to-year comparisons of funding difficult. However, it is apparent that the proportion of APHIS' funds for containing and eradicating forest pests has decreased significantly since FY2010.

As federal budget grow tighter, Congress appears to be less willing to fund APHIS' programs on the wood borers. That is, Congress has asked the agency to focus on its historical core programs.[26] The FY2012 congressional appropriation reduced funding from nearly $76 million in FY2011 to $55.6 million for woodborers. The bulk of the cuts were in its emerald ash borer program. As a result, the number of traps used to detect this pest is expected to fall from 65,000 in 2011, to 12,000 in 2013.[27] Trapping efforts in a great arc of states, from Minnesota south to Tennessee, then north to New Hampshire, were affected.

Figure 2. Declines in Funding for USDA forest pest programs

Funds in millions of dollars

USDA Animal and Plant Health Inspection Service

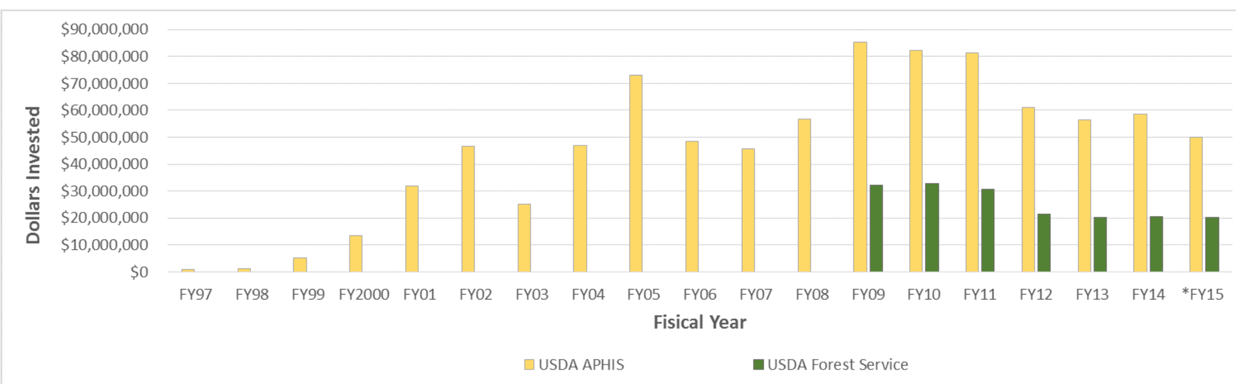
	FY11 CR	FY12 enacted	FY13 CR (post-sequester)	FY14 enacted	FY15 Pres' proposed funding
Tree & Wood pests	$ 75,994,000	$ 55,638,000	$52,273,000	$54,000,000	$45,392,000
Specialty crops	$150,079,000	$153,950,000	$142,086,000	$151,500,000	$137,393,000
SOD specifically	$5,336,000	$5,365,000	$4,034,000	$4,678,000	Unknown at present

USDA Forest Service

	FY11 CR	FY12 enacted	FY13 CR (post-sequester)	FY14 enacted	FY15 Pres' proposed funding
S&P, FHP	S132,228,000	$111,735,000	$105,900,000	$104,577,000	$104,600,000
Amt of FHP for NIS*		$15,794,000	14,608,000	14,891,000	14,891,000 ~13% of total
Research	$306,637,000	$295,800,000	$279,854,000	$292,805,000	$275,000,000
Amt of R&D for NIS*	$8,154,000	$5,640,5000	$5,477,000	$5,565,000	$5,247,000 <2% of total

*"amount for NIS" does not include funding for programs targetting such native pests as the southern pine beetle or western bark beetles; subterranean termites; or invasive plants species.

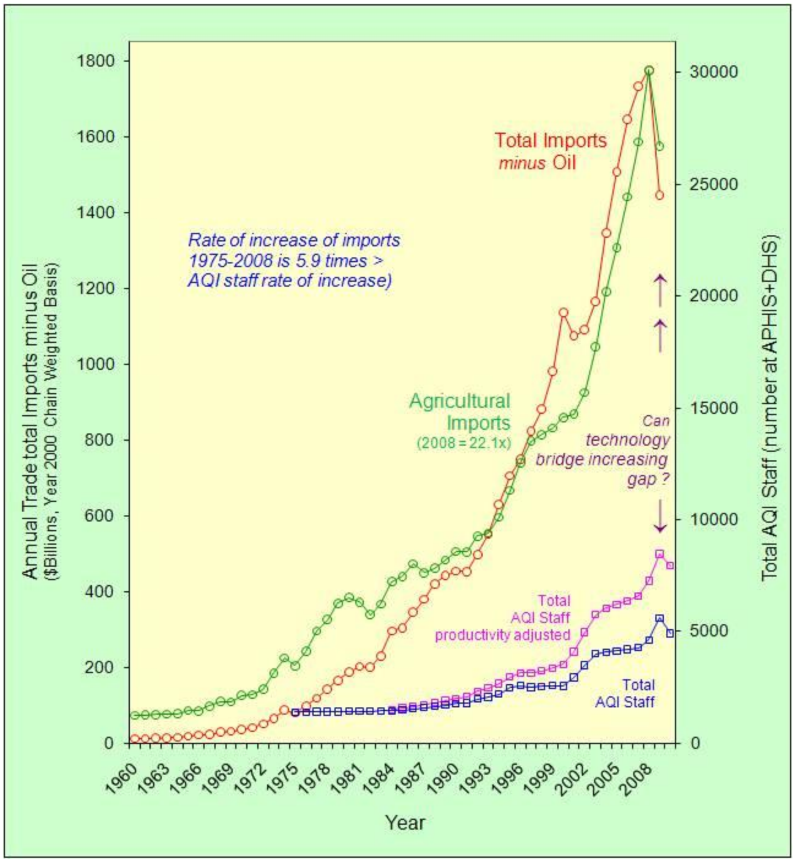
Total USDA spending for forest pests, FYs 1997 – 2015 (last is proposed level)



APHIS spending levels in some years was enhanced by emergency funding from Commodity Credit Corporation and carry-overs from previous years' funding.

At a time when imports are at record levels, overall support for APHIS' plant pest program has dramatically declined since 1975, per billion U.S. dollars of goods imported. Thus, even before recent cutbacks, funding had fallen behind.

Figure 3. Value of U.S. Imports Compared to USDA/APHIS Resources



Graph prepared by Allan N.D. AuClair, USDA APHIS

USDA Forest Service spending on individual pest species (does not include spending on native pests, subterranean termites, or invasive plant species).

Species	Agency	FY11	FY12	FY13	FY14	FY15 proposed
ALB	USFS FHP	200,000	60,000	120,000	120,000	108,000
	USFS Research	147,000	50,000	50,000	50,000	50,000
EAB	USFS FHP	4,995,000	2,300,000	500,000	500,000	500,000
	USFS Research	1,428,000	1,792,000	1,295,000	1,297,000	1,168,000
SOD/P. ramorum	USFS FHP	1,600,000	1,350,000	1,350,000	1,350,000	1,350,000
	USFS Research	2,103,000	375,000	244,000	270,000	219,000
GSOB/TCD/LW	USFS FHP	300,000	580,000	580,000	580,000	580,000
	USFS Research			506,000	509,000	499,000
Euro. Gypsy moth	USFS FHP	12,020,0000	8,132,000	8,769,000	8,350,000	9,102,000
	USFS Research	1,624,000	849,000	987,000	987,000	888,000
HWA	USFS FHP	3,500,000	1,900,000	1,900,000	1,900,000	1,900,000
	USFS Research	1,923,000	2,335,000	1,821,000	1,892,000	1,782,000
Oak wilt	USFS FHP	600,000	500,000	400,000	500,000	500,000
	USFS Research	125,000	75,000	74,000	74,000	74,000
POC	USFS FHP	189,000	189,000	175,000	175,000	175,000
Sirex	USFS FHP	50,000	400,000	400,000	400.000	250,000
	USFS Research	229,000	140,000	120,000	120,000	114,000
Whitebark pine pests (incl WPBR)	USFS FHP	700,000	250,000	450,000	450,000	450,000
	USFS Research	575,000	24,000	310,000	296,000	327,000
TOTAL*		27,869,000	23,285,000	20,161,000	20,532,000	20,138,000

6. CONCLUSION

The following general statement regarding U.S. policy on the entry and spread of exotic forest pests emerges from this chapter.

In the few instances where policy improvements have been made, their impact has been significant. But history shows that needed changes are often:

- slow to be developed and implemented;
- incomplete in scope;
- inconsistent;
- poorly enforced; and
- under-funded.

Chapter 7 provides suggestions on how improvements can be made.

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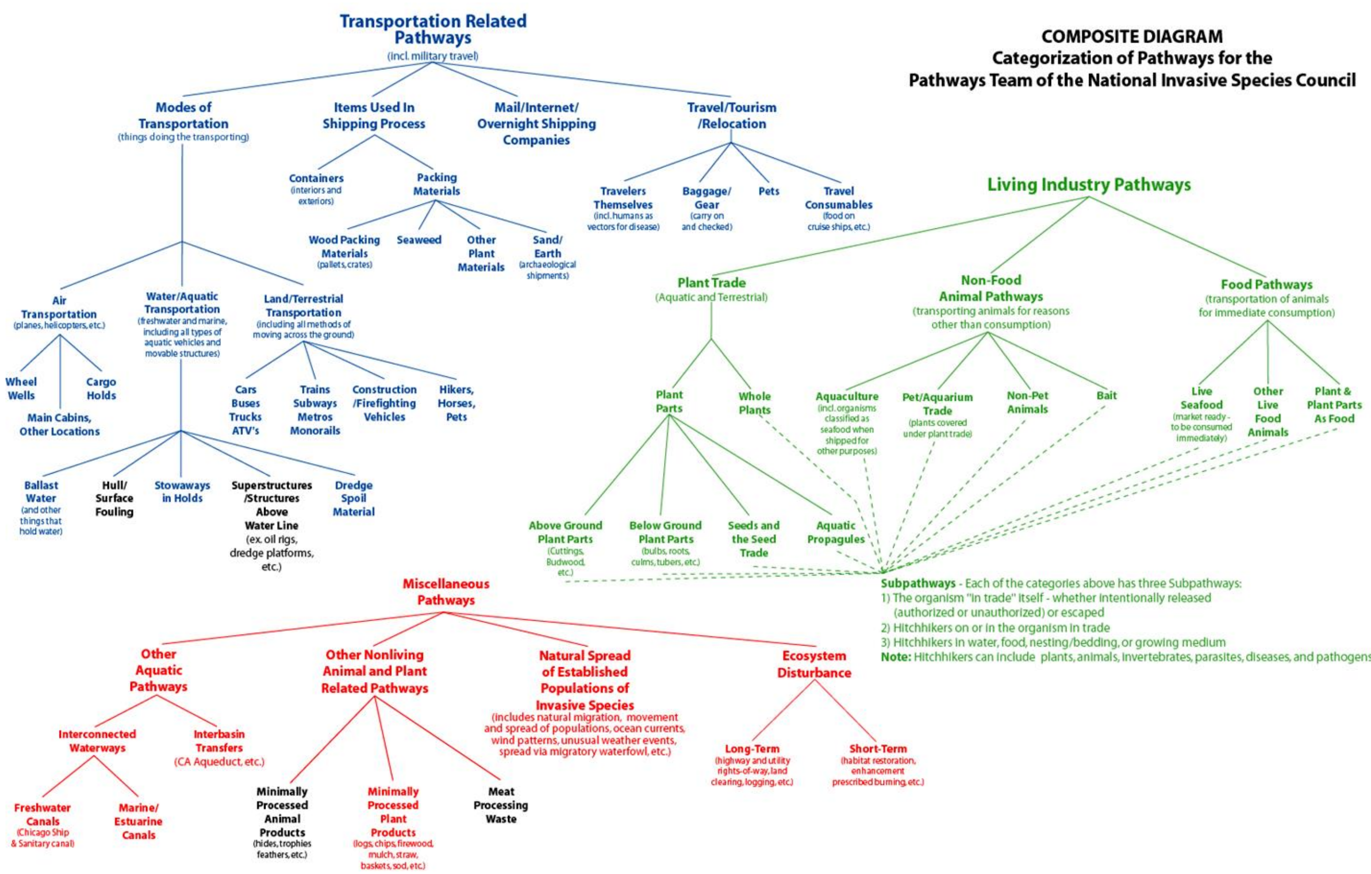
Chapter 4 Invasion Pathways

Damaging forest pests have been reaching North America since at least the early 1800s, when American chestnuts began to die from *Phytophthora cinnamomi*, a pathogen probably imported on potted plants.[1] With few exceptions, importations of all forest pests have been either directly or indirectly connected with international trade[2] (Figure 1). The number of pathways by which pests move is actually small. But their relative importance varies as transportation systems evolve, energy costs fluctuate, new trade agreements are made, and other polices change.

Figure 1. Pathways Into North America



Visual depictions of introduction pathways
Developed by the "Prevention" subgroup of the national
Invasive Species Advisory Committee, 2002

Over the years, most introductions of foreign tree pests have arrived on:

- Imported living plants (called "plants for planting" by phytosanitary agencies);
- Associated soil;
- Minimally processed wood, e.g., logs, lumber and wood chips, particularly when bark is still attached; or
- Packaging materials made of solid wood (crates, pallets, spools, etc.).

Since the United States no longer allows the import of many types of plants in soil, this pathway has almost disappeared. However, imports of live, whole plants continue, along with that of plant material without roots, intended for vegetative propagation. Such live plant imports have accounted for the vast majority of imported forest pests over the past century and this pathway remains high-risk.[3]

In recent decades, wood packaging has been the most important pathway for introducing forest pests. Imports of logs and lumber have not been linked to significant pest introductions during this time.

Some pathways are less important overall, but they are significant for specific pests. For example, ship superstructures and hard-sided cargo (like shipping containers and automobiles) transport egg masses of gypsy moths. Serious pests also have been detected or introduced in imported handicrafts or knickknacks made of unprocessed wood or other tree parts (*e.g.*, bark and pine cones). Occasionally, tourists use their luggage to smuggle living plant material, which may be contaminated, for example, with chestnut gall wasp.

MAJOR PATHWAYS

Progress has been made to curb pest entry along each key route, but the pathways remain far from closed. Each major and minor pathway of introduction is covered below. Its status and trends are described, along with policies that changed in the last ten years. Where possible, there are suggestions of issues that may be important in the future.

1. The Living Plants Pathway

Legal or illegal imports of nursery materials from foreign countries have been repeatedly proven to transmit devastating forest pests.[4] The parties to the International Plant Protection Convention have categorized "plants for planting" as a high-risk category of commodity.[5]

Rhododendron infected by sudden oak death pathogen;
Photograph courtesy of Jennifer Parke, Oregon State University

Status and Trends

The number of nursery plants imported into the United States has increased rapidly, exceeding 3.15 billion plants in 2007.[6] In 2011, U.S. imports of living plants equaled 9 percent of all such imports worldwide.[7] The increasing threat of importing pests on "plants for planting" stems not just from these rising numbers, but also from the greater variety of plants being imported, and the growing number of countries from which they come. Together, these trends increase the variety of pests that can be introduced.[8] Nearly all the sap-feeding pests (*e.g.*, hemlock woolly adelgid, other aphids), almost 90 percent of the foliage-feeding insects, and approximately half of forest pathogens, all established between 1860 and 2006, most likely arrived on imported plants.[9]

Table 1. Damaging Forest Pests Probably Introduced on Living Plants

Disease Species	**Primary Host(s)**
Phytophthora cinnamomi	American chestnut Allegheny and Ozark chinkapins other species in nursery and field conditions
Chestnut blight	American chestnut, Allegheny and Ozark chinkapins
White pine blister rust	five-needle pines
Port-Orford-cedar root disease	Port-Orford cedar
Butternut canker	butternut
Dogwood anthracnose	flowering and Pacific dogwoods
Sudden oak death*	more than 100 species of trees, shrubs, herbaceous plants
Insect Pest Species	**Plant Host/s**
Balsam woolly adelgid	balsam and Fraser fir
Larch casebearer	Eastern and western larches
Beech scale	American beech
Citrus longhorned beetle **	Variety of hardwood species
Pisonia scale	*Pisonia grandis* (on Palmyra and other Pacific atolls)
Asian cycad scale	native cycads on Guam
Erythrina gall wasp	native and exotic coral trees in *Erythrina* genus on Hawai`i
Cycad blue butterfly	native cycads on Guam
Bromeliad weevil	bromeliads in southern Florida

* genetic evidence indicates that the sudden oak death pathogen, *Phytophthora ramorum*, has been introduced to North America several times; three distinct genetic strains have been found in North American nurseries.[10] [11] Furthermore, one strain (EU1) became distinct from the other two strains (NA1 and NA2) at least 165,000 years ago.[12] This means that there is probably more than one foreign site or population from which further introductions can occur.

** eradicated

Sources: Compiled by F.T. Campbell from various sources.

Chestnut blight disease on American chestnut sprouts.
Photograph by Scott E. Schlarbaum, The University of Tennessee, and is in the public domain.

Box 1. The Global "Plants for Planting" Pathway

The threat of pest introduction *via* the "plants for planting" pathway is global.

For example, the sudden oak death pathogen is established in nurseries across Europe. In Great Britain and Ireland, in particular, the disease is spreading where climate is suitable, within both native and introduced plants.[13] When 601 nurseries in 21 European countries were surveyed, mostly between 2000 and 2012, 94 percent were found to be contaminated by one or more of 40 different species or other taxa of *Phytophthora*. In infested nurseries, these organisms were present in 79 percent of fields and container stands.[14]

As of 2009, the citrus longhorned beetle was found in nurseries or nearby woodlands at six sites in Italy, plus one each in France and the Netherlands.[15] The pest is now established in Italy, but the French and Dutch outbreaks were eradicated; in 2010 and 2011, beetles were found in Denmark, too.[16]

The greatest risk is associated with imports of whole plants. US trade data are collated for the following categories of whole plants: roses; rhododendrons and azaleas; and trees and shrubs bearing fruits or nuts. The fruit and nut group is subject to stringent regulation because of the recognized pest risk. Trade data show that the regions receiving the largest numbers of rhododendrons and azaleas per year are, in descending order, Michigan and Ohio (combined, 471,000); New York and New Jersey (combined, 369,000); Maryland and Virginia (combined, 274,000); Oregon (247,500), and California (232,500).[17]

One trend is encouraging: a growing proportion of plant imports are cuttings and slips, used for vegetative propagation, like rooting and grafting. Cuttings increased 242 percent between 1996 and 2005, while overall plant imports during that period increased 28 percent.[18] Cuttings are less likely to carry pests than are whole plants, although damaging invaders can be introduced on any kind of plant material, even cut foliage. States receiving the largest volumes of cuttings are, in descending order, California (slightly over 15 million); Florida (14.8 million); Ohio (12 million); Illinois (11.6 million); and Colorado (7.6 million).[19]

Upon arrival in the United States, imported plants are sent to one of USDA's 17 Plant Inspection Stations, where visual examinations are carried out by agricultural experts, employed by APHIS.

Inspection at an APHIS Plant Inspection Station
Photograph courtesy of USDA APHIS

The effectiveness of visual inspections is not encouraging. A study compared APHIS port inspection data from Fiscal Year 2009 for six commonly imported genera with results from more intense inspections of those genera undertaken for program evaluation (Agriculture Quarantine Inspection Monitoring, or AQIM). In this small sample, approximately 12 percent of incoming living plant shipments had reportable pests, a rate more than 100 times greater than for imported wood packaging.[20] There is considerable variation in the infestation rate among the six genera. Again, for this small sample, APHIS inspectors at Port Inspection Stations did not detect 72 percent of infested shipments.[21] The study results cannot be extrapolated to other genera. Nor did the study address how many shipments, in total, were infested, but not displaying symptoms.[22]

Interception figures gathered from standard inspections almost certainly understate the problem.

The logistics of the plant trade amplify the risk. In 2010, seventy-two percent of plant imports transported by ship entered the U.S. at one of three major metropolitan areas: Los Angeles-Long Beach-Santa Ana (37.3 percent); New York City-Northern New Jersey-Long Island (23.3 percent); or Miami-Ft. Lauderdale-Pompano Beach (11.6%). Two of these ports (New York and Miami, receiving more than one-third of all plant imports transported by ship) tend to receive plants primarily from source ecosystems similar to those in the receiving region – thus increasing the likelihood that a damaging pest will establish. Miami receives plants primarily from the subtropical/tropical moist broadleaf forests biome; New York City from temperate broadleaf/mixed forest biome. Los Angeles also receives plants primarily from the subtropical/tropical moist broadleaf forests biome. While the natural ecosystems around Los Angeles would not be suitable for plants hosting pests from moist regions, many areas of the region are irrigated artificially, and thus might contain suitable hosts.[23]

Furthermore, three-quarters of all the plants imported by ship were probably sent on to a limited number of retail sales outlets in 154 counties which are located primarily in California, Florida,, New Jersey and Connecticut, and in portions of Washington, New York Pennsylvania, and Maryland.[24] The urban and rural areas in these metropolitan areas have strong economic interactions that facilitate the establishment and spread of any pests associated with the imported pests. [25]

Past Major Policy Actions (2002-2011)

APHIS' actions

In APHIS' December 2004 Advance Notice of Proposed Rulemaking, or ANPR,[26] the agency outlined a strategy for reducing pest introductions *via* this pathway. The strategy had two major steps.

First, the agency would create a temporary holding category for plants suspected of transporting insects or diseases. This would allow APHIS to suspend imports of particular plants, from certain countries, until a full risk assessment was completed.

Second, APHIS would issue regulations establishing a general framework to minimize the presence of pests. Using this, the agency would negotiate country-specific requirements for imported plants, working toward an approach that would rely on "integrated measures."

Box 2. Integrated Measures Proposed by APHIS

The odds that imported plants are carrying known or unknown pests can be minimized in a number of ways. An important option is to focus largely on the production facilities, and phytosanitary agencies, of exporting countries. In its 2004 ANPR, APHIS proposed to do just that.[27] The agency was considering a program to integrate producers' procedures, standards, audits, and record-keeping, in which:

- Production facilities would generate plants from propagative material free, or nearly free, of pests;

- Production facilities would have an approved set of standard operating procedures, ones that include adequate pest control; regular inspection and testing; and detailed recordkeeping of all aspects of plant production. This would include the origin of plants intended for export – so that they can be traced back, if a pest is detected by the importing country;

- The phytosanitary agency of the producing country would oversee the production facility, and perform regular audits, to ensure that all elements of the production system comply with program standards;

- APHIS could perform on-site audits of the production system. Also, APHIS would audit imports to ensure that plants meet the standards mandated by the program;

- Penalties and remedial action, in the case of noncompliance, would be established through negotiations between APHIS and the exporting country's phytosanitary agency; and

- APHIS would require plant brokers to keep records facilitating trace-back and to follow specified procedures to ensure the continued phytosanitary status of plants under their control.

Appendix I describes the integrated measures adopted by the international community, under the International Plant Protection Convention. APHIS' proposal is similar.

Years went by without APHIS implementing either of the steps called for in the ANPR. Instead, the agency curtailed imports of certain plants from certain places that were considered to pose particularly high risks, by issuing federal orders (Box 3). However, many other taxon/origin combinations continued to be handled by standard inspections at the time of shipment. Nor did APHIS adopt regulations aimed at encouraging producers to shift toward safer plant materials (such as seed or tissue culture).

Box 3. Federal Orders

APHIS issues a federal order when the Administrator considers it necessary to act to prevent entry and subsequent establishment of a pest or disease. For example, APHIS issued a Federal Order to restrict import of plants for planting known to be hosts of *Phytophthora ramorum* in April 2012. In May 2013, the agency used a federal order to renew and revise restrictions on importing plant hosts of the citrus longhorned beetle and the Asian longhorned beetle.[28]

Federal Orders are effective immediately and contain specific regulatory requirements. They are issued under authority provided by the Plant Protection Act of 2000, as amended (Section 412[a], 7 U.S.C. 7712[a]). Federal Orders remain in effect until they are revised by another, or until an interim rule on the subject is published.[29]

After reviewing comments on its original ANPR, APHIS formally proposed to create the temporary holding category, which it called "not approved (for importation) pending pest risk assessment," or NAPPRA. The proposal was published for comment in summer 2009;[30] the regulations were finalized in May 2011[31] – six and one half years after the intention to take this action was announced in the ANPR. In adopting the NAPPRA rule, APHIS reiterated the need to encourage, <u>but not require</u>, the plant import trade either to rely on low-risk plant materials or to adopt pest-reduction methods.

In July 2011, APHIS published the initial list of species proposed for inclusion in the NAPPRA category.[32] This list was finalized in April 2013.[33] APHIS staff has identified additional plant taxa that are associated with high-profile pests. A second list of species proposed for NAPPRA listing was published in May 2013.[34]

In its first NAPPRA list, the agency acted boldly by including some plants that are imported in high volumes. Also, APHIS targeted some plant taxa for regulation as hosts of pathogens, but without insisting on laboratory proof of their host status. However, the NAPPRA list will not help APHIS in preventing introduction of pests that are, so far, unknown. It includes only plant taxa known to host specific pests that already have a high profile.

Table 2. Sample of Plants Included on the NAPPRA List (First round)

The following plants are hosts of forest pests and among those placed in APHIS' new regulatory category, named "Not Approved (for Importation) Pending Pest Risk Assessment," or NAPPRA.

Plant Import/Host	Pest Species
Woody plants in 72 genera, including: *Acer, Betula, Camellia, Cornus, Ilex, Juglans, Malus, Pinus, Platanus, Populus, Prunus, Quercus, Rhododendron, Rosa, Salix, Ulmus,* and *Viburnum* Imports of some genera, from some countries, are permitted.	Citrus longhorned beetle
Larix, Pseudolarix	*Lachnellula wilkommii*
Alnus	*Phytophthora alni* subsp. *alni*
Five genera of palms	*Rhynochophorus palmarum*

Source: See the full list of plants, at http://www.aphis.usda.gov/import_export/plants/plant_imports/Q37/nappra/downloads/HostsofQuarantinePests.pdf.

International actions

Progress in requiring foreign plant suppliers to adopt systems-based, or integrated, pest-reduction approaches has been more obvious in the international arena than in APHIS' domestic actions. Authority for requiring such programs was initially adopted at the regional level by the North American Plant Protection Organization (NAPPO).

RSPM #24. Three years of negotiations involving the U.S, Canadian, and Mexican governments, industries, and non-governmental groups resulted in adoption of the Regional Standard for Phytosanitary Measures (RSPM) #24, in 2005.[35] NAPPO's objectives were to:

- Prevent the introduction and spread of quarantine pests associated with plants for planting and imported into NAPPO countries; and
- Facilitate equitable and orderly trade into, and within, the NAPPO region, using, to the extent possible, best product/management practices.

Regional standards such as RSPM #24 have no power *per se*. They must be implemented by the individual countries, through their normal regulatory procedures.

The Canadian nursery industry began adopting pest-reduction systems, in anticipation of U.S. regulatory action. In April 2013, APHIS published a proposal to implement RSPM #24.[36] Also, some members of the U.S. plant industry adopted measures to comply with expected Canadian rules, growing out of the regional standard. The U.S. nursery industry as a whole, however, is still not moving forward to implement the approach in RSPM #24. (See also the discussion of *P. ramorum*, sudden oak death, in Chapter 5.)

ISPM #36. The political dynamic, under which U.S. nurseries have delayed using integrated measures, might change due to adoption of International Standard for Phytosanitary Measures (ISPM) #36 by the International Plant Protection Convention in spring 2012.[37] ISPM #36 is similar to RSPM #24 in most respects. It is summarized in Appendix I.

2. The Solid Wood Packaging Material Pathway

A second high-risk pathway for alien forest pests is the import of solid wood packaging material (SWPM), such as crates and pallets.

Live larva found in wood packaging with ISPM mark;
Photograph courtesy of Oregon Department of Agriculture

Status and Trends

The threat of pest introductions *via* this pathway rose to prominence with outbreaks of the Asian longhorned beetle in New York in 1996, then in Chicago in 1998, followed by Toronto in 2003. Detection of the emerald ash borer in 2002, in Detroit, firmly embedded SWPM in the regulatory community's awareness. Scientists have identified more than 40 exotic wood borers, detected between 1985 and 2011, that are suspected as having been introduced by this pathway.[38]

Among the pests likely to be introduced are bark beetles and wood borers (like cerambycid and buprestid beetles), and siricid woodwasps), and deepwood fungi.[39] [40] Specific examples include the Asian longhorned beetle, emerald ash borer, *Sirex* woodwasp, and redbay ambrosia beetle.

Since 1990, new wood-boring species have been detected at a rate of 1.2 per year, which is nearly three times the rate in previous decades. This rising detection rate contrasts with the steady rate of detections for forest pests overall.[41] The increasing detection of wood borers is particularly alarming, because these organisms' impacts total more than $3 billion per year in the United States. (See Chap. 2).

Woodborers' countries of origin have varied considerably between 1984 and 2008. There was a dramatic decline in interceptions from Europe, during the 1980s and 1990s; this was counterbalanced by an increase, since 2000, in interceptions from Central America and, especially, Mexico.[42]

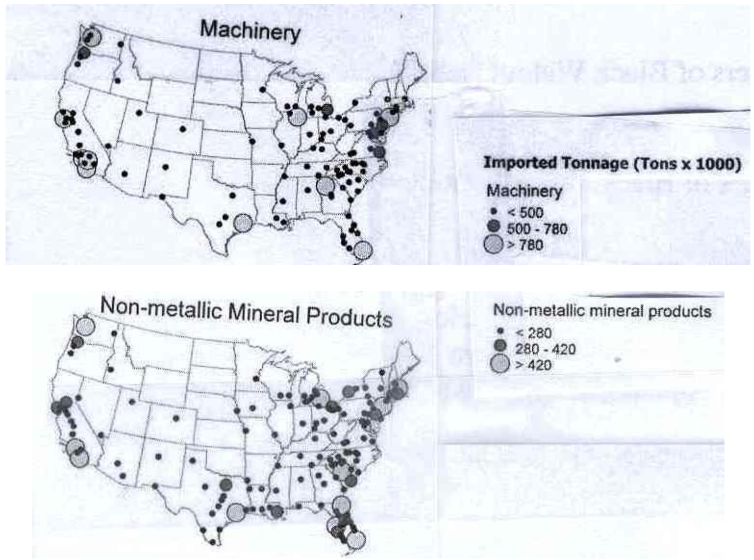
The efficacy of measures to eliminate pests from wood packaging is of great importance since U.S. imports of commodities that are often packaged in wood are projected to rise rapidly in coming decades, exacerbating the threat of introductions. These commodities include nonmetallic minerals (*e.g.*, ceramic tiles and marble) and machinery. Imports of such minerals are expected to more than double between 2002 and 2035; imports of machinery from Asia are expected to increase by 720 percent.[43]

Box 4. The Global Wood Packaging Pathway

The threat of insects in wood packaging is recognized as international: insects in the genus *Anoplophora* (which includes the Asian longhorned beetle and its closest relatives) were intercepted 219 times by 17 countries during the period 1980–2008. Ninety-seven percent of interceptions on solid wood packaging material, for which the country of origin was known, were from China. (All were assumed to be the Asian longhorned beetle.) The most interceptions reported worldwide, in a single year, were 44 Asian longhorned beetles in 1998.[44]

All parts of the country are at risk of an introduction *via* the wood packaging pathway, because of the distribution network associated with imported goods. Colunga-Garcia and colleagues ranked 3,126 urban areas across the continental United States, as a final destination for imports of non-metallic minerals and machinery. Fifty-six urban areas, in 22 states, received 80 percent of the imported machinery. Ninety-six areas, in 28 states, received 80 percent of imported nonmetallic mineral products.[45]

Figure 2. Maps showing principal destinations of imports of machinery & non-metallic metals – goods often associated with wood packaging



Maps from Colunga-Garcia, M., R.A. Haack, and A.O. Adelaja. 2009. Freight Transportation and the Potential for Invasions of Exotic Insects in Urban and Periurban Forests of the US. J. Econ. Entomol. 102(1): 237-246 (2009), courtesy of M. Colunga-Garcia

Generally, states where wood-boring insect pests have first been detected coincide with those receiving the highest volumes of imports.[46] However, the same is not always true regarding the pests that cause the most damage. Some introduction sites for the Asian longhorned beetle (Worcester, Massachusetts and Belem, Ohio) do not rank high as recipients of Asian merchandise. The redbay ambrosia beetle was introduced in Savannah, Georgia, which ranked 72nd for imports of Asian machinery, and 88th for Asian non-metallic minerals.[47] Such anomalies show that early detection efforts will miss significant pests, if they focus exclusively on the obvious, that is, cities receiving high volumes of imports.

A study of beetles introduced to Europe and North America found that the number of newly established beetle species, in most cases, might be primarily determined by the identity of the trading partners and the volume of imports.[48] The authors also found that the value of imports was the strongest predictor of the number of exotic bark beetle species to become established in the United States, and of exotic ambrosia beetle species to become established in Europe. The suitability of climate and other attributes of the local environment in the recipient region was less significant.

However, for exotic ambrosia beetles introduced into the United States, climate was more significant than import volume. A large majority of these are from southeastern Asia, which has a generally warmer and wetter environment than corresponding biogeographic areas in the United States. If climate change makes the U.S. Southeast more like Asia, we can expect th more ambrosia beetles to thrive there.[49]

Some scientists are concerned that ambrosia beetles can carry damaging pathogens – as has happened with the redbay ambrosia beetle, the primary vector for laurel wilt;[50] and the polyphagous shot hole borer.[51] (Ambrosia beetles can also be transported in pathways other than wood packaging.)

Wood packaging imported from Canada and Mexico, also has the potential to introduce forest pests. So far, the United States and Canada have exempted the movement of SWPM between themselves from regulation – and inspections are infrequent. As a result, wood-inhabiting pests have been intercepted from Canada, although the numbers are low. In addition, about 20 percent of wood pallets manufactured in Canada and the United States contain small bark patches. Insect species that APHIS considers worthy of official action have been found with bark on pallets from Canada.[52]

Past Policy Actions (2002 – 2011)

Significant progress has been made since 2002 in closing the wood packaging pathway. APHIS and its Canadian counterpart (the Canadian Food Inspection Agency) led a major, world-wide effort, beginning in 1998, to accomplish this. They pioneered an innovative approach: adoption of an international "standard" that mandated application of phytosanitary measures to all wood packaging used in international commerce.

International Standard for Phytosanitary Measures (ISPM) #15

The text of the new standard was finalized in 2002 and revised substantially in 2009. As of 2011, more than 70 countries had implemented it.

ISPM #15[53] recommends that countries require treatment of all wood packaging by one of a few approved methods, without having to prove the pest risk associated with any particular crate or pallet. This represents a major advance in several ways. It provides a mechanism to overcome problems of proving risks for multiple pests of different biological taxa and geographic origins, as well as for those that have unknown risks.[54] Also, the 2009 amendments, for the first time, included fungi and fungal-like organisms (oomycetes, such as the sudden oak death pathogen, *Phytophthora ramorum*) as pests of concern.[55]

In 2010, APHIS proposed to end the exemption for imports of wood packaging material from Canada.[56] However, final regulations have not yet been published.

Given the huge volumes of wood packaging already in trade (see Chapter 1), along with projected increases noted above, it is vitally important that this phytosanitary measure be effective. Schortemeyer *et al*.[57] calculated that, in the worst case, a single wood pallet from China could be infested by up to nine Asian longhorned beetles, or 38 emerald ash borers. If all the pallets in one shipping container were infested at a similar level, that single container could transport up to 396 Asian longhorned beetles or 1,677 emerald ash borers. Assuming that a new pest population could become established by a single reproductive pair, any quarantine treatment should allow for no more than a single survivor per container. That requires a treatment efficacy of over 99.75 percent, for Asian longhorned beetles, or 99.94 percent, for emerald ash borers.

Unfortunately, the efficacy of ISPM #15 cannot be determined.

Box 5. The Pests Keep Coming

In early 2012, a warehouse worker near Philadelphia found a large beetle. He showed it to the pest control company that works at the facility. The pest company contacted state officials. The beetle was determined to be a yellow spotted longhorned beetle never previously reported in Pennsylvania. It is native to eastern Asia.[58]

The beetle damages fig, holly, and mulberry trees.[59] It has been detected before in Europe and North America, originating in wood packaging used for imported goods.[60] In the United Kingdom, it was associated with imported plants.[61]

Problems Implementing ISPM #15

The success of ISPM #15 has been clouded by continuing detections of pests in wood packaging, suggesting that it has not achieved the desired level of effectiveness. These detections could have a number of causes.[62] [63] [64] The treatment required for wood could be less effective than expected. Treatments might be improperly applied. Pests might tolerate treatment, or infest wood afterward. Also, there are questions about shippers' compliance, including the likelihood of outright fraud. Wood is stamped to show it meets treatment requirements, but port inspectors cannot verify, by visual inspection, that treatments were actually carried out.[65]

Interception data cannot show efficacy

In a summary of the few studies done after ISPM #15 was implemented, the proportion of SWPM harboring live insects was 0.1 percent in the United States, 0.3 percent in the European Union, and 0.4 percent in Australia. In all three surveys, live bark- and wood-infesting insects were present – even on some SWPM marked as having been treated according to ISPM #15's requirements.[66] A separate study of the genus *Anoplophora* found that the United States intercepted five Asian longhorned beetles in 2008, probably in SWPM.[67]

APHIS' port inspection data[68] show significant decreases in numbers of pests intercepted since adoption of ISPM #15. However, these data cannot be used to evaluate whether the number of pests associated with any volume of wood packaging (what we call the "approach rate") has declined. In fact, none of the more than 70 countries implementing the standard has ensured that their data collection methods provide an accurate measure of how well it has curtailed introductions.

This is because data are not collected from random samples. Nor are data adjusted for changes in inspection intensity, or varying quantities of the kinds of commodities being imported. Furthermore, all official inspection data refer to "consignments," rather than individual pieces of wood packaging. Therefore it is impossible to know how many individual crates, spools, or pallets were inspected, and what proportion of those harbored insects.[69] [See Appendix II on "approach rates"].

Pest survival after treatment

Several published studies indicate that the treatments, themselves, are insufficient. However, the studies did not follow the ISPM#15 heat treatment protocols precisely, so the issue is unresolved.[70] [71] A considerable variety of wood fungi are resistant to either heat treatment or ISPM #15's specification for fumigation with methyl bromide.[72] APHIS' scientists are in the process of re-evaluating both methyl bromide penetration of various kinds of wood, and also pests' ability to survive the heat treatment protocol.[73]

Colonization of wood after treatment

Studies carried out after adoption of ISPM #15 found that insects of quarantine significance colonized wood after required treatment, especially when bark was present.[74] In April 2009, the parties to the International Plant Protection Convention amended the standard to limit the size of residual bark pieces allowed. No studies seem to be under way to evaluate whether the new limit on bark has curtailed pest presence.

The Problem of Fraud

It is likely that some apparent failures of the international standard are due to fraud: claims by exporters that wood has been treated, when it has not. In each of recent years, Customs and Border Protection, in the Department of Homeland Security, has detected 700 or more shipments in which wood packaging was marked as having been treated, but live insects were present.[75]

Under ISPM#15 and APHIS' implementing regulations, the agency has no power to penalize the foreign entities that export goods to the United States. APHIS can refuse entry to such products, which imposes a financial penalty on importers. The agency has been prevented by the USDA Office of General Counsel from imposing stronger penalties on the importers of goods that happen to be in infested packaging. APHIS continues to explore possible authority to take stronger actions.[76]

Meanwhile, Customs and Border Protection imposes punitive actions under its own regulatory authority.[77] Both agencies are increasing efforts to educate the range of groups involved in international trade about pest risks. These include, for example, customs brokers, air transport associations, and businesses that manage money transfer between exporters and importers.

Weakening of ISPM #15

The original goal of ISPM #15 was disappointingly weak.[78] The stated "level of protection" was "to practically eliminate risk for most quarantine pests and significantly reduce risk from a number of others." Unfortunately, the measure was further weakened in 2009 by parties to the International Plant Protection Convention. They substituted a new goal: "reduce significantly the risk of introduction and spread of most quarantine pests."[79] Thus, the international community seems to be backing away from setting ambitious goals that encourage real effort to prevent introductions *via* this pathway.

In April 2013, the treatment schedule was revised to recognize dialectric heat treatment (microwaves) as an approved treatment.[80]

ADDITIONAL PATHWAYS

1. Ship Superstructures

In a few instances, forest pests have been inadvertently transported on the superstructure of cargo ships. These hard surfaces can harbor egg masses of gypsy moths and, perhaps, other Lepidopteron species.

Two subspecies of gypsy moth are present in temperate Asia, including in the Russian Federation, the Republic of Korea, Mongolia, China, and Japan. These moths are attracted to lighting at ports, where the females can lay their eggs on ships at anchor, or on cargo containers. Then, they can be transported overseas.

The two Asian subspecies feed on a greater variety of plants than the European gypsy moth, which is already widespread across eastern North America. In addition, female Asian gypsy moths can fly up to 40 kilometers, unlike the European strain; this would accelerate their spread if they gain a foothold in North America.[81]

Department of Homeland Security Customs and Border Protection works to detect, and mitigate the threat of AGM when vessels from high risk country enter the United States.
Photo courtesy of DHS CBP

Status and Trends

Asian gypsy moths reached the United States, by this pathway, several times during the early 1990s. Each time, emergency control programs coordinated by APHIS and the USDA Forest Service eradicated the outbreaks.[82] Since 1992, APHIS and the Canadian Food Inspection Agency have required inspections, and other measures, for ships that have visited infested ports in the Russian Federation.

Beginning in 1998, Asian gypsy moths have been detected on ships (and their cargo) that had visited Japan, during the period when female were flying. Similar detections were made, since the mid-2000s, on ships that called in ports in China and the Republic of Korea.[83]

Past Policy Actions (2002 – 2011)

APHIS and the Canadian Food Inspection Agency initiated several years of intense negotiations with China, Japan, and Korea. As a result, the North American Plant Protection Organization (NAPPO) adopted, in August 2009, a regional standard governing ships travelling to North America from those countries.[84] RSPM #33 provides several actions that the Asian countries may take to prevent transport of Asian gypsy moths to North America. These include:

- Inspection of the ships, by an officially authorized party, before ships enter the NAPPO region (usually, at the port of departure);
- Adoption of a systems approach that combines surveillance for, and monitoring of, insect populations with exclusionary tactics (removing trees near ports, reducing port lighting, using areas where pests are not prevalent, *etc.*); or
- Designation of pest-free areas that are verified by monitoring and other scientific studies.

Also, the NAPPO countries (Mexico, the United States, and Canada) may require phytosanitary certificates for ships; inspect ships; and refuse entry to all of North America if a ship lacks such a certificate. If inspectors detect Asian gypsy moths on a ship, it is required to leave the waters of the NAPPO region until it has been cleaned. In the case of repeated incidents of non-compliance, the NAPPO countries can review the exporting country's management program. The three countries share information, and accept each other's clearance documents. After a phase-in period, the standard went into full force in March 2012.

The first year of official implementation revealed significant problems. In 2012, 31 ships approaching North America were found to have Asian gypsy moth infestations – a record number. All but two of these ships had been certified by the appropriate Asian country as moth-free. One ship was found to be infested four times, despite having been ordered to clean off the egg masses. Thirteen of the infested ships had sailed from Japan. U.S. officials believe that the Japanese certification entity does the inspections too far in advance of the ship's sailing, thus allowing additional moths to re-infest the ship.[85] In 2013, the Bureau of Customs and ship's crew detected a total of 27 gypsy moth egg masses on a ship that had travelled from Japan to Europe and then on to the United States' eastern seaboard.[86]

2. Curios, Handicrafts, and other Decorative Articles, as a Pathway

Decorative items made of unprocessed wood are a minor pathway for introducing pests.[87] Port inspectors and others have found significant pests in these items. They are manufactured articles containing some form of wood, sometimes including bark and/or seeds, and sometimes with additional components made of plastic, paper, metal, or other materials.

Status and Trends

In recent years, Americans have bought an increasing volume of imported curios and decorative items constructed of unprocessed or minimally processed plant material, including wood. Examples include boxes and baskets; wood carvings; birdhouses; artificial Christmas trees or other plants; trellises; lawn furniture. These items are intended for use both indoors and out.

Past Policy Actions (2002 – 2013)

This import pathway has been dominated by goods from China. Over a three-year period beginning in 2002, APHIS took emergency action 304 times in response to pests in wood décor, curio, and crafts from China. As a result, APHIS suspended imports of such items beginning April 1, 2005, while it assessed risks and explored mitigation measures.[88] In April 2009, APHIS proposed a new rule that required treatment of such articles, before they would be allowed to enter the United States. The regulation was finalized in March 2012.[89]

In explaining the rulemaking, APHIS[90] noted that the curio pathway is extremely difficult to manage. A wide variety of articles pose a risk. Information is lacking about the species and geographic origins of most of the natural materials involved. And the categorization of these articles as "manufactured goods" on shipping manifests makes them hard to pick out by inspectors.

The APHIS pest risk analysis for imports from China

APHIS completed a pest risk analysis, in 2007,[91] to accompany its proposed regulation. It identified 510 arthropods that were not only likely to be associated with articles coming from China, but also to pose a threat to the United States. Approximately one-fourth of the 510 pest species (28 percent) were wood boring beetles. Because they feed on a wide variety of plant hosts, woodborers are generally considered to be of high consequence to ecosystems if they become established. Their immature stages live inside wood, so they also are likely to enter the country with wooden items.

APHIS analyzed seventeen representative insect genera more thoroughly, with an emphasis on woodborers in the beetle family Buprestidae and the beetle genus *Anoplophora*; the woodwasp genus *Sirex;* as well as bark beetles in the subfamily Scolytinae.

All were ranked as posing a high risk of introduction. A large volume of décor items were being imported before the 2005 prohibition was put in place. Also, there were no approved methods to prevent contamination of plant materials, either during the growing season, or at harvest. In addition, nearly all the pests had been intercepted alive, indicating their ability to survive transport.

The insects also were thought to have a high likelihood of establishment in the United States. Climates were similar between the two countries and there was a wide range of shared host plant genera. Furthermore, twelve of the 17 pest genera had a high potential for dispersal.

Previously introduced species that either are in the same taxonomic groups or have similar life histories have already caused great damage. All of the 17 genera were ranked high, overall, for the consequences of introduction. Sixteen genera were given a rank of high for economic impact. The 17th (*Tomicus)* ranked medium. Fifteen genera ranked high for environmental impact. One (*Hylobius*) ranked medium, and another (the termite *Cryptotermes*) ranked low.

There apparently has been no analysis of similar items imported from countries other than China, although the risk appears significant. At least 26 of the beetles on the list of quarantine pests from China are also native to areas of Europe, Africa, and other parts of Asia. There has been at least one emergency action, targeting pine cones imported from India.[92] Aside from a few such emergency actions, no other regulations have been adopted by APHIS.

North American rules

Recognition of the risk associated with imported décor led the NAPPO countries to adopt a regional standard, RSPM #38,[93] in February 2012. It calls for regulation of the following types of articles:

- Wooden commodities which contain bark and/or foliage, and are unfinished, and/or intended for use outdoors;
- Bamboo commodities used outdoors.

Regulated items include: carvings; baskets and boxes; birdhouses, artificial plants or Christmas trees containing wooden trunks or branches; rough or rustic wooden furniture; stakes, trellises and fencing; wood chips for crafts and/or potpourri; and bark and/or other natural components of a tree, such as foliage, cones, *etc.,* used for crafts. Wooden commodities that are free of bark and foliage, finished smoothly on all sides, and intended for use indoors, are considered to pose little risk. Therefore the standard suggests that these not be regulated.

Relying on whether an object is intended for use indoors or outdoors is risky. In many parts of the United States and Mexico, doors and windows are left open for extended periods. “Indoor” objects are often used on decks, balconies, or patios. People who observe insects exiting a carving, furniture, or other item are likely to place or discard these outside, to prevent infestation of the home or office.

RSPM #38 recommends that wood articles without bark be treated, like wood under ISPM #15. However, wood bearing large pieces of bark poses a greater risk, and the efficacy of treatments approved by ISPM #15 is uncertain. Therefore this category of imports is to be treated more aggressively, that is, at higher temperatures, for longer. Under RSPM #38, wood is heated to 60^{o}C for 60 minutes, *versus* 56^{o}C for 30 minutes under ISPM #15. As always, alternative treatments are accepted if the exporting country demonstrates their effectiveness to the importing country. Such alternatives are approved through bilateral agreements.

While APHIS has formally adopted this standard, it has no practical effect until the agency proposes, revises, finalizes, and implements, new regulations. History indicates that proposed rules – just the first of many steps – may not be put forward for several years.[a]

3. Minimally Processed Wood Pathway

In the 1990s, the greatest risk for introducing pests was expected to be associated with imports of logs and minimally processed wood products, such as wood chips. Concern about proposed imports of logs from Siberia, and other distant sources, led to preparation of five U.S. Forest Service-led risk assessments. These addressed proposed import of softwood logs from Siberia, New Zealand, Chile, Mexico, and Australia. None addressed threats posed by importing hardwood logs and lumber, other than the one on eucalyptus trees from South America. These five analyses cost more than $700,000,[94] not including the salaries of the many scientists who volunteered as technical experts.

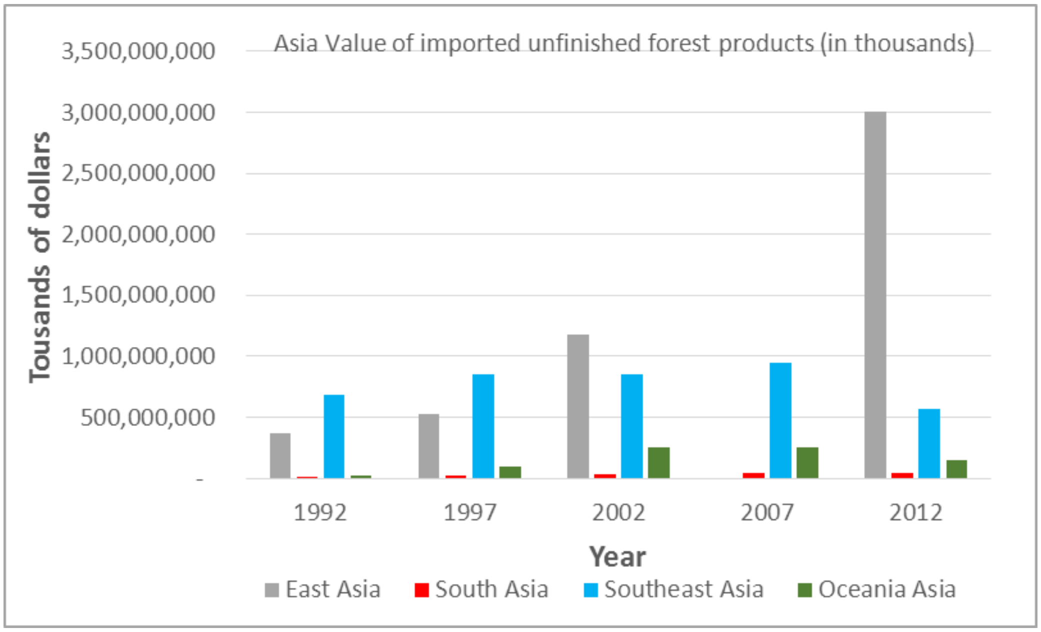
In April 2001, the U.S. Forest Service issued the risk assessment on imports of *Eucalyptus* grown on plantations in South America, where the genus is not native.[95] The assessment concluded that logs and chips might be relatively free of most damaging organisms. Nevertheless, numerous potential pests had a high likelihood of being introduced to the United States *via* this pathway. The risk varied by country and by species.

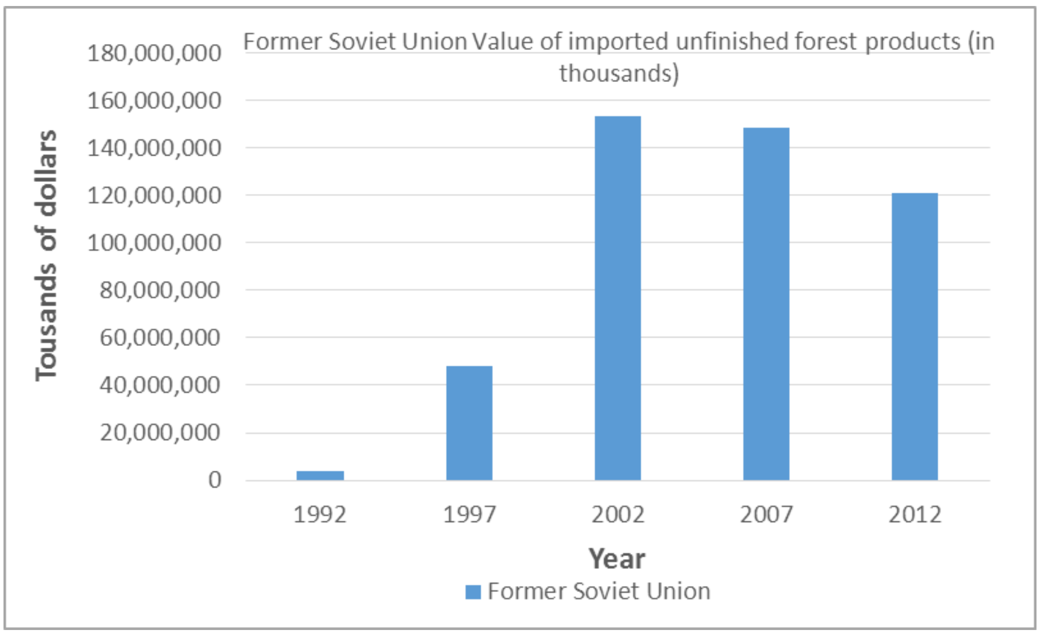
Status and Trends

U.S. imports of logs and lumber continued apace, until the slowdown in house construction and the subsequent economic recession in 2007-2008. Imports of logs and wood chips,[96] measured in cubic meters, increased 12-fold between 1992 and 2006. Throughout this period, the overwhelmingly predominant supplier was Canada, rising from 88 percent, in 1992, to 96 percent, in 2006. The relative importance of other source countries varied from year to year.

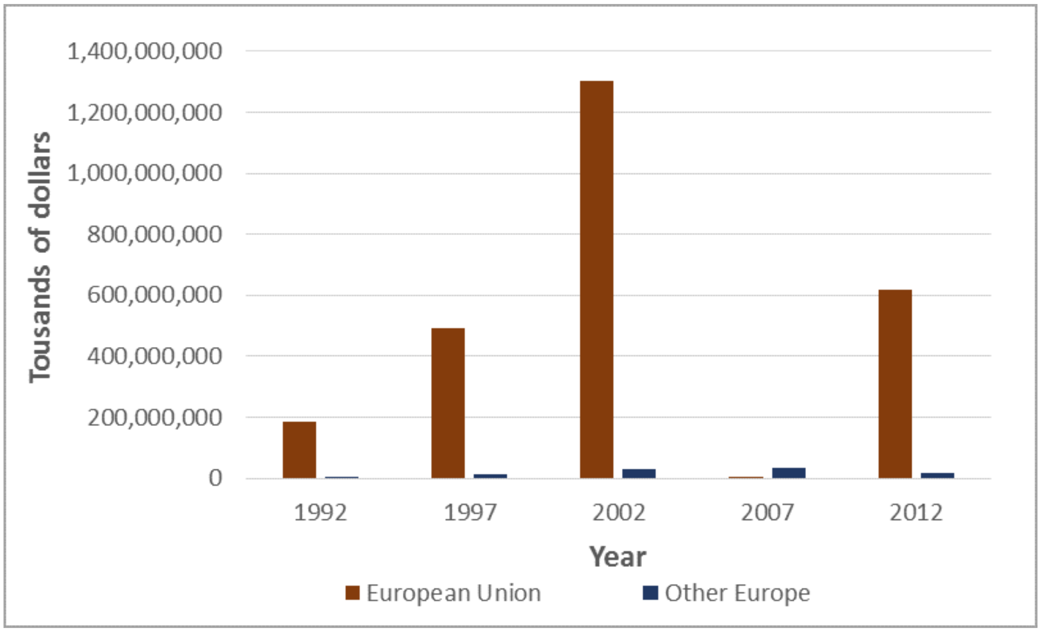
[a] APHIS' proposed rule to implement ISPM #15 were published one year after the standard was adopted. The proposal to implement the regional standard on plants for planting (RSPM #24) was published by APHIS more than seven years after the standard was adopted.

Imports of Unfinished Forest Products

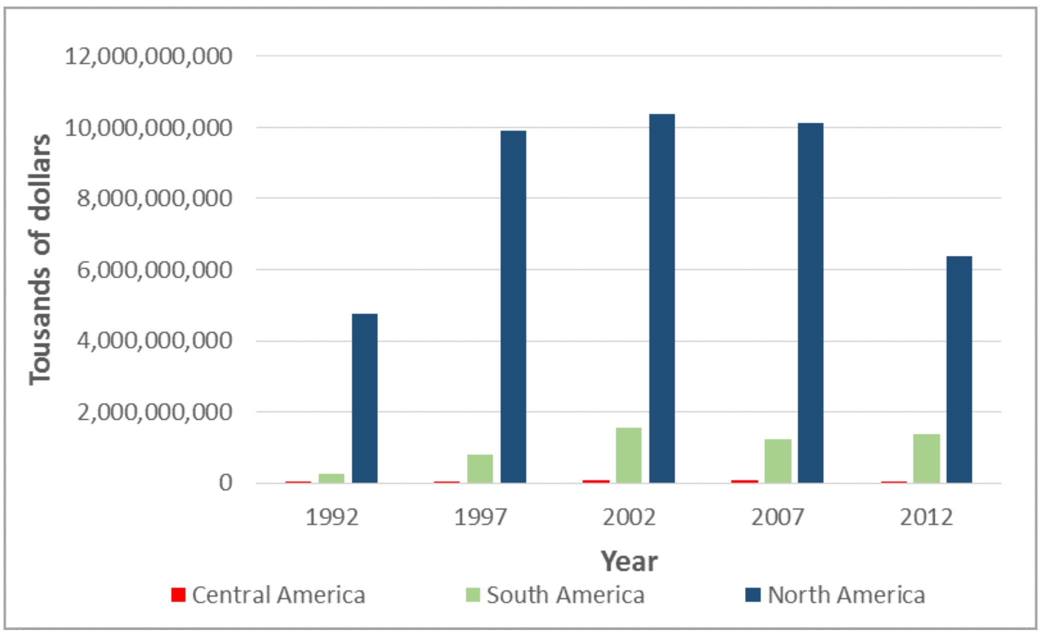




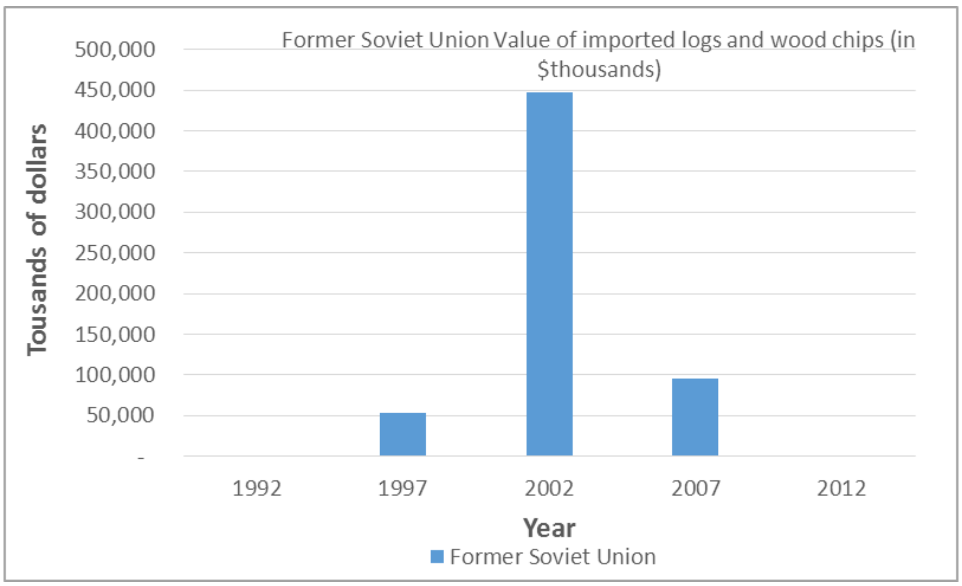
Europe: value of imported unfinished wood products (in thousands)

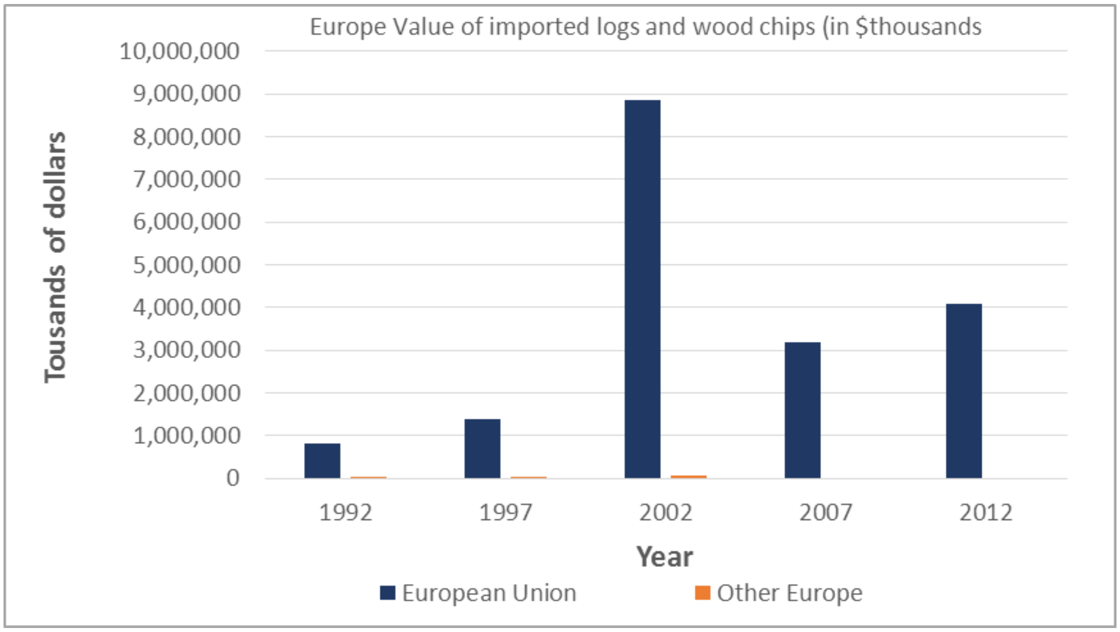


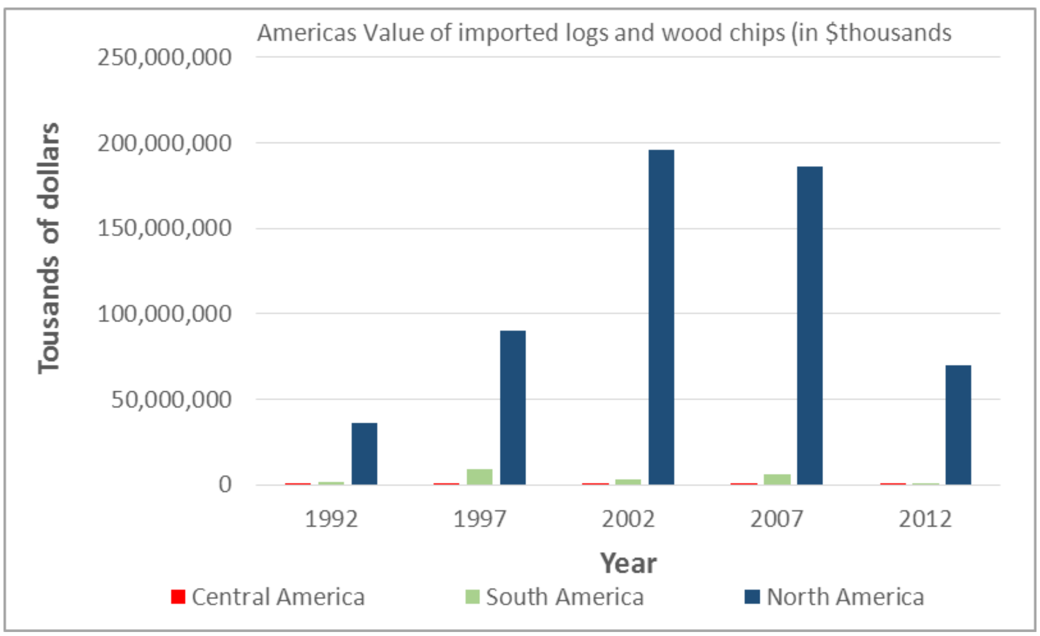
Americas: value of imported unfinished wood products (in thousands)



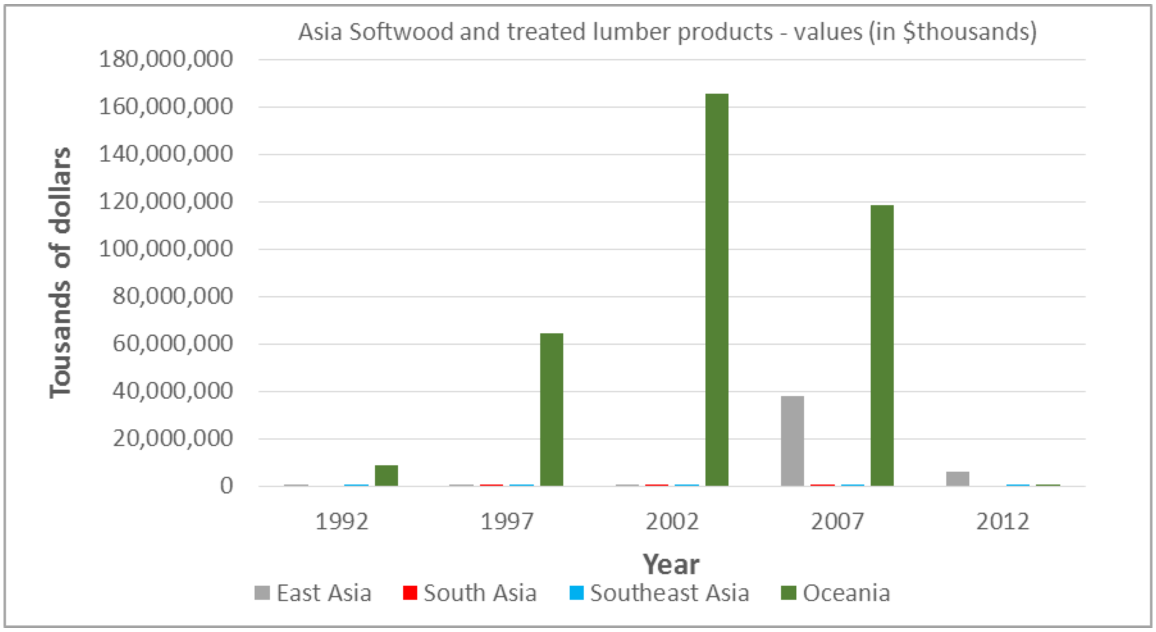
Imports of Logs and Wood Chips

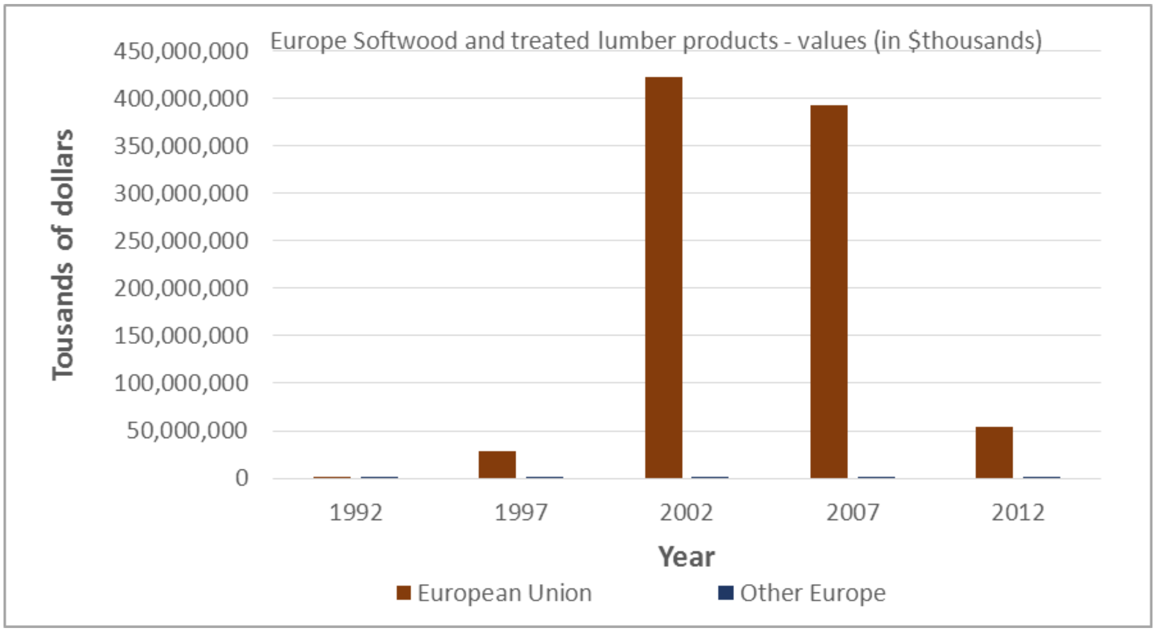


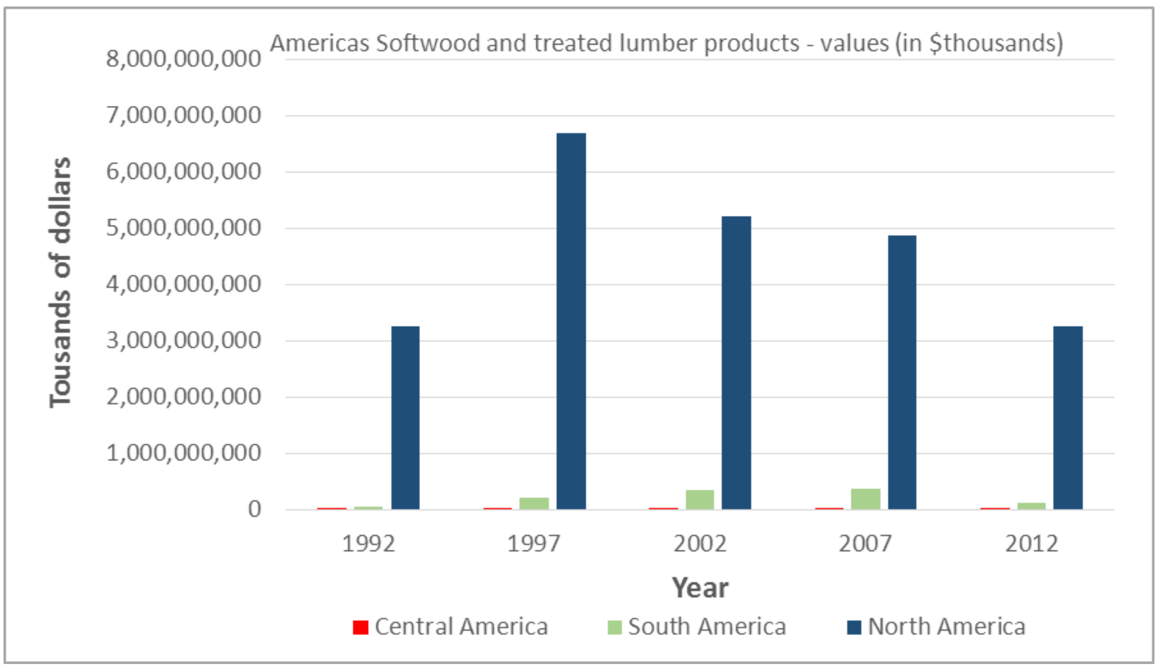

Europe Value of imported logs and wood chips (in $thousands
Tousands of dollars
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
1992
1997
2002
2007
2012
Year
European Union
Other Europe


Americas Value of imported logs and wood chips (in $thousands
Tousands of dollars
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
1992
1997
2002
2007
2012
Year
Central America
South America
North America

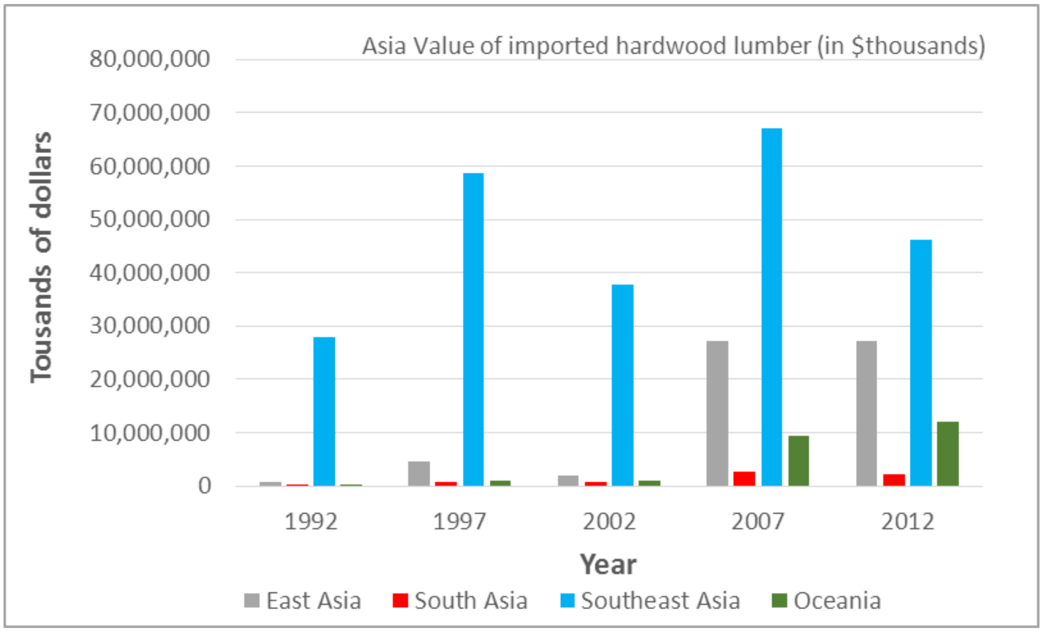
Imports of Softwood Lumber & Treated Lumber

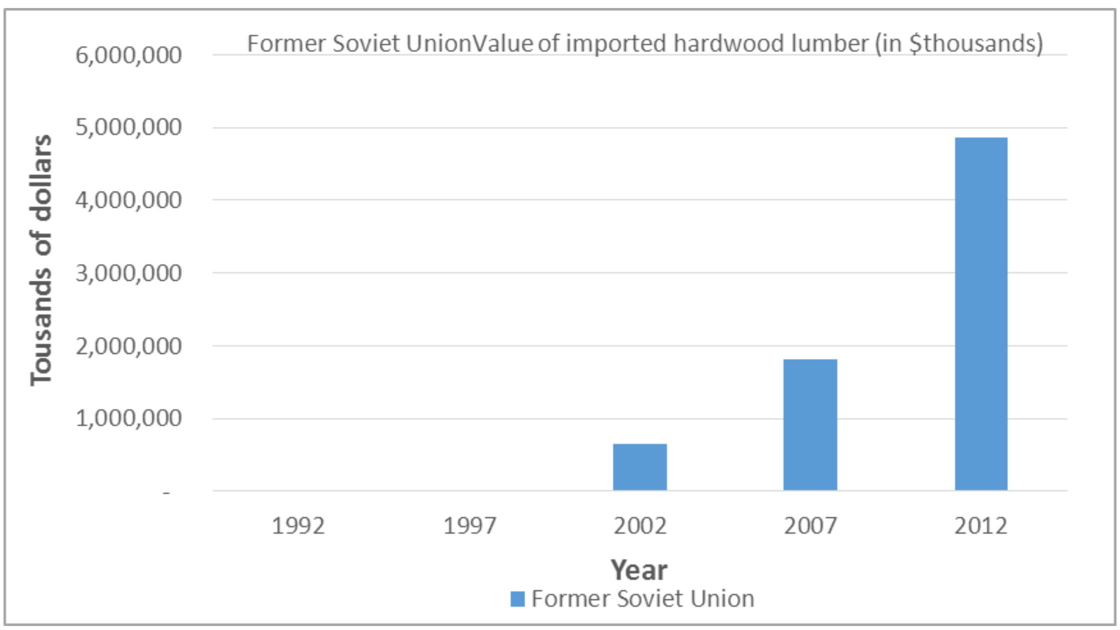


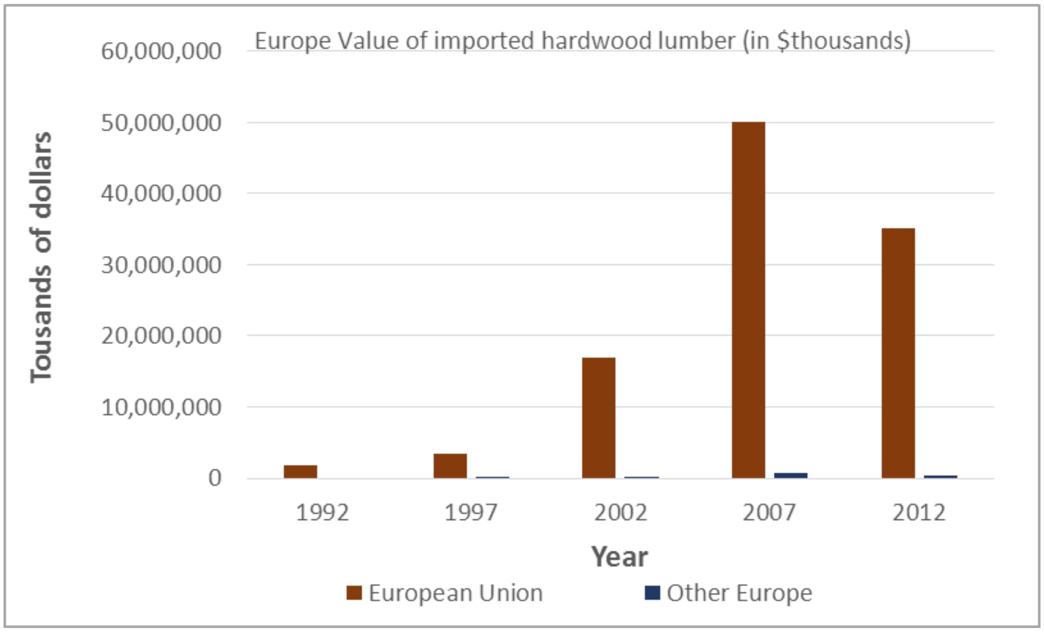

Europe Softwood and treated lumber products - values (in $thousands)
Tousands of dollars
450,000,000
400,000,000
350,000,000
300,000,000
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
1992
1997
2002
2007
2012
Year
European Union
Other Europe

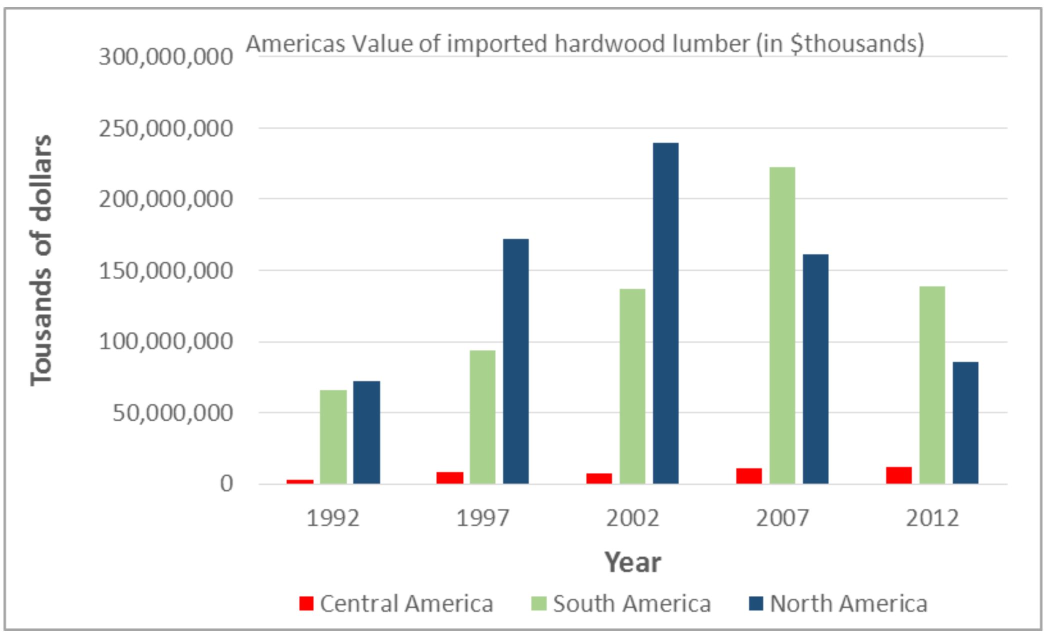

Americas Softwood and treated lumber products - values (in $thousands)
Tousands of dollars
8,000,000,000
7,000,000,000
6,000,000,000
5,000,000,000
4,000,000,000
3,000,000,000
2,000,000,000
1,000,000,000
0
1992
1997
2002
2007
2012
Year
Central America
South America
North America

Imports of Hardwood Lumber






Europe Value of imported hardwood lumber (in $thousands)
Tousands of dollars
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1992
1997
2002
2007
2012
Year
European Union
Other Europe


Americas Value of imported hardwood lumber (in $thousands)
Tousands of dollars
300,000,000
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
1992
1997
2002
2007
2012
Year
Central America
South America
North America

Past Policy Actions (2002 – 2013)

APHIS has not asked the U.S. Forest Service to conduct a risk assessment of this pathway since the analysis of Australian pine was completed in 2006. Nor has APHIS adopted specific regulations governing imports of logs or chips made from South American *Eucalyptus*. This is probably because the early risk assessments covered most of the major suppliers of high-volume softwood imports.

Wood from places not addressed by specific rules is regulated by APHIS under broader ones, sometimes called the "universal requirement".[b, 97] Hardwood logs from areas outside China are subject only to inspection, as long as they are destined for the continent.[98] For a discussion of weaknesses in these regulations, see Campbell and Schlarbaum, Fading Forests II http://treeimprovement.utk.edu/FFII.htm

While most wood from Canada is not regulated, imports of ash logs from Canada are strictly regulated, because of the presence of the emerald ash borer (EAB).[c] These rules apply to ash logs and wood, including cants and stumps, that originate in both a county and a province or territory regulated for emerald ash borer. Ash logs and wood that originate in a county not regulated for emerald ash borer require an import permit and phytosanitary certificate.

Future Outlook

Despite rising import volumes and the weakness of regulations governing imports of hardwoods, few of the many new pests introduced to North America in recent years have been attributed to imports of logs, lumber, or wood chips. The most important exception is the soapberry borer, which was transported to Texas in firewood.[99] (The goldspotted oak borer in California is also transported in firewood, but the California population came from Arizona, not Mexico.[100]) That this pathway poses a viable threat is illustrated by the repeated interceptions of pinewood nematodes in shipments of wood chips from North America to Nordic countries.[101]

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[b] 7 Code of Federal Regulations, Part 319, Subpart 40-5(d) adopted 1995.

[c] Ash logs imported from Canada are governed by 7 CFR § 319-40-2(a), supplemented by inspection provisions of § 319-40-9. Online at: www.federalregister.gov/articles/2007/06/01/E7-10562/importation-of-emerald-ash-borer-host-material-from canada#p-28. Accessed December 21, 2011.

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Chapter 5
Pathways by which Forest Pests Spread within the United States

Colonization of North American forests by exotic pests begins at ports-of-entry or in the cities and suburbs to which imported goods are delivered. From this point of origin, a pest usually spreads across the natural range of its woody host/s. The invasion worsens *via* progressive expansion of the pest's population. Also, pests spread when infected materials are disseminated.

Depending on the pest, its spread can be relatively slow, lasting many decades, *e.g.*, the spread of the European gypsy moth or beech bark disease. In the past, the Great Plains and Great Basin areas deterred the natural spread of most forest pests, particular those that infested hardwood species. Today, however, pests can spread quickly across long distances, eased by changes in transportation, and in how goods are distributed.

Modern transportation systems for delivering imports are well-designed and highly coordinated. Specialized ports facilitate the rapid transfer of shipping containers to U.S. roads, rails, and canals. Also, many corporations have built their own networks of distribution centers, which receive containers and quickly disperse them into local markets, by truck. The volume of freight transported around the United States by road has grown by 454 percent since the 1960s.[1] This makes the entire country susceptible to pest introductions shortly after goods leave U.S. ports, or when infested or infected goods are distributed from areas where the pest is already established.

Some of the highest-profile exotic pest introductions, those that have come to our attention within the last two decades, have either already spread or threaten to spread quickly across large swaths of North America. These include emerald ash borer, sudden oak death, and thousand cankers disease. www.dontmovefirewood.org/gallery-of-pests

The sizeable financial and ecological threat posed by these three pests has drawn attention to the pathways by which exotic insects and pathogens spread within the country. Some challenges in addressing these pathways mirror those at U.S. borders, e.g., developing detection and control strategies tailored to the biology of specific pests, and finding the resources to address them (See Chapter 4). Managing domestic pathways, however, has some unique challenges.

The primary concern is the movement of pests across the natural barriers of the Great Basin and Great Plains, which have historically limited the risk to eastern forests from pests in the West, and *vice versa*. Such pest movement can occur *via* the full range of pathways.

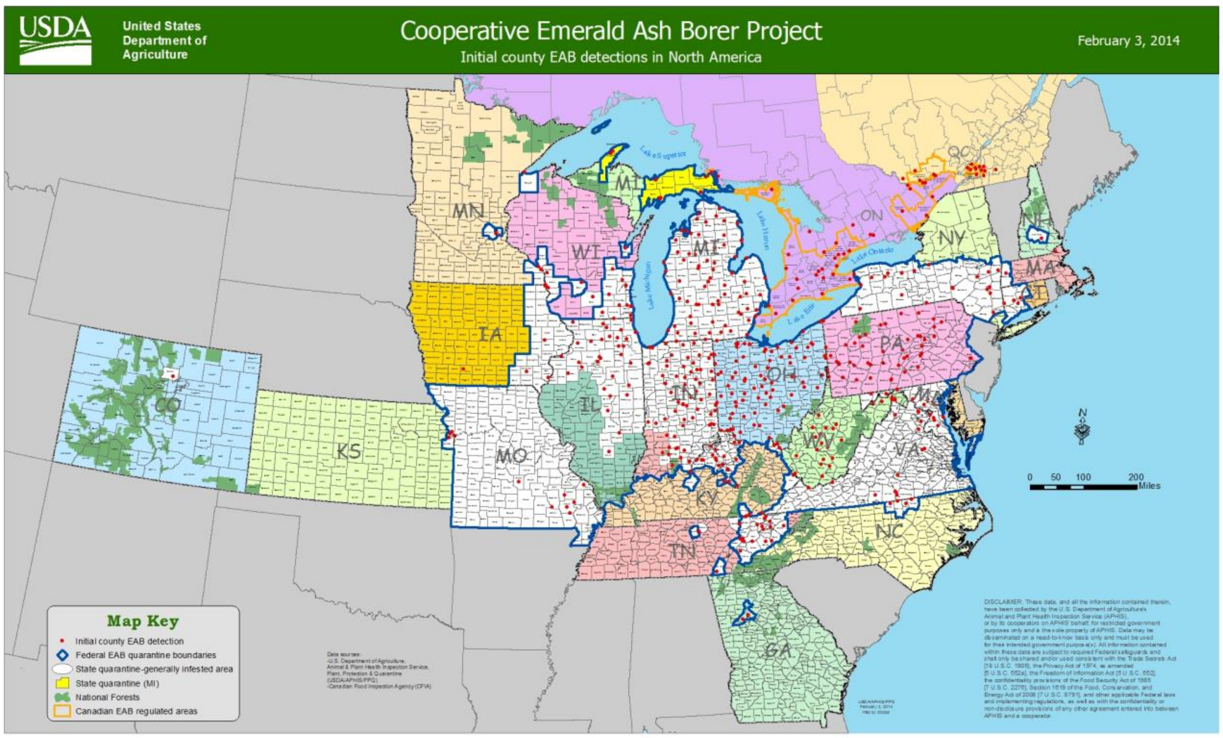
MAJOR PATHWAYS

1. Firewood

Pests are known to be present in firewood. When officials examined firewood from vehicles crossing Michigan's Mackinac Bridge in 2008, 23 percent of the wood contained live borers; 41 percent more had evidence of previous infestations.[2] While "green" firewood presents the greatest pest risk, "seasoned" wood is still a significant hazard, depending on the length of time the wood has been air dried. Even long seasoning periods might be inadequate to kill some pests. In studies in Kansas and Colorado, adult insects emerged from one-third of firewood bundles labeled "dried" wood.[3]

Emerald ash borers have been detected at ever-increasing locations since 2002 (Figure 1). This has focused attention on intra- and interstate transportation of firewood cut from hardwoods. Several outlier, or satellite, outbreaks – quite distant from the main body of the infestation – began in, or near, campgrounds.

Figure 1. map of EAB outbreaks



In addition to emerald ash borer, the movement of hardwood for firewood has been blamed for, or recognized as a potential pathway for, spreading the:

- Asian longhorned beetle;
- Gypsy moth;
- Goldspotted oak borer;
- Beech bark disease;
- Oak wilt;
- Laurel wilt disease complex; and
- Thousand cankers disease of walnut.

Firewood derived from pine trees has probably helped the spread of conifer pests, like pitch canker, *Sirex* woodwasp, and the native mountain pine beetle.

There are several reasons why firewood is so likely to transport pests. First, it is often made from trees that were stressed, crooked, damaged, or already diseased or insect-ridden.[4] Second, bark frequently remains on the wood for extended periods, increasing the ability of already-present pests to survive. This habitat also makes firewood more attractive to secondary pests.[a5]

Wood used for firewood is characteristically unsuitable for other uses. Logs are often cheap or free, and easily obtained from the residue of logging operations, tree services, clearing land, and homeowners.[6] Potential firewood is abundant, in both urban and rural settings. It is also readily accessible to resident pests. Tracking firewood, however, is a problem, as it is transported throughout the country by commercial shippers, as well as individuals.

Status and Trends

There are an estimated 41 million wood stoves and wood-burning fireplaces in homes throughout the United States. Wood is burned regularly in approximately 30 million homes. These consume huge quantities of wood, up to an estimated 57 million cords per year.[7]

There is considerable regional variation in the proportion of harvested logs used as firewood, and in the species used. Hardwoods are the overwhelming choice across the Northeast, Midwest, and South; softwood logs are used in the Rocky Mountain and Pacific Coast regions – due to the scarcity of hardwood species that can produce suitable firewood.[8] As a result, firewood can facilitate the spread of both hardwood and conifer pests.

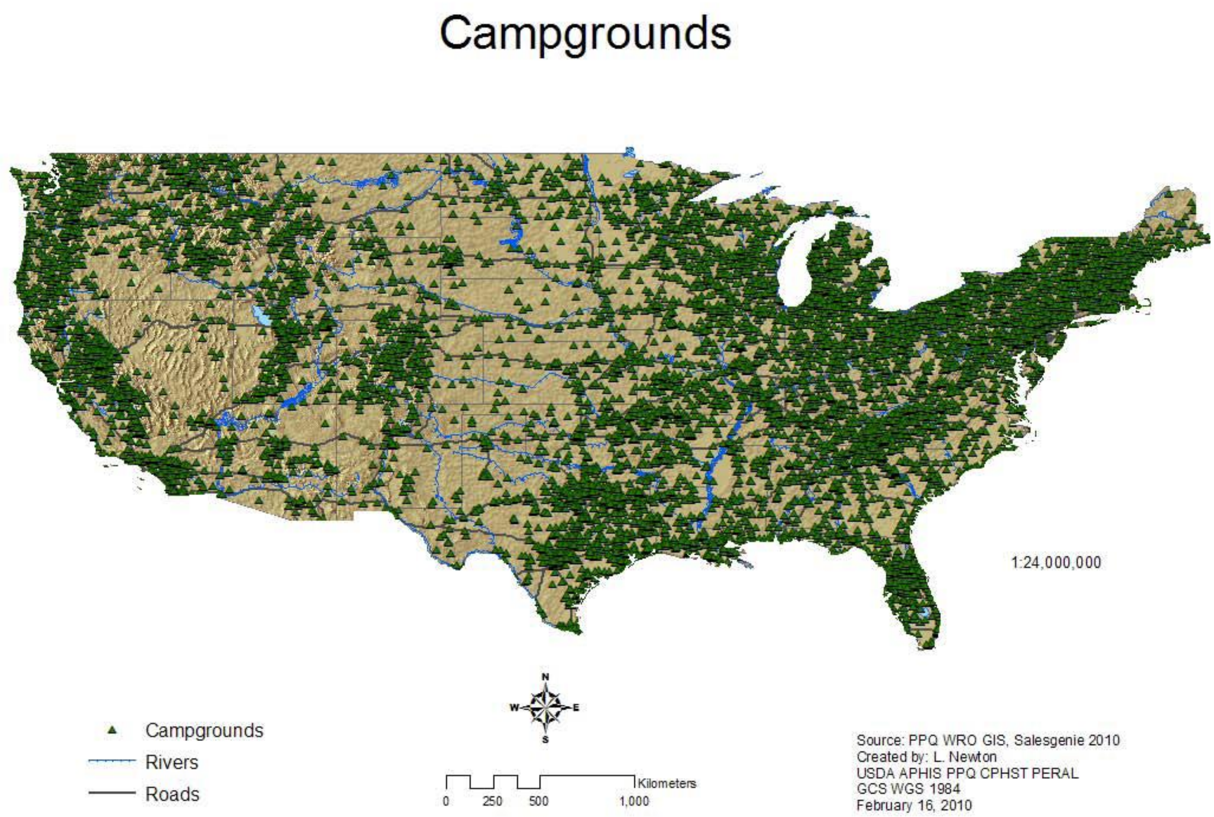
Camping

People transport firewood over long distances, due to its expense or scarcity at their destinations. Many of these are campers. Surveys from the West and Northeast indicate that up to half of all campers take firewood from home, often travelling 100-200 miles.[9] Some 330,000 campers take firewood to national parks in the Rocky Mountain West every year.[10] In New York State campgrounds, in 2007, 27 percent of people camping in the Catskills transported firewood from home; as did 51 percent of people camping in the Adirondacks.[11]

Thousands of campgrounds across the United States[12] (Figure 2) are mostly in, or near, vulnerable woodlands.

[a] Pests that normally infest only stressed, weakened, damaged, or downed trees – and thus are not considered to cause significant damage or mortality.

Figure 2. Campgrounds in the United States



Map from United States Department of Agriculture Animal and Plant Health Inspection Service
Risk Assessment of the Movement of Firewood within the United States
May, 2010

One study analyzed more than five years of reservations at federal campgrounds operated by the U.S. Army Corps of Engineers, Bureau of Land Management, U.S. Forest Service, and National Park Service.[13] The data included more than 7.2 million visits to 2,525 campgrounds.

The median distance traveled from home was only 100–150 km, but still a distance that can move forest pests well beyond their natural dispersal range. Ten percent of visitors traveled 500 km to their campsite, and five percent traveled 1,000 km.[14]

The authors calculated that probably 3-5 percent of these campground visits posed a risk of dispersing forest pests *via* firewood. (They assumed: 1) that 30-40 percent of campers carried firewood from home, or other distant locations; 2) that approximately 20 percent of the firewood was infested with live wood borers; and 3) that biological factors limited pest establishment to some extent.) Since visits to these federal campgrounds average 1.2 million per year,[15] an effective infestation rate of only 3-5 percent means that between 36,000 and 60,000 separate possible pest introductions occur each year.

These calculations do not include visits to more than 9,000 privately owned,[16] state and local, or other federal campgrounds. Including these would significantly raise the opportunities for spreading pests to new locations.

However, transportation of firewood does not necessarily increase a pest's distribution. Given the large quantities of pest-infested wood probably being moved by campers, Koch *et al*.[17] asked why there has not been a greater proliferation of exotic insects. They suggested four possible explanations, and concluded that some combination probably is the answer:

1) Environmental conditions are unsuitable for colonization, or the reproductive capacity of the introduced insects is inadequate;

2) The insects' life history hinders establishment at specific campgrounds. For example, different insect families infest host material at highly varying rates. The number of insects in one log can range from a high of 100-250 bark beetles, to 20-30 buprestids, or 5-10 cerambycids.[18] So a bundle of infested firewood is more likely to contain enough bark beetles to become established, but not enough of the larger wood borers;

3) Quarantines and other regulations, as well as public awareness campaigns, deter movement of infested wood; or

4) Many infestations initiated by firewood exist – but they have not been detected yet.

Firewood in metropolitan markets

The commercial firewood industry moves significant amounts of wood to meet high demand in metropolitan areas. The number of such companies, and the amount of firewood involved, is large, although exact amounts are not known. A database kept by APHIS contains 1,093 businesses that report the sale of firewood as their primary source of income.[19] Dealers are found throughout the United States. However, nearly one-quarter are clustered on the West Coast, with a slightly higher percentage in the Northeast.[20] These data do not include "mom and pop" dealers.

A risk assessment conducted by APHIS[21] noted that even local movement of firewood can advance the leading edge of a forest pest outbreak. For example, two outlying outbreaks of the Asian longhorned beetle in southern Ohio were probably caused by movement of firewood from the nearby original introduction site.

Past Policy Actions (2002-2013)

Because firewood has only recently come to our attention as a high-risk pathway for spreading pests, it is a "new" commodity that federal and state departments of agriculture are not accustomed to regulating. The current regulatory framework is less developed than, for example, regulations for nursery stock.

APHIS establishes quarantine zones for species being addressed by federal action. Now, there are seven official "quarantine pests" that affect forests: pine shoot beetle, Asian longhorned beetle, emerald ash borer, sudden oak death, European gypsy moth, as well as the Japanese beetle and light brown apple moth. Also, APHIS regulates the pathways by which pests can be moved outside quarantine zones – by firewood and other possible vectors.

As of 2010, 28 of the 48 coterminous states had internal or external state quarantines relating to the movement of raw, or unprocessed, logs. Some of the more recent ones cite firewood explicitly. Others address "logs" and "branches" of one or more species, including firewood implicitly, rather than explicitly.[22] Neither the National Park Service nor U.S. Forest Service has yet adopted a nation-wide policy on firewood. These agencies largely follow the regulations of the state where their lands are located.

The APHIS risk assessment[23] found conflicting evidence as to whether regulations and outreach can effectively curtail movement of firewood by the general public. A 2008 "enforcement blitz," at an automobile racetrack in Bristol, Tennessee, found that 75 percent of the people moving firewood knew about the emerald ash borer quarantine – but moved wood out of the quarantine zone anyway.

On a more hopeful note, people who made reservations at campgrounds that expressly directed them not to bring firewood, did not do so.[24] Wisconsin found that its regulations, and accompanying outreach, reduced almost by half the proportion of campers carrying firewood to state campgrounds: from 44 percent in 2006, to 27 percent in 2008.[25] Wisconsin officials see the interaction between campground staff and visitors as a "teachable moment," one that far outperforms messages in the mass media. As a result, by 2010, 93 percent of campers had heard of emerald ash borer and other wood-associated pests; 98 percent were aware of the link between forest pests and firewood. In 2006, only 68 percent were aware of this nexus.[26]

In 2007 and 2008, there was a widespread sense that efforts to curtail transport of pests in firewood were insufficient. Both the National Plant Board[27] and the National Association of State Foresters[28] adopted resolutions urging APHIS to act. In response, APHIS established a task force. Also, it sponsored several "listening sessions," in 2009, to gather views on what combination of regulations, outreach, and education would be best. The Firewood Task Force issued its recommendations in March 2010 (Box 1).[29]

Box 1. Recommendations of the APHIS Firewood Task Force

The report of the Task Force called for:

1) A coordinated outreach strategy, engaging federal and state governments, non-governmental organizations, *etc*., with coordinated messages supporting regulatory efforts;

2) Significant effort by non-governmental entities, *i.e.*,
    a. Large producers and retailers would adopt best management practices;
    b. Best management practices would link to a national certification program for firewood, with labeling and record-keeping requirements;
    c. Public and private campgrounds would make locally-produced firewood available. (The Task Force did not say campgrounds should prohibit outside firewood); and
    d. Firewood consumers and local producers would adopt their own set of best management practices.

3) Implementation of a regulatory strategy with the following components:
    a. APHIS would issue rules requiring labeling, record-keeping, and treatment based on best management practices;
    b. States would issue regulations governing movement of firewood within their boundaries, and have similar requirements for labeling, record-keeping, and treatment. Free movement of firewood would be allowed over distances less than 50 miles, except if such movement violated a quarantine; and

c. State, federal, and private parks, forests, and campgrounds would institute policies encouraging campers to use local firewood, and to not move firewood out of the local area.

At the time the Task Force issued its report, people expected that an industry certification program would be adopted before the end of 2010. APHIS expected to issue regulations to establish label and record-keeping requirements for dealers shipping firewood interstate shortly afterwards.

Both activities have been delayed. On the industry certification front, the American Firewood Producers and Distributors Organization was organized in early 2012; it represents primarily large national/regional producers. AFPDO has been developing a certification program for its members that would rely on third-party verification. The program is intended to meet the requirements of APHIS' quarantines. Individual states could recognize the program if it meets their requirements. This certification program would operate under the umbrella of the USDA Agriculture Marketing Service' (AMS) "process verified" program. While AFPDO has been consulting within the industry, with APHIS, and with AMS, a second organization, the National Firewood Association, has formed; it represents smaller producers who operate more at the local level.[30]

At the meeting of the National Plant Board in August 2013, APHIS stated that its long-delayed agency rule that will establish label and record-keeping requirements for dealers shipping firewood interstate was currently undergoing review in the Department of Agriculture. Thus, it is still several months from being published for comment.

"Don't Move Firewood" and other outreach

Most of the federal and state regulations on firewood are buttressed by significant outreach and education efforts, *e.g.*, enforcement blitzes, billboards, posters, and press releases issued at key times. The Don't Move Firewood campaign, managed by The Nature Conservancy and the Continental Dialogue on Non-Native Forest Insects and Diseases, provides a focal point for such efforts.

This campaign targets the members of the public who are most likely to move firewood. These include 18-35 year-olds who hike, camp, own recreational vehicles, or heat their homes with wood. The campaign uses a combination of new media, such as websites, Facebook and online advertisements, combined with more traditional means, like networking among professionals in forest health agencies, and conducting in-person outreach at fairs and festivals.

The message is simple: "Buy firewood near where it will be used to prevent the spread of forest pests." Don't Move Firewood has reached millions of people since 2008. Lately, APHIS has funded the program to help coordinate the activities of federal and state agencies and non-governmental organizations. Much of this funding has come from APHIS, from either the emerald ash borer program, or from grants funded by the Farm Bill's Section 10201.

The Future

Urban areas situated in forested regions of the United States continue to expand. APHIS' risk assessment concluded that forests bordering on urban areas are particularly vulnerable to pest infestations *via* firewood.[31] Transportation and trade often bring potentially infested goods to the neighborhood of these fragmented forests. At the same time, the cost of managing pests in urban areas is relatively high, which could delay or stop homeowners from managing or treating their trees. Urban sprawl will be a significant factor in future pest control issues.

The impact of increased use of firewood for home heating is currently debatable. Some expect this use, and its attendant pest risks, to increase, because of improvements in technology, and rising prices for home heating oil. Alternately, increasingly stringent air pollution regulations apply to burning wood, which could limit the use of firewood.

According to the Firewood Task Force, states were expected to complete their firewood regulations by the beginning of 2013; we are not aware that any of the 20 conterminous states that lacked such regulations in 2010 has since filled this gap. It is unclear when any voluntary national certification program for industry will be complete. Meanwhile, APHIS' funding for the emerald ash borer program began collapsing, in 2011, and Farm Bill grants are for limited time periods. It is unclear whether there will be a stable source of funds for these programs in the future.

2. The Living Plants Pathway

The movement of living plants, or "plants for planting," is a major pathway for introducing exotic forest pests into the United States. This pathway is equally effective in distributing pests across the country.

Phytophthora ramorum, the causative agent of sudden oak death (SOD), has been a major focus. "*P. ramorum* is one of the most dramatic examples of unintended linkages between the horticultural industry and the health of forest ecosystems. The emergence of this pathogen has brought to the forefront the complexities of balancing ecological and economic well-being."[32] Because detailed records exist, this pathogen's occurrence and spread show how living plants carry exotic pests within the United States – and how policymakers respond.

Status and Trends

Presence of the pathogen in wildlands and nurseries

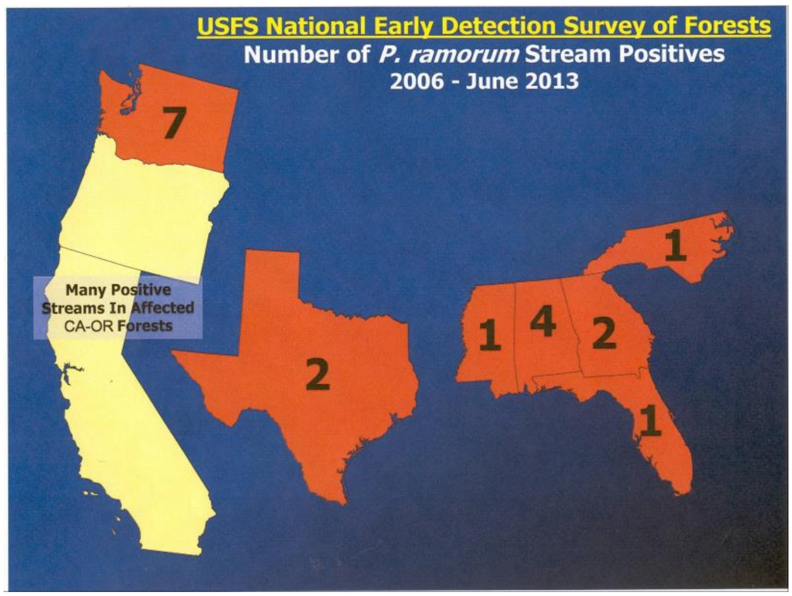
The pathogen of sudden oak death was first detected in the mid-1990s in California, where forest trees were dying. In 2001, research demonstrated that a newly described pathogen, *Phytophthora ramorum*, was the cause.[33] Before long, the pathogen was detected to be present on private and public forests in a number of counties in California and one county in Oregon. Over the next decade, wildland outbreaks have spread to 14 counties in California, have expanded in the Oregon county, and have filled in areas not originally infected.

While the cause of the introduction was not immediately apparent, a genetic analysis of the pathogen in California forests eventually demonstrated that infected nursery plants in the Santa Cruz area were the original source of the entire California epidemic.[34]

Meanwhile, contaminated plants were quickly found in a small number of nurseries in California, Oregon, Washington State, and British Columbia. Both Oregon and California adopted regulations intended to prevent spread of the pathogen; APHIS followed with its own regulations in 2002.

In 2004, despite the state and federal precautions, thousands of possibly infected plants were shipped from a few west coast nurseries. By the end of 2004, 176 nurseries, in 21 states across the country, had received infected plants.[35] Emergency regulations implemented by APHIS (see below) reduced the number of nurseries with infected plants significantly in subsequent years – to between 20 and 30 nurseries. However, the number of infected nurseries has not continued to decline in recent years; that number rose to 34 in 2010,[36] then fell to 21 in 2012 and 17 nurseries in 2013.[37] Between 2003 and 2011, a total of 464 nurseries located in 27 states have tested positive for the pathogen, the majority as a result of shipments traced from infested wholesalers.[38] Throughout this period, nearly one third of the infected nurseries have been located outside of the three originally infested west coast states.[39].

Meanwhile, the pathogen has been detected in eleven streams and ponds outside nurseries in Alabama, Florida, Georgia, Mississippi, North Carolina, and Washington State. Once *P. ramorum* is detected in a stream, subsequent tests are always positive. The conclusion is that the pathogen has become established, most probably in the soil along the stream.



To date, spread of the pathogen to vegetation beside the affected stream or ditch has been found only twice: in Mississippi and Washington. Transmission has not been detected in California, despite high spore levels in streams which flow from infested private and public forests.[40] The infected vegetation in Mississippi and Washington was removed. Subsequent monitoring has not revealed any additional infections on surrounding host plants.

Past Policy Actions (2002-2013)

Despite considerable activity by both states and the federal government, a program effective in preventing spread of *P. ramorum* through the nursery trade has not resulted.

In 2001, the two states known to have wildland outbreaks, Oregon and California, acted to prevent the spread of *P. ramorum* into, or within, their borders. The Oregon Department of Agriculture issued quarantines restricting the import of plants from California and the movement of those in Curry County. The California Department of Food and Agriculture issued emergency rules, requiring permits to move host plants or materials within, or from, seven infected counties.

In 2002, APHIS issued an interim regulation, similar to California's rules, limiting interstate shipment of a range of plants and materials. The federal action quarantined ten California counties, plus the one in Oregon. Also, the federal rule required annual nursery inspections for those shipping regulated plants outside the quarantine area,[41] and a U.S. National Nursery Survey was implemented, to determine the extent of the pathogen's presence.[42]

The nationwide spread of infected plants in 2003 spurred several actions. First, states and APHIS spent at least $15 million investigating more than 1.6 million nursery plants, checking for infections and destroying diseased plants. In one contaminated nursery in southern California, over 1 million camellias, worth $9 million, were destroyed.[43]

Second, regulators realized that at that time, just a few years after *P. ramorum* had been named by science, important facts about the disease were unknown; this lack of knowledge undermined decisions. Thus, authorities had not realized the extent of plant taxa susceptible to the pathogen, specifically the genus *Camellia*. Also, regulators did not anticipate that nurseries in drier, hotter locales would have microclimates that were more humid – and conducive to growth of the infection.

In 2004, in response to the widespread shipping of potentially infected plants the year before, 17 states took unilateral action to limit plant imports from California;[44] APHIS called the situation "regulatory chaos".[45] Also, APHIS issued three Federal Orders, each stricter than the last.[46] Tighter restrictions were placed on the interstate movement of stock from most nurseries in California, Oregon, and Washington; this resulted in first-time inspections for about 1,400 nurseries in the three states. APHIS also imposed requirements for inspecting, sampling, and cleaning up nurseries.[47] The APHIS rules were considered temporary, and set to expire in three years.

Negotiations among APHIS, state regulatory agencies, and their national associations led to development of protocols intended to limit the spread of the pathogen, and to assist industry in managing the pathogen, if it was detected. These changes eliminated some of the disparities between states' regulations, and were put in place in 2005.

More regulatory changes came in 2007.[48] An interim rule established restrictions on the interstate movement of stock from nurseries in non-quarantined areas in California, Oregon, and Washington; added restrictions on the movement of decorative trees without roots, from quarantined areas; and restricted the interstate movement of all other nursery stock, from nurseries in quarantined areas. Also, it updated the list of plants regulated, and the list of quarantine areas.

These federal regulations applied to more than 3,500 nurseries in the three regulated states: 1,500 that propagate ornamental plants susceptible to the disease, and 2,000 that grow non-host plants.[49]

However, as noted above, a small but disturbing number of infected nurseries have continued to be infested despite the regulatory action. Most detections of the pathogen occur now in regulated nurseries, during their annual certification surveys, so before potentially infested plants are shipped. However, in 2012, half of the infected nurseries identified by regulators were infected for the first time.[50] As of summer 2013, 17 nurseries had been detected as having infested plants; 12 of these nurseries ship plants interstate – although no infected plants were found as the result of trace-forward inspections.[51] It is difficult to ascertain whether the pathogen is spreading further, or the detection program is increasingly effective.

The continuing number of nurseries testing positive for *P. ramorum* in recent years is probably explained, at least in part, by several years of wet weather on the West Coast, which was conducive to the pest's growth, and thus the development of visible symptoms on plants. However, nurseries also continue to follow practices that increase the risk of the pathogen establishing. A study by the Oregon Department of Agriculture in 2011 and 2012 observed the following potentially risky conditions at nurseries during agency inspections: [52]

- 79 nurseries used untreated water from rivers and ponds to irrigate.
- 113 nurseries had standing water in greenhouses and/or in plant production areas.
- 39 nurseries allowed heavy amounts of plant debris to build up.
- 36 nurseries placed cull piles in risky locations.
- 113 nurseries placed containerized plants on native soil.
- 157 nurseries stored potting media on native soil.
- 207 nurseries did not clean or sanitize containers before they were re-used.

In either case, infections may not be observed by inspectors, under most circumstances. So, the risk persists that infected material could be shipped from west coast to eastern nurseries. It is important that the program either become more effective in eradicating *P. ramorum* from these nurseries, or restrict infested nurseries from shipping plants to un-infested regions of the country.

Updating federal approaches

APHIS has been struggling for several years to update the 2007 rules. The agency carried out an extensive "National Program Review" in 2009 and 2010, involving a wide range of stakeholders. The review resulted in a new consensus goal (Box 2), as well as recommendations for action.[53]

Box 2. Consensus Goal for the *P. ramorum* Program

"The program will take a proactive approach to protect native biodiversity, wild lands, and managed landscapes from *Phytophthora ramorum* through a system of voluntary (which we interpret as performance-based Best Management Practices) and mandatory approaches focused on Critical Control Points."[54]

Best Management Practices are actions which reduce a hazard of pest infestation or infection. They can include ways that nurseries manage plants, irrigation water, or growing medium; staff training; sanitation of pots, water, soil, and tools.

Critical Control Points are particular steps in the plant production process at which control can be applied to effectively prevent or eliminate a hazard, or reduce the hazard to an acceptable level.

"Confirmed Nursery Protocol" – cleaning up infections. Following the program review, APHIS has focused on infected, or "positive," nurseries, especially "repeat" nurseries that have had infected plants for more than one year, despite using the mandated clean-up measures. In 2012, half the positive nurseries were repeat nurseries; in previous years, the proportion had been higher.

Under the regulations in effect since 2007, all positive nurseries in California, Oregon, and Washington must implement a set of actions called Confirmed Nursery Protocol (CNP), aimed at cleaning up potential reservoirs of infection. These actions include: elimination of leaf litter from the growing area; staff training; and destruction or segregation of any returned or "seconds" plants belonging to *Camellia* or *Rhododendron* genera, or other genera that have tested positive in that nursery. Nurseries under CNP are also surveyed more extensively and repeatedly, before they are allowed to ship interstate again.

The regulations in effect since 2007 have not required positive or repeat nurseries to complete a critical control point assessment. That is, they did not have to analyze the risk factors and hazards associated with their plants, soil, pots, irrigation water, etc., or with their procurement and handling procedures; production processes; and distribution to retail outlets. However, APHIS tried to encourage nurseries to conduct such assessments voluntarily by offering technical assistance and expertise. Since nurseries vary in size, business practices, the host plants they propagate, location, and other factors, APHIS opted for such a flexible approach.

Once determined to be free of the pathogen, a nursery is "released" from the Confirmed Nursery Protocol. Then, it may revert to annual inspection and sampling, and have its plants certified for interstate movement.[55] If, instead, a nursery becomes a "repeat" nursery, APHIS and the state department of agriculture determine the appropriate course of action, which may include additional mitigation measures.

APHIS believes the cleanup measures it recommends will be more successful in coming years. Scientific research has improved techniques for cleaning up soil and water, which are frequent reservoirs of infection. This research has been funded largely through a program in §10201 of the Farm Bill, and much of it has been carried out at the National Ornamentals Research Site, at Dominican University, in California.

Nurseries' adoption of these new approaches remained largely optional, since the agency's 2007 regulations have not been amended. Some of the states have acted to promote adoption, but their engagement depends, to some extent, on federal funding through the Farm Bill.[56]

APHIS regulates the pathogen and imposes critical control point approach.

As APHIS representatives at the 2013 meeting of the National Plant Board conceded, the lengthy delay in adopting the proposals from the 2009 program review had frustrated all concerned. The APHIS representatives noted several "challenges and opportunities" that had plagued the program for some years:

- Both APHIS and the states are hampered by restricted funds; eastern states resent having to spend resources on finding possibly infected plants shipped from West Coast nurseries ("trace-forward" plants);
- Despite scientific findings demonstrating that *P. ramorum* should be regulated regardless of whether it is found in a plant, water, or soil, the regulations required detection of diseased plants;
- Stakeholders want adoption of the concepts developed through a long policy review process;
- The confirmed nursery protocol should require repeat nurseries to implement best management practices to address the causes of repeated or continuing infestation.

The APHIS representative noted that the Agency has already taken the following steps to simplify the program:

- Required advance notification to importing states of shipments by nurseries with a history of having had infected plants;
- Deregulated nurseries in California, Oregon, and Washington that ship only plants that are not hosts of *P. ramorum*;.

He promised that APHIS would soon move forward with the following changes:

- Stop regulating nurseries outside the counties with wildland infestations that have never been detected to have a *P. ramorum* infection.
- Apply the same regulatory regime to any nursery in any state where infected plants have been detected. Nurseries could be de-regulated if they sell only as local retailers.

In January 2014, APHIS issued a Federal Order that goes into effect at the end of March, 2014. Under the new regulations,[57] nurseries in the regulated areas of California, Oregon, and Washington that ship host plants interstate will be released from federal inspection and certification requirements if the pathogen has not been detected in that nursery on or after March 31, 2011. If *P. ramorum* has been detected in that nursery on or after March 31, 2011, that nursery must be inspected, sampled, and certified in order to ship regulated and associated articles interstate. The regulatory samples will be taken from soil, standing water, drainage water, irrigation water, growing media, and other articles, not just the plants themselves.

Nurseries that are outside the West Coast regulated states or the 15 quarantined counties will be subject to the revised regulations only if they ship *P. ramorum*-host plants interstate and the pathogen has been detected at the nursery on or after March 2011.

<u>All</u> nurseries, wherever they are located, that have had *P. ramorum* detected on their premises must enter into a compliance agreement with APHIS under which the nursery adopts mitigation measures to address sources of the pathogen identified as present in the nursery. In other words, adoption of a critical control point approach is now mandatory rather than voluntary for nurseries found to be infested in tests conducted after the end of March.

Nurseries that have tested "clean" over a three-year period – beginning in 2011 – w ill be exempted from the federal inspection and certification requirements.

Nurseries in the 14 California counties and one Oregon county in which sudden oak death is established in the wild will remain under the federal inspection and certification requirements.

Other regulatory updates by APHIS. Earlier APHIS updates had added new taxa to the list of plants that are hosts or associated with *P. ramorum*, for example, in January 2012.[58] These additions both reflect a growing understanding of the disease and paint a truer picture of our forests' vulnerability.

Also in 2012, another Federal Order[59] required nurseries in Europe (where *P. ramorum* has been established for a decade or more) to comply with the same inspection/testing regime required of U.S.-based nurseries.

Two Federal Orders removed notification requirements for nurseries that have never tested positive for *P. ramorum*, or have tested negative for the past three years;[60] and ended federal regulation[61] of nurseries located in regulated sections of California, Oregon, and Washington but that do not contain and do not ship plants that are proven hosts of the pathogen, became exempt from federal rules.

Best management practices. Nursery associations have continued to promote voluntary best management practices; presumably their advice will now assist nurseries required by APHIS to adopt critical control point programs. The California nursery industry is hosting a series of workshops and has developed an online tool which allows nurseries to customize their efforts based on the pests and pathogens under quarantine or of concern at their location (county). [62]

The California Oak Mortality Task Force has compiled:

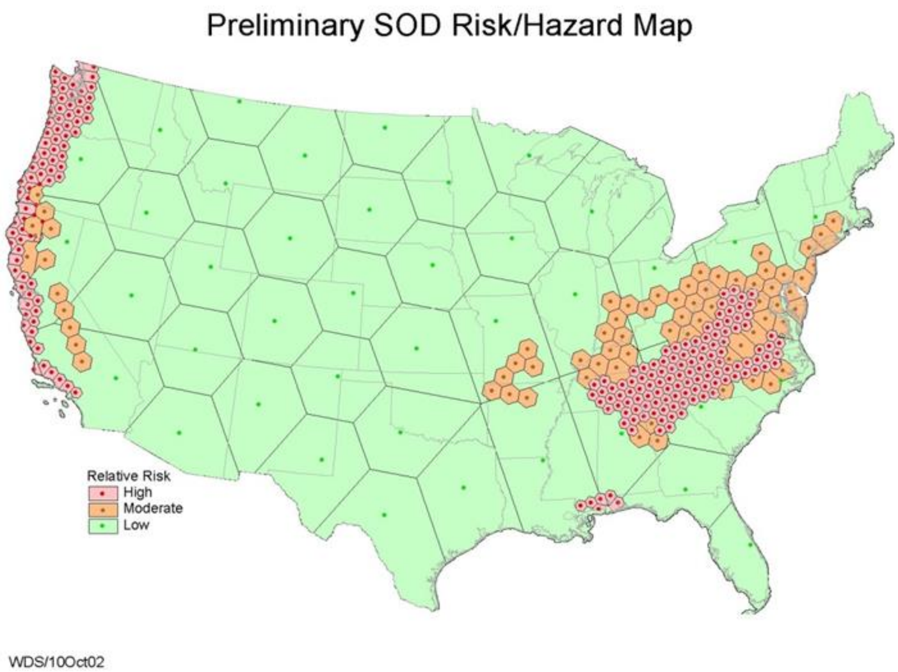
- A list of 15 manuals, certificate programs, publications, presentations and other information on best management practices for the nursery industry. These were offered by states, industry, and other organizations, from 2006 through 2012;[63] and

- A group of ten best management practices, for other users and activities, presented from 2006 through 2010.[64]

The risk of interstate spread to oak forests nationwide. Finally, it is important to remember that APHIS has jurisdiction over only those nurseries that ship interstate. Nurseries that sell within a state are subject to its regulations, the stringency of which varies.

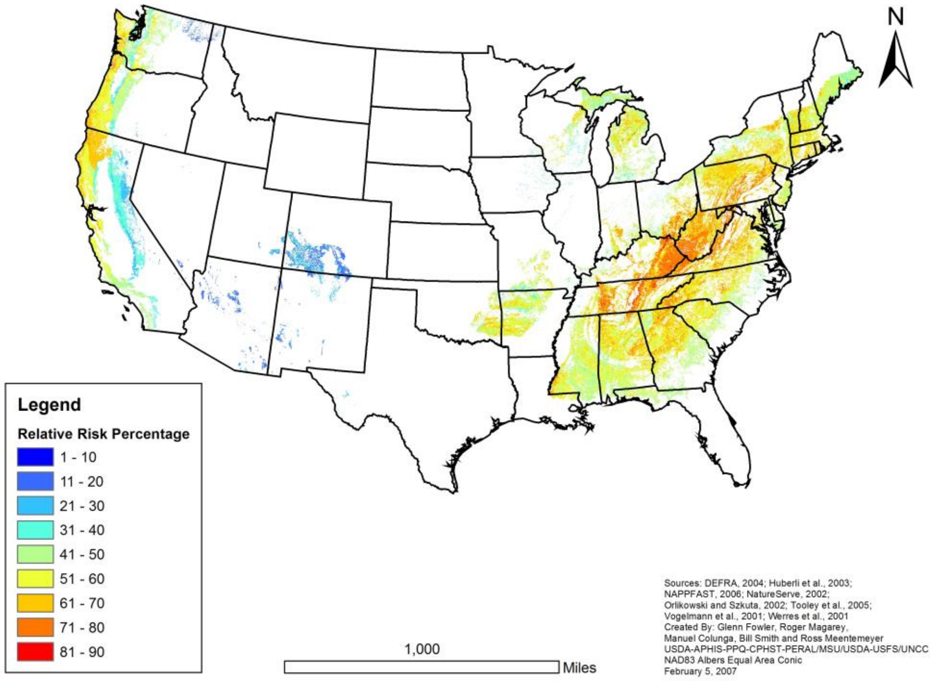
The lingering presence of *P. ramorum* in the nursery trade perpetuates the risk that the disease will become established outside the California-Oregon area, especially where oak trees predominate. APHIS, the U.S. Forest Service, and an academic epidemiology modeling team have developed risk maps for the pathogen. These indicate that significant areas in the South and the East are at risk. We have already noted that the pathogen is established in streams and ponds outside nurseries in Alabama, Florida, Georgia, Mississippi, and North Carolina.

Several risk maps have been produced over the past decade, using different approaches and considering new information as it becomes available. They are remarkably consistent in their findings.



Prepared by the USDA Forest Service FHM & Southern Research Station in 2002

Most recent forest service in 2011 - So Station rept; Koch, Smith
Shows more risk in so portion ; less in NE



APHIS PERAL SOD risk map, prepared 2007

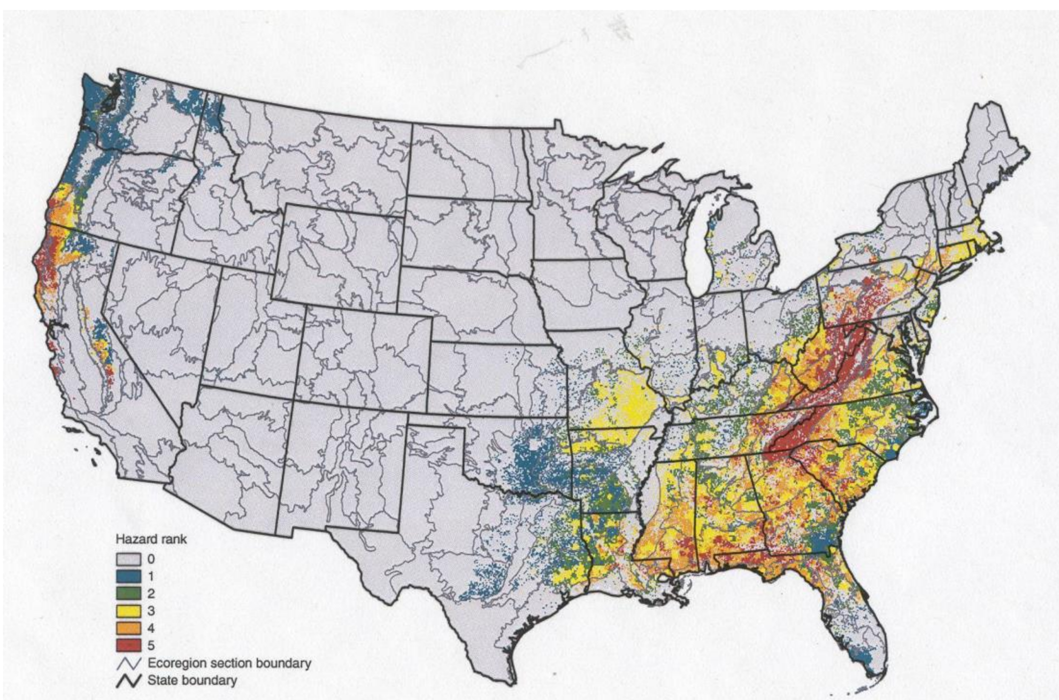
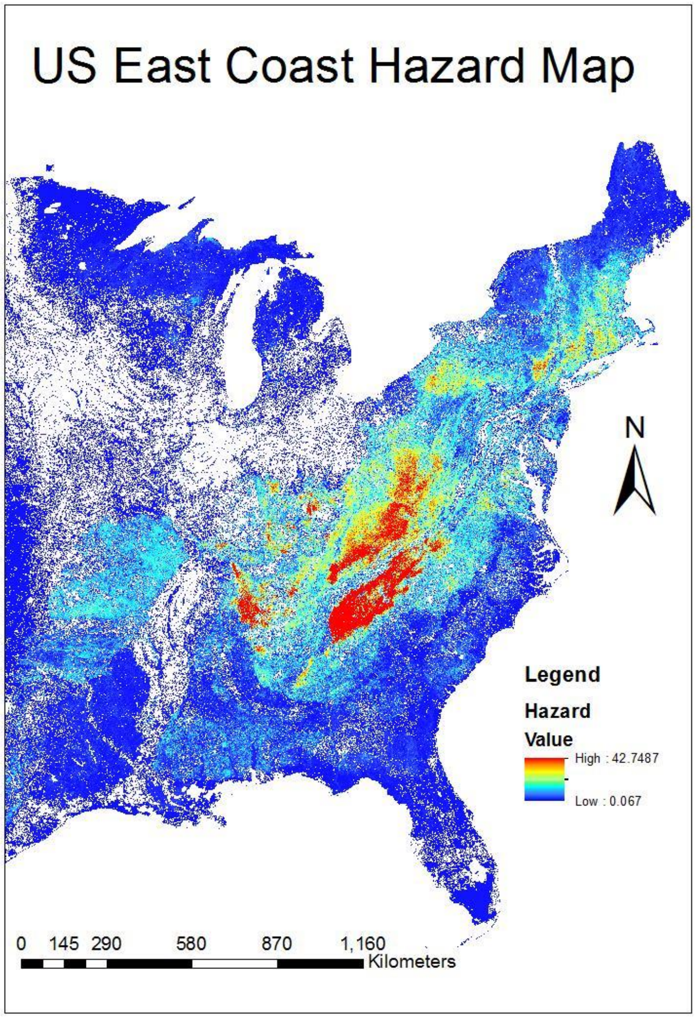


Figure 7.5—Hazard layer generated by combining the host and climatic suitability layers. Please see text regarding the determination of rank scores. Ecoregion section (Cleland and others 2007) and State boundaries are included for reference.

Potter, K.M. and B.L. Conkling. Forest health monitoring: 2009 national technical report. USDA Forest Service, Southern Research station. GTR-SRS-167.



Map developed to evaluate SOD risk in east by Dr. Prof. Chris Gilligan, Cambridge University

As part of its 2011 program review, APHIS also revived the National Nursery Survey in all 47 "non-regulated" states. (Some states had stopped testing for *P. ramorum.*) The regulations do not require states to survey all nurseries that ship *P. ramorum* hosts. But APHIS staff say they are trying to persuade states to do so. The survey protocol now calls for sampling to find evidence of the pathogen, not just diseased plants. Nevertheless, a "positive" water sample does not give APHIS the right to declare the nursery infected.

Box 3. Another Plant Disease: `Ohi`a Rust

`Ohi`a, or *Puccinia* rust (the pathogen *Puccinia psidii*),[65] was apparently transported to Hawai`i *via* trade in cut foliage.[66] The rust was first detected in nurseries in April 2005. By August, only four months later, it was found throughout the main Hawaiian Islands.

`Ohi`a rust infects a wide range of plant species in the family Myrtaceae. Hawai`i has seven unique, or endemic, species in this plant family, including its most widespread native tree, `ohi`a (*Metrosideros polymorpha*), and *Eugenia koolauensis*, a shrub listed by the U.S. Fish and Wildlife Service as endangered.

The endangered *Eugenia* has been severely damaged by the rust.[67] But, so far, it has caused little damage to the `ohi`a. This tree dominates approximately 80 percent of Hawai`i's remaining native forest, or about 1,500 square miles. Also, it provides habitat, food, and shelter for most of the islands' remaining native birds. Up to one-half of Hawai`i's approximately 300 endangered plants rely on `ohi`a-dominated forests for shade.

There would be significant changes to the structure, composition, and, potentially, the function of forests if a more virulent form of the pathogen evolves, or is introduced. These changes would be felt on a landscape level.

To address the pest risk from plants to planting more broadly, state departments of agriculture and the nursery industry have developed a program called "SANC" – "a systems approach to nursery certification". The goal is to improve state nursery certification programs by incorporating systems approach/critical control point approach. The expectation is that such an integrated program would allow more effective use of resources to manage (reduce) the pest risk more effectively. It is hoped further that nurseries and state agencies would become partners in managing the risk and both sides would learn more. Since integrated measures must be tailored to each nursery, it is a complex system to set up. After three years of discussions, a few nurseries in several states are expected to pilot the program in summer 2014.[68]

OTHER POTENTIAL PATHWAYS

1. The Wood Packaging Pathway

Status and Trends

Huge quantities of wood packaging move about North America. According to the National Wooden Pallet and Container Association, 93 percent of all goods move on pallets, meaning that 1.2 billion pallets are currently in circulation in the United States.[69]

There are no estimates for the amounts of crating and dunnage used within the country, or shipped between the United States and Canada. Nevertheless, these also represent large quantities of packaging able to transport foreign pests.

Past Policy Actions (2002-2011)

At present, APHIS issues domestic quarantines for specific pests. These identify articles and areas that are regulated, and set conditions for the interstate movement of regulated articles from quarantined areas. The domestic quarantines for wood-boring pests, such as emerald ash borer and Asian longhorned beetle, regulate the movement of unmanufactured wood articles, including wood packaging material; these quarantines vary from pest to pest.

However, it is widely feared that regulations tied to specific geographic regions (the quarantined areas) are not effective. The first reason is that the restrictions apply only when the wood packaging leaves the quarantined zone. APHIS did not regulate manufacturers and purchasers of pallets as long as they are located within the quarantined area. When the pallet or crate is transferred to the custody of a shipper, that shipper might not be informed about the requirement to treat wood packaging shipped out of the quarantined zones, and so might unknowingly violated the regulations.

A second factor is that scientists and regulators often do not know the true extent of an infestation. For example, since discovery of the emerald ash borer in 2002, APHIS has expanded the emerald ash borer quarantine 22 times.[70] Wood harvested outside the known area of infestation could easily have been infested by the beetle.

In 2007, manufacturers of pallets, and shippers operating within quarantined areas, were reluctant to accept APHIS' requirements for treating wood. Some argued that all wood packaging should have to meet the same requirements, to ensure consistency, fairness, and efficacy. Sixteen organizations came together, under the auspices of the Continental Dialogue on Non-Native Forest Insects and Diseases, to send a letter to APHIS, in June 2008. They asked that APHIS regulate all wood packaging, moving interstate, or between the United States and Canada.[71]

In August 2009, APHIS published an Advance Notice of Proposed Rulemaking (ANPR)[72] in which APHIS announced that it was considering extending the treatments required by the international standard (ISPM #15; see Chapter 4) to domestic wood packaging.

Unfortunately, no one collects data on the pest load associated with wood packaging used in interstate commerce. Strong opposition to the ANPR, combined with the absence of supporting data, led APHIS to abandon its rulemaking, in July 2011.[73]

2. Woodworkers

An outbreak of laurel wilt[74] [www.dontmovefirewood.org/gallery] was associated with transportation of redbay wood to a new location, by an amateur woodworker. Also, it appears that thousand cankers disease, which infects walnut, has been introduced into eastern forests *via* the woodworking and veneer industries.

This raises the specter of another, less visible, pathway for the transport of forest pests: raw wood used by hobbyists, or professional, woodworkers. .

Status and Trends

Concern about this pathway rose significantly after the 2008 description of thousand cankers disease of walnut.[75] [www.dontmovefirewood.org/gallery] Black walnut is a very popular wood. In 2011, one of several websites[76] offering wood for turning, carving, or other projects, listed walnut from more than 40 sources in the West, where thousand canker disease is present.

Woodworkers are different from firewood users, although their use of un-manufactured wood presents a similar regulatory challenge. Less is known about their numbers and practices. For example, we do not know how far they move wood; whether they obtain it "green," dried, or treated; to what extent they prefer that bark be attached; and whether they are aware of key pests and how their activities may spread them.

Some of these questions were answered in 2012.[77] Woodworkers can be grouped by those who turn wood on a lathe, those who carve it, those who build various types of furniture (cabinetry), *etc*. Some turners and carvers prefer to use blocks of green wood, with bark intact, because it dries more slowly. Such green wood is transported regionally, nationally, and internationally. Wood is sold at large shows, events, and on the Internet. Also, it is traded among individuals. The risk of transporting pests is high, due to the attached bark.

Past Policy Actions (2002-2013)

Officials of concerned state agencies and conservation groups are working with woodworkers' associations to raise their members' awareness of pest issues. After contacts on a largely individual basis in 2011, the Continental Dialogue on Non-Native Forest Insects and Diseases produced an educational factsheet for wider distribution, in 2012. It was endorsed by 11 organizations, including the National Plant Board, National Association of State Foresters, Walnut Council, Society of Municipal Arborists, and two woodworkers' associations – the American Association of Woodturners, and the International Society of Wood Collectors.[78]

3. Logs, Lumber and Veneer

Operations that process logs and lumber or produce and ship wood veneer move large quantities of raw materials between states. In some cases, these shipments have been implicated in movement of damaging forest pests.

Companies in the veneer industry move large stumps of black walnut from west coast walnut orchards, *via* rail, to eastern states for peeling. Black walnut is used as root stock in California, where it is grafted to English walnut (*Juglans regia*) for nut production. After the orchards become obsolete, the trees are cut down. The black walnut stumps, which are now quite large, are used for veneer. The increasing detection of thousand cankers disease on black walnut in different eastern states may be related to this aspect of the veneer industry.

Thousand cankers disease was detected near a lumber and veneer dealer in Butler County, Ohio in late 2012. The dealer had imported walnut burls from California since the mid-1980's (many of the walnut orchards in California are infected). State officials are still trying to determine how large the infestation is.[79]

In June 2012, a large infestation of the emerald ash borer was detected on the Virginia-North Carolina border. The beetles were initially detected in logs being processed at a mill near the town of Danville.[80]

This overview of the current situation shows that the United States lacks a coherent, effective program to prevent spread of pests from the site of original introduction or detection through a significant portion of the hosts' range. In some cases, official quarantines and actions by USDA APHIS have not proved effective (although, in other cases, APHIS' efforts have been effective). In other cases, federal and state actions together have not resulted in removing a pest or pathogen from the pathway of most likely spread. In still other cases, APHIS has chosen not to engage, leaving the states to try to coordinate responses among themselves.

Federal and state agencies understand the need for coordination; fledgling programs have been started focused on firewood and nursery plants. However, other pathways remain largely unregulated at either the federal or state level.

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Chapter 6
The Challenge of Restoration

"The next century will, I believe, be the era of restoration in ecology"
Edward O. Wilson,1992[1]

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, transformed, or destroyed. In its simplest form, restoration is accomplished by removing or modifying a specific disturbance, thereby allowing natural ecological processes to bring about recovery. Initiating recovery from species-decimating exotic pests, however, is much more complex, requiring mitigation of the pest and reintroducing a host species into a much altered environment.[2]

Will the 21st century indeed be the era of restoration? We agree that restoration probably *should be* a primary thrust in future environmental programs, given the many negative ways natural resources have been altered. Restoration of a forest tree species, however, is a daunting and expensive process that requires long-term commitment, strong infrastructure, and significant funding. Resources required for restoration are poorly understood by the general public and politicians. Restoration is often overshadowed by achievement of pest control, and few realize that control is not the final step in returning a decimated forest tree species to the environment. Thus, programs that focus on restoration face societal as well as technical challenges.

Forest tree restoration is a multiple-step procedure that requires significant resources and infrastructure to accomplish. Restoration is predicated on achieving pest control; it is pointless to begin restoration without pest control that allows the reintroduced trees to survive and successfully compete. Additionally, it is necessary to have germplasm (collection of genetic resources for an organism) of host species available for restoration. These two steps toward preparing for restoration, followed by the actual restoration itself are accomplished over a number of years, even decades, and require sustained commitment and funding.

1. Pest Control Mitigation

The primary focus in a new or resident exotic pest problem is usually eradication or control, both in terms of funding and publicity. If eradication fails, then efforts switch to control strategies. Mitigation of the pest to allow restoration includes the following approaches:

- Development of resistant genotypes-(if possible);
- Use of biocontrol;
- Use of management techniques; and
- Other approaches, *e.g.*, chemical applications.

These control strategies can be applied singly or in combination.

Host-Plant Resistance
Development of resistant tree genotypes usually involves breeding and selection. Breeding for host plant resistance has been almost exclusively conducted by tree improvement programs. The rare exception is the work of private foundations, like the American Chestnut Foundation and the American Chestnut Cooperators Foundation.

Such breeding programs address both pest mitigation and restoration, as pest resistant planting stock is the end result.

A number of scientists are working on host-plant resistance (cf. Johnson et al., 2012). Breeding and selection for resistance is possible for: American chestnut (Anagnostakis, 2012;), American beech (Koch and Carey, 2005), Port-Orford-cedar (Sniezko et al. 2012a), American elm (Smalley and Guries, 1993; Townsend et al., 2005), black walnut (Utley et al., 2013), butternut (Utley et al. 2013), flowering dogwood (Holzmueller et al., 2007), redbay (Mayfield et al. 2009), and North American white pine species (Bingham, 1983; Fins et al. 2001; cf. Sniezko et al. 2004, 2012b).

Planting hybrid Carolina / Chinese hemlock seedlings at Upper Mountain Research Station, Laurel Springs, North Carolina. Photograph courtesy of Fred Hain.

Control measures against exotic forest pests using this approach have been successful enough to allow for restoration of host species in certain instances. These include western white pine, sugar pine, and American elm.

Biocontrol

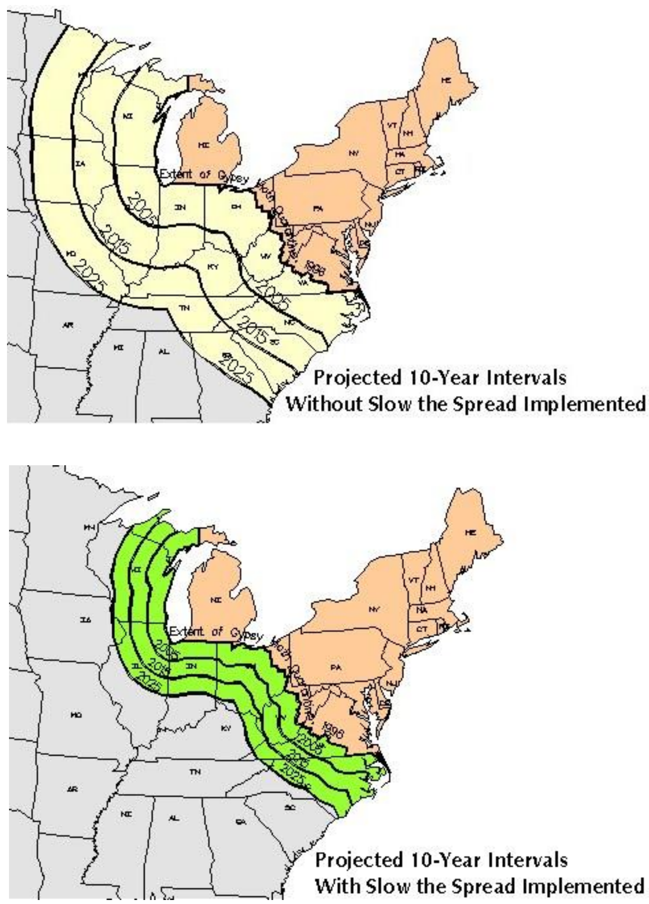
Biocontrol usually involves release or application of another organism to attack a specific pest. This approach has been used to address a variety of agronomic, horticultural, and forestry pests. For example, introduction of two European parasitic wasps has reduced populations of the larch casebearer, a moth which attacks western larch trees in North America. Biocontrol also has been used to provide control of the chestnut blight (causal pathogen – *Cryphnectria parasitica*) through introduction of virus-carrying strains (cf. Anagnostakis, 2012). *Cryphonectria* strains infected by a virus can be used to debilitate more virulent strains of the fungus, causing a hypovirulent reaction which allows the tree to recover.

Two biological agents are registered for use to control European gypsy moth. GypChek is an aerial spray that contains a naturally occurring nucleo-polyhedrosis virus that specifically targets gypsy moth larvae. A bacterium *Bacillus thuringiensis* var. *kurstaki* (BtK) is also used, but can affect some non-target lepidopteran species. Biocontrol does have an element of risk, and there are a number documented instances where the biocontrol organism has exhibited unexpected behavior and caused harm to non-target species (Simberloff and Stiling, 1996; Simberloff, 2005).

Management Techniques

Integrated pest management (IPM) and forest management techniques have been successful in addressing exotic forest pests. Like biocontrol, IPM strategies have been successfully applied in various crop/forestry species. The USDA Forest Service's Slow-the-Spread Program is an excellent example of an IPM program controlling a serious pest, European gypsy moth (Sharov et al., 2002; Tobin et al. 2007, 2012).

Figure 1. Projected Spread of European Gypsy Moth With and Without the Slow-the-Spread Program



Source: http://www.fs.fed.us/ne/morgantown/4557/gmoth/spread/, credited to Virginia Technological University.

Application of silvicultural techniques can probably sustain butternut in eastern forests from succumbing to butternut canker disease. Thinning around surviving butternuts to ensure that the crown is free from competition to grow and maintain vigor appears to be related to survival, even in the presence of the disease.

Chemical Control

Widespread chemical control of exotic forest pests has become increasing unpopular since the 1960s. In local situations, however, chemical control can be effective and desirable. For example, eastern hemlocks can be kept alive in areas like campgrounds and popular trails by applications of imidacloprid, a systemic insecticide (Cowles et al., 2006).

Changes in Mitigation Strategies since 2002

Efforts to develop host resistance and biocontrol have taken a quantum leap in numbers since Fading Forests (1994). Since 2002, when Fading Forests II was issued, they have become even more widespread, involving additional tree species. Breeding and selection efforts, as well as related studies in pathology, entomology, physiology, *etc.*, are being conducted across the country. Symposia periodically address biocontrol of exotic pests, such as hemlock woolly adelgid, emerald ash borer, American chestnut, and beech bark disease.

Integration of molecular biology into breeding strategies has also become more prevalent.[3] Molecular-based research toward early identification and selection of resistant genotypes for American chestnut and American beech is now being conducted. DNA analysis has also separated pure butternut from hybrid trees that are now occurring in natural landscapes from introgression with Japanese walnut cultivars. Additionally, development of transgenic trees (GMO trees), by inserting a gene that confers resistance, is being explored with American chestnut, despite controversy surrounding this approach.

2. Conservation of Host-Plant Germplasm

Ideally, the first stages of a restoration strategy would be conservation of the host species' genetic resources from within or proximal to affected areas. Unfortunately, this important step is often ignored, as resources are usually focused on shorter-term needs, such as monitoring for pest outbreaks, and controlling pests that are already present.

A germplasm conservation strategy should be developed and initiated if invasion is imminent or once an exotic pest has invaded and is likely to become a resident pest species. Efforts to conserve germplasm can range from simple actions, like seed collection and preservation of host species from a small number of plants to utilizing highly designed sampling schemes that are guided by studies of genetic diversity within the species. Preservation of germplasm can range from simply freezing seeds to cryopreservation of excised embryos or tissue cultures. Ultimately, the degree of conservation is usually determined by the availability of resources to procure and process the germplasm.

Conservation of genetic resources can be either *in situ* or *ex situ. In situ* conservation occurs in the host species' natural habitat. *Ex situ* refers to conservation outside of the species natural habitat. There are many options within each approach. For example, seed and pollen can be collected and preserved (*ex situ*). Tissue samples, embryos from seeds that do not store well, or clones can be placed in cryogenic or low temperature storage (*ex situ*). Naturally occurring populations can be protected (*in situ*). A tree plantation can be established on a site outside of the pest's range (*ex situ*).

The approach depends on species biology, current and future availability of resources, and when restoration is anticipated. Seed of some species, e.g., oak species, do not retain viability under long-term storage. An alternate approach would be establishing an *ex situ* plantation. These plantations, however, require land dedicated to long-term preservation of the planting, periodic maintenance, and protection against pests. Such land is usually limited to state or federal lands, where ownership will not change.

An ex situ genetic conservation planting of Fraser fir in Wisconsin. The plantation was a collaborative effort between the tree improvement programs at the University of Tennessee and Tennessee Division of Forestry and the USDA ForestService, Eastern Region Genetic Resources Program.
Photo by USDA Forest Service.

Seed collections

Seed collections may provide the greatest preservation of individual genotypes, but a seed can be used only once. Once germinated, the seedling has to be planted, and it may be many years before such plantings produce enough seed to replenish the germplasm collection. For many species, not enough seed can be stored over multiple years, especially for large-scale reforestation projects. A more probable use for a germinated seed collection would be to establish seed production areas or orchards. If seed for reforestation is needed in the near future, this approach would only be feasible in tree species with rapid growth and early sexual maturity. Eastern or Carolina hemlock, for example, would be poor choices. These species grow and mature very slowly. Even sexually mature trees would not produce the large quantities of seed needed, until they are large.

Seed collections guided by local or rangewide biochemical studies of the species' genetic diversity are important to ensure that the samples are not biased and that rare genotypes are not lost. Such collections, however, may not be suitable for use in restoration of specific areas. The molecular or biochemical markers used to detect genetic diversity do not represent gene function. For example, genetic diversity in eastern hemlock among contiguous populations in the southern Appalachian mountains is relatively small according to isozyme studies (Potter et al., 2008). From a practical standpoint, however, trying to restore high elevation hemlock populations with genotypes from much lower elevations would be challenging. Budbreak is usually under strong genetic control, and lower elevation genotypes would break bud too early if planted at higher elevations. Dieback from frost injury would occur.

In the absence of research on a species' genetic diversity, simple seed collections can be made with a little understanding of species biology and seed handling. Processing and storage protocols for most American forest tree species are outlined in *The Woody Plant Seed Manual* (2008). For example, most butternuts occur in riparian zones near streams and rivers with a terrace or floodplain. There is a good chance that butternuts from along one stream/river are related, because the seed can be dispersed by water. Thus, if trying to preserve butternut genetic resources with no *a priori* information, a collector should target different watersheds to potentially obtain the least related materials.

United States National Plant Germplasm System

America has an old and excellent system to protect plant genetic resources, including forest tree species. The U. S. National Plant Germplasm System (NPGS) was conceived in the late 1800s. Preservation of seeds, tissues, and plants in the United States is the mission of the NPGS (White et al. 1989; National Research Council, 1991, Committee on Managing Global Genetic Resources 1991a).

Technologist in seed storage unit at NPGS, Fort Collins
http://www.ars.usda.gov/Main/docs.htm?docid=17892#PGRPP

The key facility for long-term germplasm preservation in the NPGS is the National Center for Genetic Resources Preservation in Fort Collins, Colorado. The Center's mission is to acquire, evaluate, preserve, and provide a national collection of genetic resources to secure the biological diversity that underpins a sustainable US agricultural economy. While the Center focuses on agricultural crops, the NCGRP also stores germplasm of native woody and non-woody flora.[4] Research on storage methodology and storage of different types of germplasm, e.g., seed, tissue cultures, pollen, semen, embryos, is conducted at the Center and other NPGS facilities.

The NPGS also operates four regional Plant Introduction Stations that conserve genetically-diverse crop germplasm, conduct germplasm-related research, and encourage crop improvement and product development.

At the state level, *in situ* preservation predominates. Most states have an uncoordinated network of natural heritage sites, private conservancy lands, and state and federal lands. These land bases, however, are only good for *in situ* conservation as long as exotic plant pest species are absent or under control. In most cases, states make no or scant effort toward *ex situ* preservation.

In the private sector, the Missouri Botanical Garden founded the Center for Plant Conservation in 1984 to coordinate a national effort for *ex situ* conservation of rare plant materials. It is the only coordinated national program of its kind and is directed to provide materials for restoration.

Changes in Germplasm Preservation since 2002

Preserving germplasm of host species with exotic pest problems is a higher priority now than when Fading Forests II was published in 2002. Two tree species, in particular, are receiving attention. Collections of seeds from eastern and Carolina hemlocks are under way, in response to the widespread decimation caused by the hemlock woolly adelgid.[5] Also, seeds from ash species are being collected, in anticipation of emerald ash borer outbreaks.[6] The on-going collection of ash species is noteworthy, as some collections are from areas not yet infested. The seed is being stored at the National Center for Genetic Resources Preservation.

Coalitions of private citizens, citizen groups and state/local organizations to save seed from natural populations are becoming more prevalent. For example, the Friends of the Cumberland Trail State Park in Tennessee have a seed-saving project, as does the Atlanta Botanic Gardens in Georgia (http://atlantabotanicalgarden.org/conservation/native-plants).

THE RESTORATION PROCESS

Forests can generally recover from damage caused by native forest pests, but often there is no natural check and balance, *e.g.*, native predators, for exotic pests. Restoration, therefore, requires intentional interventions to restore host species and associated ecosystem structure and function.[7]

If germplasm of host species has been conserved and pest control has been achieved, then movement toward restoration can begin. The use of the term "restoration" is now fairly common in the exotic and conservation literature. In fact, articles about restoration in scientific journals have roughly doubled every five years, from 1995 to 2010.[8] As mentioned earlier, people often seem to associate the accomplishment of pest control with the problem being solved and restoration activities are an afterthought. In reality, restoration may be more difficult to achieve than control in some instances.

When properly conducted, restoration involves:

1. production of propagules (seed or clones);
2. mass propagation in growing facilities, e.g., bare-root seedling nursery or greenhouses;
3. site preparation of former habitat and planting; and
4. post-planting maintenance.

Each of these activities requires different skill sets, equipment, facilities, and infrastructure. Each also requires established protocols or research to establish a protocol. In general, activities under 1 are conducted by state agencies, state agricultural experiment stations (usually at land grant universities), and/or federal agencies. For (2), some states have state nurseries, while other states contract at private nurseries. Federal nurseries have become uncommon. Activities under (3) and (4) can be done by governmental personnel, private contractors, or landowners. If funds are available, there is an adequate labor force to accomplish these tasks. For that reason, activities under (3) and (4) will not be discussed further with the exception of a discussion about site preparation and restoration of species not commonly planted.

Large forestry corporations, *e.g.*, Weyerhaeuser, have the infrastructure to conduct restoration. However, these corporations are usually involved with a relatively small number of coniferous species. Unless an exotic pest impacts a commercial species, industrial infrastructure will probably not be utilized for restoration.

Production of propagules

Restoration on a landscape scale requires a large number of seeds or clones. Seeds originate from collections of trees occurring in the landscape or seed orchards. There are various disadvantages to collections from landscape trees including irregularity of year-to-year production, seed damage from pests, predation of mature seed, and question about origin. Seed production in orchards, particularly genetic orchards created by tree improvement programs, can be more reliable because of fertilization and irrigation, have fewer pest problems due to control measures, protected from predation by deer and other herbivores, and will be of known origin.

Clonal production can be used with some species, instead of seedlings. There are, however, distinct drawbacks with this approach. In general, it is more expensive than seedling production. Genetic diversity can be reduced in restored populations, which may be very important to survival as the climate changes.

Tree improvement programs have traditionally been the nexus for constructing seed orchards and the less common stool-bed or *in vitro* systems for production of clones. Breeding for host-plant resistance has been almost exclusively conducted by tree improvement programs with the rare exception of some private foundations involved with restoration of American chestnut and American elm.

The volume of seedlings/clones needed to successfully restore a host species is important and directly related to the number of acres that potentially can be annually restored. Stored seed for germplasm conservation is a finite resource unless it can be quickly replenished. Ideally, seed orchards need to be created well before control. Otherwise, trees will not be large enough to produce enough seed to satisfy annual restoration needs. Hence timing and coordination of activities is critical. For species that can be cloned, technology will be needed to generate large numbers of clones in a short time.

Seedlings or clones used for restoration need to be of sufficient quality to survive and competitively grow in a natural setting. Incorporation of disease resistance is not enough to ensure successful restoration. Poor quality seedlings/clones will either not survive or will cost too much money for post-planting management to ensure survival. In general, each species has different requirements for production of high quality seedlings/clones. For some species, e.g., eastern white pine, production protocols have been well defined for a number of years. Much less information is available on producing high quality seedlings for other species, *e.g.*, redbay, with no commercial or ornamental value.

Site preparation and establishment of species not commonly planted

Species such as eastern hemlock may be very difficult to restore to the eastern forest landscape. Eastern hemlock is a riparian species and is not generally planted in natural settings. Site requirements, *e.g.*, light, and pre- and post-planting procedures are not well defined for eastern hemlock. Furthermore, as the hemlocks die, other woody vegetation will invade the sites and will have to be removed or thinned to promote successful regeneration. Additionally, site preparation for eastern hemlock restoration may be difficult due the proximity of streams. The use of machinery, certain herbicides, and perhaps, other forest management practices must be carefully managed in order not to affect water quality.

Changes in Restoration since 2002

Perhaps the most significant event in forest tree restoration since 2002 was the reintroduction of hybrid chestnuts from the American Chestnut Foundation's breeding program (Clark et al., 2010). These highly anticipated seedlings were from the BC_3F_3 generation in the Foundation's breeding program and claimed to be on the average 15/16 American chestnut with the remaining 1/16 being Chinese chestnut (Hebard, 2005). Although seedling morphology resembles American chestnut and growth rates are close to pure American chestnut (Clark et al. 2012), only approximately 17 percent have been estimated to be resistant (Hebard, 2012).

The Challenge of Implementing Restoration

Restoration of a host species is the last step in the complete resolution of exotic forest pest problems. It must be coordinated with other actions, *e.g.*, pest control, but is an independent component of overall resolution. Like other steps in addressing nonnative pests, it is long-term in nature and requires sustained commitment. Without restoration becoming an integral part of an exotic pest strategy, which includes prevention and eradication, American ecosystems are doomed to continuity of transformation.

There are many steps to ensure restoration of a host species that is locally adapted to its native environment, and there are woeful deficiencies in resources at each step. Overall, there are two primary areas of concern:

1. Tree improvement programs across the United States are in decline: and
2. Efforts to conserve germplasm for the trees attacked by exotic pests are unorganized, uncoordinated, and relatively unsupported by state and federal budgets.

Declining infrastructure of tree improvement programs

State (including land grant universities) and federal infrastructure to conduct activities to directly support restoration have become fragmented over the last two decades and seriously underfunded with support declining or stagnant. In the 1970's, tree improvement programs were so common that there were four biannual conferences held in the eastern states (cf. Schlarbaum, 1998). In the 1970's, there were meetings of the Southern, Lake States, Central States and Northeastern Forest Tree Improvement Conferences. Unfortunately, changes in: 1). research funding priorities in the United States; 2). state and federal budgets supporting research, and 3). priorities, and changes in the timber industry have caused an inordinate reduction of traditional tree improvement programs. In eastern states, now only the Southern Forest Tree Improvement Conference meets with any regularity, and attendance has been steadily decreasing.

Land Grant University Programs

At one time, most of the land grant universities had tree improvement programs. At present, university tree improvement programs have dwindled to a handful of university-industrial cooperatives and a few independent programs. This reduction is partially due to a decrease in state and federal base-line funding and to a corresponding increasing importance of obtaining competitive grants.

University programs, like similar state and federal programs, require sustained funding over decades. The McIntire-Stennis Act of 1962 was designed to support ongoing research at universities, including tree improvement and supporting areas of forest pathology and forest entomology. The low levels of funding and relative stagnation of McIntire-Stennis funding has been a major factor in the closure of many of these programs. This has caused a loss of capacity to sustain long-term applied research such as the breeding and testing for durable resistance that comprise tree improvement programs. Instead, scientists have shifted to more basic research areas which are more competitive in federal grants programs. Funding received from competitive grants can augment certain aspects within a university tree improvement program, *e.g.*, molecular marker-aided selection of disease-resistance genotypes. Competitive grants, however, cannot be relied upon for sustained support of traditional breeding and testing activities, the core of tree improvement programs.

While the McIntire-Stennis program was authorized at about $150 million in Fiscal Year 2010, the total appropriation was $29 million, no more than 19 percent of the authorized level.[9] As shown in Table 1, this is a common trend over the recent years. In 2013, the McIntire-Stennis funding fell below the two previous years. (Federal administrative costs, a small business set-aside, and funding for biotechnology risk assessment make up the difference between the total payment to states and the total appropriation, for any given year.).

Table 1. McIntire-Stennis Funding for Forest Research, FY2003-FY2013

Fiscal Year	Total Payments to States
2003	20,539,663
2004	20,555,921
2005	20,854,070
2006	20,794,402
2007	28,356,226
2008	23,420,475
2009	26,004,126
2010	27,389,470
2011	31,110, 110
2012	31,077,985
2013	28,494,985

Sources: U.S. Department of Agriculture, National Institute of Food and Agriculture. McIntire-Stennis Formula Grant Opportunities – Final; Fiscal Year Distribution Authorization Letters. Online at http://www.csrees.usda.gov/business/awards/formula/mcintire_stennis.html. Accessed August 27, 2013.

Decreasing sustained funding for long-term forestry research, including tree improvement, will be disastrous in the long-term, particularly with the growing exotic pest problem.

State agency programs

Tree improvement programs sponsored by universities and state agencies are directed toward meeting needs on state and private lands, usually on a state-by-state basis. In 1998, a survey showed that approximately half of the 50 states still had tree improvement programs (Schlarbaum 1998). A 2013 survey for this publication shows that approximately half (28) of the states still have some type of tree improvement activity. However, this can be misleading as some of these states are only maintaining seed orchards and have no active breeding and testing programs.

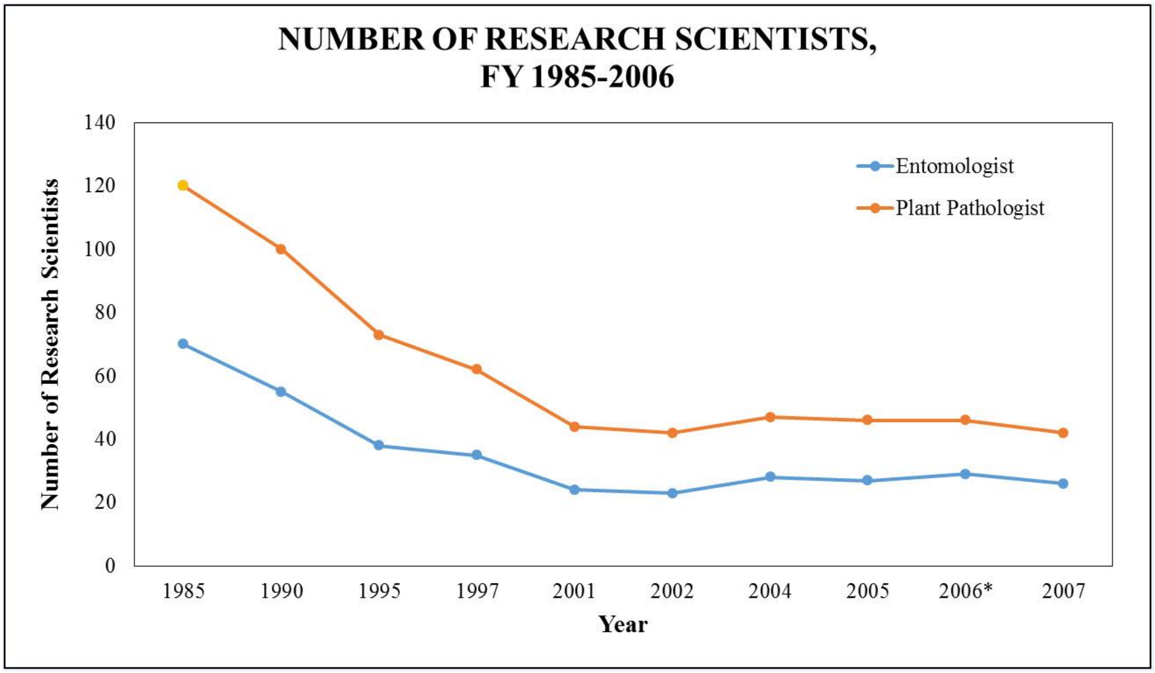
Additionally, a portion of these states are members of university-industrial cooperatives and do not conduct many activities with species outside of the cooperative's focus, which is often on a small number of commercial species, e.g., loblolly pine or poplars. Many of the species with exotic pest problems are not commercially grown in plantations. While there are a number of tree improvement-related research efforts outside of the university-industrial cooperative (cf. Johnson et al. 2012), they are not coordinated and not necessarily sustainable over time.

Federal programs

Restoration activities on federal lands are either absent or sporadic, unless they involve the U.S. Department of Agriculture Forest Service (USFS) and Bureau of Land Management (BLM), to a much lesser extent. Other federal agencies with significant forest holdings, including the National Park Service and the U.S. Army Corps of Engineers, have no tree improvement programs. Restoration activities, excluding control, on those land bases tend to rely on state programs and the National Forest System, Genetic Resources Programs (Regional Programs) or simply do not occur. The USFS Regional Programs now provide the majority of federal response to exotic forest pests, aside from some BLM seed orchards.

Downward trends exist in the BLM Tree Improvement and USFS Regional Genetic Resources programs. The BLM program was never very large, having a budget of $2 million nationwide in 1998 (Schlarbaum, 1998). The FY2013 BLM budget for tree improvement is now just under $1 million ($952,000) (Schlarbaum, personal communication). The USFS Regional Tree Improvement Programs (now called Genetic Resources Programs) began decreasing in scope and budget in the early 1990s. In the 1990s, the programs in Regions 2 and 3 (combined before 1990) and 4 were suspended and eventually placed under the jurisdiction of the Region 1 program. By 1998, the budgets for all programs had slipped to under $15 million nationwide (Schlarbaum, 1998). In FY13, they had a combined budget of $6,035,000 million (Schlarbaum, personal communication). As a result, species have been dropped or placed into caretaker status and seed orchards have closed.

Another troubling trend is the decrease in USDA Forest Service, Research and Development, pathologists and entomologists. Scientists in these disciplines characterize pest damage and resistance in host species, which is critical to development of resistant trees. In the period from 1985 to 2007, the number of pathologists decreased from 50 to 17 (Graph below; source USDA Forest Service). Likewise, the number of entomologists showed a severe reduction, decreasing from 70 to 26 in the same time period.



Lack of Coordination

Nationwide coordination of tree improvement programs presents a challenge. While the country has a long history of tree improvement associations, none has binding control over the resources and program direction of individual programs. Nor is there an overarching committee among the federal agencies to coordinate activities, such as the National Plant Board.

National Plant Germplasm System

In contrast to the declining infrastructure in tree improvement programs, the NPGS has the facilities and expertise to support long-term storage of seed, pollen etc. There is, however, very little funding available for preservation of forest tree germplasm.

In summary, a complete solution to an exotic forest pest problem includes mitigation and restoration, both of which are resource-demanding. There are a number of tools that can be used to mitigate resident pests, ranging from developing genetically resistant hosts to biocontrols. Mitigation, however, does not restore host species that are adapted to location conditions to the forest ecosystem. First a source of germplasm has to be available to generate seedlings used for restoration. The germplasm has to be in a form, either seed or clones, that can be readily propagated in significant numbers for landscape-scale restoration. Restoration sites have to be prepared for planting in accordance with host silvics, and most species will require some form of post-planting maintenance to become successfully established.

Once established, an exotic forest pest problem is never eliminated, but is brought under control through various means. Long-term academic and governmental programs are necessary to respond to these exotic challenges to our natural resources. Although technology exists for pest mitigation and host restoration in most cases, the current infrastructure to utilize these technologies is declining in the United States, as is financial support. The U.S. Germplasm

System is an excellent resource for seed and clonal storage, yet it has limited funding to initiate germplasm preservation/conservation collection in host species. Host-resistance breeding and restoration are functions that can be encompassed by tree improvement programs, yet those programs have dwindled nationwide to a scant number, aside from university-industrial cooperatives, which are primarily focused on commercial species. Additionally, there is a lack of coordination among academic and governmental programs directed toward resolving exotic forest pest issues.

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Chapter 7
Future Forests – America's Choice

The preceding chapters have described the ever-increasing problem of North American forests being altered by non-native pests. This problem is clearly national in scope, as the effects wash over the entire landscape – public and private lands alike. Furthermore, the cause of rising invasions is also national – our reliance on free trade. Finally, the level of effort our governments and economic entities put into pest prevention and control reflects decisions by society at large.

Ultimately, then, the future of American forests is in the hands of our nation's people. In choosing our elected representatives, holding other government officials accountable, and making our private choices, we decide the priority of whether addressing the causes and solutions to these pest issues is a priority – and, thus, whether we will keep of our natural heritage. There is already a strong foundation for action. This chapter details what needs to be done, and how to do it, in order to build on what has gone before.

Bold action by Congress and federal agencies to address non-native pest problems is not unprecedented. Federal officials took decisive action in the first part of the 20th century, by passing the Plant Quarantine Act of 1912 (See "Then and Now" section). This statute was designed to limit the entry, and interstate movement, of known carriers of insect pests and diseases. Today we need commitment from both federal administrators and politicians, like that shown by pioneers Charles Marlatt – the USDA official who worked to pass the Plant Quarantine Act, and was then in charge of implementing it – and Representative John Lacey (R-IA) – who successfully passed a similar federal law to limit risky animal imports.

Enactment of the 1912 Quarantine Act reminds us that:

- Substantial policy change takes persistent effort, often over decades;
- Crises build a sense of urgency, multiplying opportunities for change;
- Emergencies make quick action possible – especially if scientific evidence has been marshaled; drafts of stronger law and regulations are ready; and officials are willing to step forward;
- Measures that address pathways have a more profound impact, even when the specific pest threats stimulated action;
- Businesses and trade associations make better allies than opponents; and
- Stakeholders are critical, particularly for influencing politicians.

As illustrated by enactment of the 1912 Plant Quarantine Act, the American political system responds to persistent advocacy, especially when it is voiced by a broad-based coalition. Furthermore, a larger number of people are engaged than a century ago, when the Plant Quarantine Act was adopted. Those wanting to protect our forests can make progress by building broad, inclusive, and active coalitions that engage decision-makers to advance effective policies. In this chapter, we outline a series of options that could be adopted in order to improve protection of our forests and trees.

OPTIONS FOR PREVENTING ADDITIONAL INTRODUCTIONS

CONGRESSIONAL ACTION

Strengthen APHIS' hand by making protection from pests more important than trade facilitation

Under current law, USDA's Animal and Plant Health Inspection Service (APHIS) is charged with both facilitating trade and preventing damage by foreign pests. The mandate comes from Section (3) of the Plant Protection Act of 2000:

> "[I]t is the responsibility of the Secretary [of Agriculture] to facilitate exports, imports and interstate commerce in . . . commodities that pose a risk of harboring plant pests or noxious weeds in ways that will reduce, to the extent practicable, as determined by the Secretary, the risk of dissemination of plant pests and noxious weeds .… "

Many stakeholders have noted that this pulls APHIS in opposite directions, and, too often, it gives short shrift to protecting forests.

To strengthen APHIS' hand in preventing new introductions, stakeholders could work together to encourage the Congress to amend the Plant Protection Act to mandate USDA to give a higher priority to preventing the introduction and spread of exotic pests. Specifically, the clause about "reducing" pests "to the extent practicable" needs to be strengthened by making the following changes:

> …. In ways that will ~~reduce~~ prevent, to the greatest extent ~~practicable~~ feasible, as determined by the Secretary, …

Analyze Legislative Changes to Strengthen Enforcement Powers of APHIS & Bureau of Customs and Border Protection

Congress, USDA, Department of Homeland Security, and Department of Justice explore amendments to plant protection and customs legislation that would grant APHIS and CBP stronger enforcement powers vis a vis for imports into the United States.

Create New Programs to Engage Businesses in Pest Prevention

Adopt User Fees to Support Pest-Prevention and Management Programs

Congress could enact a user fee that would be charged to companies that import or ship interstate articles that could transport plant pests. This user fee would serve two purposes: provide additional funding for plant pest prevention and management programs; and address an issue of equity: currently, businesses which inadvertently introduce pests bear none of the public costs of managing those pests. The fee need not be burdensome; a $1 tax on each of the 25 million containers that enter the country each year could raise $25 million – more than 40 percent of APHIS' current budget for addressing tree-killing pests. The fee could be reduced for businesses which adopt more rigorous pest-prevention measures.

Businesses accept greater responsibility to prevent pest introductions in exchange for indemnification for losses

The Congress could authorize programs under which businesses which import or trade interstate articles that can transport plant pests implement best management practices aimed at minimizing the presence of those pests. Businesses' compliance with program requirements would be certified by a third-party entity, as now is done for "Green Certification" programs. In turn for meeting these programs' requirements, businesses participating in such programs would be eligible for indemnification for pest-related losses, such as having their products impounded or destroyed.

A study which examined options for creating such indemnification programs for nurseries is described in Appendix IV. The author noted that any indemnification program, to be workable, must

- Result in money paid to those who suffered actual losses
- Be sufficiently broad in scope, perhaps going beyond purchase or production costs of the destroyed plants to include reductions in market price for the company's product
- Treat similar growers similarly
- Create incentives for growers to address public policy concerns. For example, the program should incentivize reporting or fighting pests.
- How would the level of risk posed by the pest affect the decision to compensate a grower?
- Finally, does compensation affect market prices, and create non-market incentives?

Various groups have advocated expanding federal compensation laws. For example, the Midwestern Governor's Association recommended that the 2012 Farm Bill include a provision to develop a "mitigation compensation fund," or an incentives program, for producers affected by invasive species – either by the species, itself, or by related regulation. The governors thought that compensation would encourage producers to participate in pest surveys and to self-report pest interceptions, without incurring the substantial impact of quarantines.[1] Regrettably, this suggestion was not included in the 2014 Farm Bill.

States could set up their own compensation programs, but most have not done so. Of 14 states that have responded to recent invasions of terrestrial plant pests or pathogens, only two have laws allowing compensation.[2] Even in those states, owners are not paid for the destruction of trees already infested with a particular pest. They can, however, be compensated for uninfested trees that they must destroy.

ACTION BY ADMINSTRATIVE AGENCIES

Apply Current Authority More Aggressively to Prevent Pest Movement in Pathways

Stakeholders could press USDA leadership to allow APHIS to apply its existing authority to the fullest extent possible – especially for preventing the movement of pests into and within the United States. For example, even in the absence of a new legislative mandate, APHIS can amend its regulations to apply scientifically-based measures to curb movement of pests regardless of whether such restrictions force some companies to stop shipping certain goods.

Amend Regulations to Prevent Pest Movement in Pathways

Any strategy to fix the problems of foreign forest pests must emphasize prevention. Each new pest's introduction dilutes already limited resources, and limits the efficacy of existing programs.

Box 1

Characteristics of a Comprehensive Prevention Program

Closing the pathways by which pests are transported will stop their spread among nations. The goal is two-fold: to minimize the likelihood that potentially damaging insects or pathogens are present in a given pathway, and to stop their entry at U.S. borders. This will always be challenging because trade links are proliferating and new technologies are leading to ever-faster transport of ever larger volumes of goods. New approaches need constantly to be devised through the cooperation of governments, trading entities, and stakeholders – and their adoption brought about by the international phytosanitary system.

The following elements are important:

- Measures that prevent the infestation of articles in trade, or that kill the organisms already there;
- Methods to verify that mitigation practices are applied correctly, and that they are as effective in large-scale practice as predicted by tests or sampling;
- Reasonable enforcement to ensure that prevention methods are applied – and the political will to stand behind it;
- Sufficient openness from government agencies to allow thorough review of their practices by external parties;
- Minimizing as much as possible the impact on commerce while ensuring that measures are effective in achieving the needed higher levels of protection; and
- Actions to stop new pests and pathways for which existing technologies are not effective, *e.g.*, banning shipment of high-risk articles until mitigation methods are ready.

Not all pest-reduction strategies need to be implemented by governments. Companies that use, move, or sell items posing a pest risk can contribute greatly by modifying their procurement and transport practices and enhancing pest surveillance. Since there are costs associated with prevention, contrasts of prevention costs and costs incurred from no or incomplete prevention, e.g., eradication, control, restoration cost, should to be publicized.

Closing the Living Plants Pathway

Living plants have historically been the most important pathway for introducing non-native forest pests, and they remain important today (Chapters 4 and 5). National and international phytosanitary agencies rely mostly on visual inspections to prevent pest movement. Inspections are done by the exporting country, when a phytosanitary certificate is issued, and by the importing country, when it receives plants, bulbs, or seeds.

There is widespread agreement in the international scientific community that the visual inspection approach has failed. Inspectors make heroic efforts … but as we pointed out in Chapter 4, they face insurmountable challenges. There is also frustration that efforts to replace it get low priority.

Proposals for enhancing pest prevention strategies have fallen into three alternatives:

1. Prohibit trade in the most risky plants

A 2011 meeting of plant pathologists and entomologists wrote The Montesclaros Declaration. The Declaration calls for phasing out all trade in live plants, and plant products, determined to be of high risk to forested ecosystems – but of low overall economic benefit. As of April 2013, it had been endorsed by 142 forest pest specialists, from 28 countries.[3]

2. Allow trade to continue under the terms of international standards

Government phytosanitary agencies, working through the International Plant Protection Convention (IPPC), have adopted a standard relying on so-called "integrated" or "systems" approaches being put in place by nurseries. (See Chapter 4 and Appendix I).

Many nurseries probably would not be able to put such systems in place. The costs of changing management practices, installing new facilities, training staff, keeping records, and fulfilling other obligations would be prohibitive. Financial support by U.S.-based importers or loans from international development agencies might help some nurseries in developing countries to put the needed upgrades in place.

Regulations requiring foreign suppliers to implement integrated systems would have domestic repercussions. World trade agreements do not allow a country to impose more rigorous restrictions on foreign suppliers, than on domestic ones. Therefore, U.S. nurseries would have to adopt this approach, also, even those without plans to export plants. This would be a financial burden, which industry is likely to pass on to its customers.

3. Use existing national infrastructure, thus retaining the responsibility for preventing pests in the U.S.

Instead of expecting foreign nurseries and governments to prevent pests from reaching our shores, we could expand the USDA's existing National Plant Germplasm System to receive and monitor most imports of the riskiest plant forms, such as whole plants and large cuttings. Once such imports were determined to be pest-free, they would be released to commercial nurseries for propagation and sale.

Ultimately, this approach would put more of the burden on taxpayers, yet those costs would be a net savings considering the overall monetary impact caused by exotic forests pests.

To meet current industry's needs, the Plant Import stations would have to be expanded. Regardless, it is likely that imports would be limited by the capacity of the facilities. Some group, *e.g.*, expert panels from industry, academia, and government, could be convened to decide which species and amounts of imports to allow each year.

Closing the Wood Pathways

In recent decades, several of the most damaging pests have entered the country with wood packaging (Chapter 4). Decorative items, although imported at a lower volume, have also proven to pose a risk. Imports of logs and lumber have not been linked to major invasions of the United States, probably because such imports are overwhelmingly from Canada.

Wood Packaging

Application of the international standard for wood packaging has probably reduced but not halted introductions via this pathway (Chapter 4). Several steps can be taken to tighten control.

1. Strengthen enforcement against violations and fraud. APHIS, the U.S. Department of Justice, and the Department of Homeland Security's Customs and Border Protection unit could give higher priority to enforcing current rules, and also prosecuting cases of apparent fraud.

2. Verify whether current treatments are effective against all pests, and adjust standard accordingly. APHIS scientists have studies under way. [text deleted]

3. Help companies convert from solid wood. To cut the pest risks associated with this pathway, USDA could work with its counterparts and foreign assistance agencies, including the World Bank, to create a funding program to help small producers of solid wood packaging to convert to other materials which would not transport pests.

Decorative Items

APHIS could adopt new U.S. rules that apply to imports from all countries. Efforts should include monitoring and outreach.

APHIS' current rules apply only to items originating in China. But other countries export similar items to the United States. APHIS could adopt rules that apply worldwide – as called for by the North American Plant Protection Organization in its regional standard, RSPM #38. Also, APHIS could monitor imports, both to evaluate the efficacy of wood treatments, and to deter violations. Greater outreach to importers and retailers needs to be part of these efforts. Businesses can be part of pest detection and mitigation programs, and should be reimbursed for losses incurred from self-reporting pests – as we have suggested earlier.

STOPPING PEST SPREAD: OPTIONS TO LIMIT INTERSTATE MOVEMENT

Interstate movement of a variety of articles is responsible for much of the spread of forest pests. Although APHIS has the lead responsibility to regulate interstate trade, and states can take action in some circumstances, this system is clearly not working (see Chapters 3 and 5). Forest pest problems are too severe, and spread too easily, to wait for application of technically perfect means or for complete agreement on regulatory action. We need greater effort now, from both USDA and state agencies, and a more united front from both.

Curtailing pest spread would benefit from development of comprehensive federal-state-cooperator strategies to address each pathway. The strategy would identify roles and responsibilities for the federal and state governments and private entities. At present, such a strategy exists only for firewood. Unfortunately, implementation of this strategy is years behind schedule (see Chapter 5). APHIS, the states, and the nursery industry have advanced components of a strategy, *e.g.*, programs addressing cleanliness of planting stock for some high-profile crops; but a comprehensive program has not yet been put in place. We are aware of no efforts yet to develop comprehensive programs for wood packaging or other forms of raw wood.

Federal Action to Address these Gaps

Support state rules on firewood. USDA's Agriculture Marketing Service could support state regulations governing movement of firewood by establishing and overseeing an industry certification program for wood treatment. APHIS could backstop the program with rules on labeling.

Minimize pest presence in nurseries – and indemnify nurseries when pests occur despite program implementation. APHIS could require nurseries to apply integrated pest management programs in cases when the plants in trade are hosts of damaging pests.

Nurseries that ship plants interstate could minimize the likelihood that pests are present by adopting integrated pest management programs as outlined in a growing body of literature and under negotiation in several fora, *e.g.*, the Systems Approach to Nursery Certification (SANC) program (see Chapter 5).[4] One component of such programs could be an indemnification program that would reimburse participating nurseries for at least some of the costs associated with pest eradication and containment, as long as the pest outbreak was not the nursery's fault (see above and Appendix IV). Highest-risk hosts, such as those of the sudden oak death pathogen (*Phytophthora ramorum*) and hemlock woolly adelgid, should be addressed first.

Gaps also undermine protection from pests that are moved in wood. Neither federal nor state programs address the goldspotted oak borer and polyphagous shothole borer in Arizona and southern California. States are working to prevent spread of thousand cankers disease of walnut but gaps remain that could be addressed by federal agencies.

State Actions to Close Gaps

APHIS has refused to regulate interstate movement of several pests (see Chapters 3 and 5). Because it is under increasing pressure to reduce spending, APHIS also is terminating programs for an increasing number of foreign pests. This process has been documented in periodic Federal Register notices in which APHIS declares its decision to end particular pest programs. Since September 2010, APHIS has announced that it will no longer regulate more than 70 pests (see Appendix III). The states now have responsibility for stopping or slowing the spread of these pests – along with those for which it never had federal aid.

Coordinate state efforts. To fill the gaps left by APHIS, states could develop a process for coordinating policies, both internally and interstate, to ensure an effective approach.

Press for meaningful APHIS support. APHIS has promised support to states and should be accountable to stakeholders.

Educating Those Who Move Wood: Woodworkers as an Example

Wood moved by woodworkers is subject to domestic quarantines imposed by APHIS or the states (Chapter 5). However, enforcement is probably minimal, because the industry is not otherwise intensely regulated. That is, woodworkers and their suppliers are not subject to requirements for certification, regular inspections, and the many other rules applied to private nurseries, for example.

There is a growing effort by federal and state agencies and concerned stakeholders to promote voluntary actions to reduce pest risks associated with woodworking. In 2012, the American Association of Woodturners and the International Society of Wood Collectors joined others in developing a flyer[5] for their members, asking that they:

1. Learn which species of wood currently are associated with established exotic forest pests;
2. Obtain their wood from local sources whenever possible; and
3. Learn about, and comply with, state and federal quarantines.

MANAGING PESTS *IN SITU* WITHIN THE UNITED STATES

Pest control can be likened to today's treatments for our own chronic diseases. With treatment, a disease may not be "cured," but its progress can be slowed, and our health improved. "Curing" a forest of long-established, and widespread, pests is not often undertaken – eradicating the pest completely is too difficult and expensive. But there are a number of successful approaches to improve the health of forests, often using pest control methods proven in crop species (see Chapter 6). Pest control must be in place before restoration of any forest species can proceed.

Funding Pest Management

All strategies for managing pests have been limited by inadequate resources. Annual appropriations by Congress have fallen short of meeting needs in this area, as in many others. As a result, the government agencies responsible for containing or eradicating foreign pests – APHIS, U.S. Forest Service, Agricultural Research Service, and their state counterparts – lack the funds for robust programs. As more pests reach the United States and then spread, the impact of funding gaps will worsen.

State and federal governments generally take one of two approaches: either provide some initial funding, that tends to decrease with time; or ignore the problem, and provide no resources. Providing nothing ensures that pests' host species will be greatly diminished or, eventually, decimated. Providing funds that diminish over time fails to recognize the difference between long-term control and short-term eradication.

Under the circumstances, it is sensible to consider possible sources of funds other than increased appropriations. Such possible sources include:

Redirect funding within agencies. This would incur no new fiscal costs, but it would disrupt or end existing programs.

Provide aid to businesses. Federal agencies could provide training and other assistance for businesses entering into pest hazard minimization and indemnification programs, as described earlier.

Collect user fees from importers and interstate shippers. As discussed earlier, user fees charged businesses that transport articles that could carry plant pests could supplement agencies' funding.

Developing Detection and Control Tools

Newly detected pests often require development and application of novel detection and control measures. The states, APHIS, the U.S. Forest Service, and the Agricultural Research Service all are involved in these efforts.

Expand research; tap stakeholders to apply it. State and federal researchers could expand their research on detecting and controlling new pests. They could engage stakeholders to develop and apply effective measures.

Coordinate Programs Targeting Established Pests

Any barriers to control generally are not insurmountable, but a matter of resources. Resources alone, however, will not provide satisfactory control of widespread pests. State and federal agencies are trying coordinate efforts, usually on a pest by pest basis. Success could be greater if a wider group participated.

Name a central coordinating body. The U.S. Forest Service's Forest Health Protection program often functions in this capacity, working directly with state agriculture and natural resources agencies.

The U. S. Forest Service can coordinate the development of flexible, country-wide pest management plans. Stakeholders could ask Congress to provides the resources to carry them out. Plans must be adaptable to account for new pests and changing distributions of resident pests. Both plans and funding would need input and review from an independent advisory board.

Additional Tools to Minimize Pest Impacts: Restoring Species and Forests

There are many steps to ensure reintroduction of a forest tree species that is locally adapted to its native environment and woeful deficiencies in resources at each step. The steps include conservation of genetic resources, developing sources for planting stock used in restoration, development of nursery stock that will be competitive in a natural environment, and pre- and post-planting protocols to restore a host species. Below are recommendations for strengthening the present infrastructure responsible for these steps.

Conservation of Genetic Resources

The United States has a sound infrastructure for preserving genetic resources, in the National Plant Germplasm System (NPGS), including forest trees. The lack of funding for preserving forest tree germplasm, however, is a severe bottleneck to facilitating full use of this infrastructure. Additional resources would allow hiring of NPGS staff to coordinate the development of state-by-state germplasm conservation strategies, through a combination of *in situ* and *ex situ* activities. These programs could work closely with state natural heritage programs, state and federal agencies, non-governmental organizations, and others.

A primary component of this program would be to provide guidance and support for seed collections for storage in the National Center for Genetic Resource Preservation in Ft. Collins, Colorado. The initial focus would be on species impacted by and those facing exotic insect and pathogen problems.

Additionally, the immediate and future needs for seed/propagule production, with respect to restoration, would be an important element in each state's germplasm conservation strategy.

While expansion of the NPGS would coordinate germplasm conservation, NPGS personnel would not be involved in actual on-the-ground collections. Non-governmental partners would be needed, as seed collections will never occupy a high priority within natural resources agencies, "Citizen science" groups are becoming more prevalent, especially to assist increasingly diminished and overloaded professionals in natural resources. There are many "Friends" groups for state and federal parks and forests, whose members donate their time to help maintain or improve the land base in a variety of ways. In addition, each state has a myriad of local land conservation organizations, private citizen groups, and other NGOs that can be mobilized to help collect seeds. With professional guidance from the NPGS, and some minor resources, these groups can make a significant contribution to protecting genetic resources and for preparing to restore host species.

Jefferson elm, National Mall; USDA Agricultural Research Service

Reviving and Redefining Tree Improvement Programs

The presence of vibrant tree improvement programs across the country is of paramount importance to restoration of forest species. Unless current trends are reversed, restoration will not succeed or, at best, will become piecemeal across a host tree's range. Also, using host-plant resistance as a strategy for controlling pests generally will not be feasible.

Policymakers could revive federal and state tree improvement programs. Developing durable host resistance to exotic pests could become a larger component of existing programs and, perhaps, the primary direction of revived programs.

Federal tree improvement activities

We suggest that all federal response to exotic forest pests in the genetic resources conservation and breeding realm should be concentrated in the USDA Forest Service's Regional Genetic Resources Programs, which have the needed infrastructure and resident expertise. These Regional Programs would provide support for agencies like the National Park Service and the U.S. Army Corps of Engineers, which do not have this type of infrastructure, and strengthen the BLM's response to exotic forest pests.

To ensure nation-wide coverage, programs in Regions 2, 3, and 4 (the Rocky Mountain and Great Basin Regions) should be reinstated and a new program developed for Region 10 (Alaska). Funding to expand the Regional Programs would have to be from new appropriations, or from internal reallocations by the USDA Forest Service.

We further suggest that a national committee or board should be formed, akin to the National Plant Board, to coordinate exotic pest-related activities among the larger group of federal, state, and private (if appropriate) tree improvement programs. Federal allocations of funds should be administered by this committee to ensure that coordination takes place.

State tree improvement activities**.**

University-based tree improvement programs also could be revived. The development and initial application of relatively new tools in breeding programs, such as molecular biology, is generally best explored by universities and the USDA Forest Service, except for the comparatively few commercial species grown by private industry.

The funding to land grant universities provided by the McIntire-Stennis Cooperative Forestry Research Act of 1962 could be increased through either increased appropriations or reprogramming of existing funds within the National Institute of Food and Agriculture (NIFA). The Act also could be amended to set aside a specific portion of funding for traditional tree improvement research, along with related forest pathology and forest entomology research for addressing exotic forest pest issues.

State agency tree improvement programs should be enhanced or revived to put research results to practical use. State and university programs should be coordinated to smoothly move materials and technology developed by university research into the corresponding state program for further development. For example, advanced generation breeding and seed production is better situated within a state agency than at a university. A mechanism for increasing support for states' tree improvement programs exists through USDA Forest Service's State and Private Forestry organization.

FROM OPTION TO ACTION

So far, this chapter has suggested what we might do. How we do things is also important. Success depends on:

- Engaging the full range of policy makers and stakeholders;
- Augmenting the stringency of methods used to address all stages of invasion, but especially the later ones – establishment, spread, restoration;
- Applying current data and existing methods, even while seeking better information and more effective means; and
- Acting immediately and aggressively.

Engaging shareholders is the focus here, especially ways to involve the private sector and business communities.

Engaging the Full Range of Stakeholders

We need the full range of groups affected by foreign pests to ramp up their outreach. These groups include private trade associations; federal, state, and local agencies; professional and non-profit organizations; and educators at all levels. These expanded efforts could:

> *Aim for comprehensive press coverage.* Stakeholders could work toward more in-depth, comprehensive coverage of forest pest issues – especially coverage that discusses the weak policies that create problems, and describes their solutions.
>
> *Enlist more stakeholders.* Homeowner and builders' groups; local governments; land trust organizations; citizens committed to "sustainable" or "green" livestyles or to "buying local" would be useful partners.
>
> *Expand K-12 education.* Public education, particularly in grades K-12, is a key to preventing future pest problems.
>
> *Engage people who move wood or live plants.* Both individuals and their associations could be included in developing and implementing pest-containment strategies.

The recent devastation of eastern hemlock trees by the hemlock wooly adelgid, plus the variety of tree and shrub species hurt by sudden oak death in western forests, have been highly publicized. A recent LexisNexis search of U.S. newspaper and wire articles since 1980 found 856 articles on forest pests and pathogens. Of those published in 2010-2012, 70 percent focused on detection, management, and treatment at local and state levels while only 14 percent covered prevention and policy solutions at regional to national levels.[6] This mode of reporting is important. However, it educates the public to think in terms of single host and pest problems, often separate from their policy context and overall impacts. In the process, a myriad of pest problems remain invisible, along with their cumulative impacts, and the larger landscape changes under way.

Economic data show that the cost of non-native forest pests hits a variety of groups hard – far beyond the traditional wood products industry. Those groups now involved with forest pest issues can reach out to new groups – and enlist their help. Additional allies bring additional constituents, which, in turn, would sharpen political will, and make politicians and regulators more likely to act.

We can ensure that invasive species issues have a strong presence in educational standards for school students. This needs to be addressed as an overarching forest health problem, of which non-native forest pests are just one component. Even in Tennessee, where forest cover is approximately one-half of the state's acreage, there are no state educational standards for biological pollution, including exotic pest issues. Graduating high school seniors, who are soon to be voters, are generally uninformed and unable to distinguish the difference in kind between mortality caused by native bark beetles and mortality caused by an introduced pest. With inclusion of invasive species issues in school standards, these new voters could give the issue higher priority.

A wide variety of people move firewood, logs, and lumber; wood for cabinetry or turning; and special wood for hobbyists. Also, people transport shrubs and trees: to plant in yards and gardens; to use in wildlife restoration projects; and to build woodlots and windbreaks. The more these people are included in pest management strategies, the more likely they will help prevent problems.

Tapping the Private Sector

A wide range of businesses produce, transport, or sell articles that can transport forest insects and pathogens. Another group of businesses provide services that bring them into contact with such pests, like pest control companies. All these businesses can reduce pest risks by:

1) raising their own and colleagues' awareness; and
2) adopting business practices that: a) minimize the presence of pests in their products or premises, and b) increase the likelihood that any pests present will be detected and reported to appropriate officials.

The following actions would be constructive, although they fall short of a fully integrated program:

Avoid high-risk imports. Voluntarily avoid imports of packaging, décor, and handicraft items made from untreated solid wood, or other plant materials. Voluntarily decline to import plants known to host high-risk pests, especially those produced in growing media and placed in containers. Instead, obtain these plants from company-owned facilities or under contract with U.S.-based operators that are certified to be pest-free.

Build a "pest-aware" corporate culture. Encourage awareness of nonnative pests. Provide training for staff, so they are alert to pest activity at receiving centers, warehouses, retail stores, growing facilities, etc. Ensure that employees report pests to company officials, who report them to appropriate state authorities and APHIS. Tap university extension services, community colleges, or other educational institutions to provide expert training.

Minimize the presence of pests in plants and décor items. Keep detailed records of when, where, and how commodities and articles were produced, treated, and stored. Conduct and document periodic inspections, and actions to eradicate any pests found. Employ other sanitary measures to minimize the presence of pests.

Manage wood packaging to prevent escape of pests. Manage the wood while it is being used, or when it is in storage. Eliminate any "pallet graveyards" near warehouses and distribution centers.

Of course, tree-care and pest-management companies also have important roles in detecting and reporting pest outbreaks.

Photograph courtesy of Anand Persad, Davey Tree Institute

Roles for "Citizen Scientists" and Volunteers

Many Americans hold environmental issues dear to their hearts. These people give their time and money to support their interests. With proper encouragement and training, many more of these people could work on important aspects of exotic pest problems. For example, they can: monitor for new pests or those that are spreading; collect seeds for tree-breeding and conservation programs; work to restore forests; and participate in other ways. People who are adequately trained can do technical work, such as breeding trees for pest resistance.

One of the best examples of a successful citizen group is the American Chestnut Foundation (TACF). Its mission is to "restore the American chestnut tree to our eastern woodlands to benefit our environment, our wildlife, and our society."[7] This non-profit organization was started in 1983 by a group of scientists who believed that a specific breeding method, called backcross breeding, could incorporate resistant genes from the Chinese chestnut into American chestnut trees.[8] [9]

The movement attracted interested individuals, who helped locate old chestnut plantings and natural chestnut sprouts and assembled materials for breeding. A donation of land, in 1989, established the Foundation's primary breeding farm in southern Virginia. Membership, formation of state chapters, and donations grew, as did progress of the breeding scheme. Volunteers provided a large amount of effort, in a wide range of activities. Almost thirty years later, the chestnuts created by the breeding program are being evaluated in the field.[10] [11]

Now, there are dozens of science projects in which the public can participate, across all branches of science. For invasive species, ordinary people usually play a role in detection and reporting to authorities. Invaders in Texas[12] was a pioneer; it runs a sophisticated program, with methods for reporting invasive plants, training volunteers, and verifying their reports.[13] A number of groups provide smartphone applications to report invasive pests.[14] [15] APHIS and the U.S. Forest Service are exploring creation of detection networks in several cities. Several non-governmental organizations, including The Nature Conservancy, are working with the federal and state agencies under the Healthy Trees, Healthy Cities program (http://healthytreeshealthycities.org). Since about 2010, volunteer programs have grown by leaps and bounds.

The public can do much less in the "rapid response" arena. Indeed, if pests detected by such programs are not met by official responses, participants are likely to grow discouraged and withdraw.

More than twenty years of experience with foreign pest issues shows that exotic forest pest strategies *have* to engage volunteers. The U.S. economy has changed substantially since the 1990s. We can no longer look to federal and state governments to provide all the solutions to problems. Nor will the growing gap in people needed to perform tasks like forest restoration be met by state and federal hiring.

To provide more resources, the following actions could be taken:

> Develop a national network. Connect natural resources professionals to volunteer groups and train them to work together for forest protection – from research to forest restoration. Urge federal and state natural resources agencies to lead training.
>
> Press environmental groups to shift priorities. While many environmental groups seek greater forest protection, few make invasive species issues a high priority. They can play a far greater role in solving problems of exotic forest pests.
>
> *Apply for crowd-sourced funding.* Individuals pledge their help to proposed projects *via* groups like Kickstarter, and some are using funds for scientific research.[16] Many projects seek a few hundred or thousand dollars. However, some technology projects have garnered up to $3 million.[17]

A FORK IN THE FOREST PATH

> *"We must develop new instruments of foresight and protection and nurture in order to recover the relationship between man and nature and to make sure that the national estate we pass on to our multiplying descendants is green and flourishing."*
>
> President John F. Kennedy, 1963[18]

American forests will become landscapes that never existed before if we continue down our current path and do not recognize the transformation that is occurring before our very eyes. As we noted in Chapter I, several factors play a role, including climate change; alterations in the characteristics of fires and when and where they occur; forest fragmentation; and ever-increasing numbers of exotic insects and diseases. Often, these threats interact. With respect to exotic forest pests, at some point the progressive increase in widespread insects and pathogens will create a situation that is too greatly altered to fix. We will lose forests as we know them today, along with many of the plants, animals, associated industries, and human values that depend on them. All of the time, money, and effort we and our predecessors have put into the forested landscape to protect it, improve it, study it, enjoy it, and extract products and values from it, will be gone or irrevocably altered. We ask: is this truly the path Americans want to take?

This report highlights changes since 2002; the improvements as well as the disappointments. Looking ahead, with the benefit of looking back over 20 years, we see an acceleration of pest imports and problems and decreasing resources and infrastructure to combat them. We see hosts with not just a single exotic pest problem, but with multiple problems – each needing a separate solution, each solution requiring significant investment, and for every resolution, the potential of the cycle starting again if entry of new pests is not prevented.

If a substantial number of the options presented here are implemented, American forests will have a fighting chance to recover and maintain their current natural character. Without action, more and more natural icons, like the American chestnut, will be pushed further toward the brink of extinction, and eventually passing into memory.

Over a century ago, President Theodore Roosevelt lamented the destruction of American forests. He warned that it was time to put the forest first, over economic gain, and America responded. Within twenty years, there were significantly more lands reserved as National Forests and National Monuments, and the National Park Service was created. The historic 1912 Plant Quarantine Act was passed. At the state level, divisions of forestry or natural resources were created or enlarged. Forestry and conservation lessons were integrated in curricula in elementary and high schools across the nation,[19] and children and young people were taught how natural resources could be used and sustained, over time.

The Spanish philosopher, George Santayana, famously wrote, "Those who cannot remember the past are condemned to repeat it."[20] A century ago, American forests were being ravaged by unchecked chestnut blight, white pine blister rust, and gypsy moth. Actions were attempted on a number of fronts to mitigate the challenges. Today, American forests are being ravaged anew by those pests and a plethora of new ones, reaffirming Santayana's view. Americans have not remembered what can happen to their forests, and, indeed, are repeating history, albeit with a different cast of insects and pathogens.

The above quote of President Kennedy was written when there was new recognition of industrial-based pollution. His words apply equally well to the problems plaguing our forests. The choice of paths, one leading to sustainability, and one leading to continued decimation of our natural heritage, resides with the American public through their democratically elected officials. Will this country respond and stop the on-going transformation of our forests? Will champions for this issue arise, from Congress, the Executive Branch, or the private sector; someone with the power needed to reshape American policy for the better? Or will the country continue to stand at the juncture and slowly watch forests change? Ultimately, the future of our forests will be an American choice.

"Two roads diverged in a wood, and I,
I took the one less traveled by,
And that has made all the difference."

Robert Frost, from "The Road Not Taken"

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Appendix I

International Standard for Phytosanitary Standards #36
Adopted July 2012
(summary)
Available at www.ippc.int/publications/integrated-measures-plants-planting

ISPM#36 is based on the premise that plants for planting pose higher pest risk than other commodities and that integrated measures may be used to manage pest risk for quarantine pests and ensure the plant meet the importer's phytosanitary requirements.

The standard recognizes two levels of integrated measures, which are to be applied depending on the pest risk identified through pest risk analysis or a similar process. The "general" integrated measures are recognized as widely applicable to all plants for planting. The second level includes additional elements designed to address higher pest-risk situations that have been identified through pest risk analysis or other similar processes.

The national plant protection organization (NPPO; phytosanitary agency) of the exporting country approves and oversees places of production using integrated measures, and issues phytosanitary certificates that attest that shipment meets the importing country's phytosanitary requirements.

In conducting a pest risk analysis to determine whether integrated measures to reduce pest risk to acceptable levels are justified, the importing country should consider factors listed in Annex 1. For example, what is the plant type (e.g., meristem tissue culture, bulb, or rooted plant); whether it is in a growing medium; source for irrigation water; and whether grown in a greenhouse or open field.

In addition to situations in which the importing country specifically requires use of integrated measures, the exporting country might offer an integrated measure program as a suitable and effective means of meeting the importing country's phytosanitary requirements. The exporting country then seeks formal approval of its program by the importing country as providing "equivalent" pest protection compared to the system already being used by the importing country.

Any producer wishing to participate in the integrated measures program obtains approval from the exporting country's national plant protection organization.

General integrated measures (suitable for widespread use)

An approved "general" integrated measures program should include:

- A plan or map of the place of production and records of when, where & how each species and type of plants for planting was produced, treated, stored, or prepared for movement;
- Records describing where and how the plants for planting were purchased, stored, produced, distributed;
- Access to plant protection specialist
- Designated contact person for the exporting country's national plant protection organization.

The place of production should:

- Examine the plants and place of production by appropriate staff at appropriate times and according to protocols developed by the exporting country's NPPO;
- Keep records of all examinations, including pests found and corrective actions taken;
- Taking specific actions where necessary and documenting these measures;
- Notifying the exporting NPPO if any quarantine pests regulated by the importing country are detected;
- Establishing and documenting a system of hygiene/sanitation

Appendix 1 provides guidance on specific pest management measures applicable to pest types; these measures are not a mandatory part of the standard. For example, to prevent infestation by pests that are likely to cause latent infestations without symptoms, growers might obtain their plants from "mother" plants verified to be free of the pest, keep the plants isolated from sources of new infection, and test the plants periodically.

Additional Measures for Higher Risk Situations (when general integrated measures are insufficient)

The place of production must provide considerable detail about its pest management program, including information on production practices, operational systems, and pest identification and management measures; plant handling procedures; internal audit and inspection systems; external audits; organizational structure; staff training; procedures for informing the exporting phytosanitary agency if a quarantine pest is detected; plant recall procedures; and other aspects of management.

The exporting country's phytosanitary agency approves the place of production after reviewing the elements of its program to ensure that they meet the requirements of the importing country. The standard also calls explicitly for the place of production's pest management program to include the following elements:

- Sanitation/hygiene procedures aimed at preventing introduction and minimizing spread of a pest within the place of production.
- Measures and procedures to prevent or treat pests. Handling of incoming plant material is aimed at ensuring that all plants that enter the place of production are free of pests regulated by the importing countries, possible pest vectors; and practically free of other pests.
- Handling of plants intended for shipment.
- Schedules and protocols governing examination of plant material and production sites to detect any pests – throughout production of the plants as well as prior to export.
- Procedures for responding to the detection of pests, including measures to ensure plants for planting not meeting the importer's phytosanitary requirements are not exported and are disposed in a manner that prevents pest buildup.
- Keeping records of all plant protection actions taken

Producers of plants under the more stringent programs must have on the premises a plant protection specialist to ensure proper implementation of sanitation, pest detection, and pest control measures. Such places of production must also train staff in pest detection and methods to reduce pest risk. This training, as well as pest detection examinations, internal audits, and other operations must be documented in records which must be available to the supervising phytosanitary agency.

Audit results and non-conformities with program requirements are presented to the producer for review; corrective actions should be completed promptly and effectively, as well as documented.

If an audit detects non-conformities, the producer or auditor must immediately notify the supervising (exporting) national plant protection organization and ensure that the affected plants for planting are not exported from the place of production until all critical non-conformities are rectified. The corrective action is undertaken immediately, and under the supervision of the exporting NPPO.

The standard distinguishes between two types of non-conformities: critical and non-critical. A "critical" non-conformity compromises the efficacy of the integrated measures or increases the pest risk. A "non-critical" nonconformity does not immediately compromise the program. The place of production loses its approval to export plants under the program if any of the following occurs:

- the exporting phytosanitary agency finds
  a) a critical non-compliance;
  b) repeated non-critical non-compliances;
  c) multiple non-critical non-compliances; or

- the importing country's phytosanitary agency notifies the exporting country's phytosanitary agency that it has intercepted a pest that is managed by the program.

The place of production may be reinstated to the program only after corrective actions are put in place and exporting country's NPPO audit confirms that the non-conformities have been corrected.

Appendix 2 lists examples of non-conformities.

The Standard also lists the responsibilities of the exporting and importing countries' national plant protection organizations. The former has the lead in ensuring the places of production comply with the programs. However, the importing country's phytosanitary agency may not only set the requirements and notify the exporter of any interceptions; it may also review and even audit the exporting country's system of approval; and may audit the place of production, including site visits – with the assistance of the exporting NPPO and when justified by non-compliances.

Appendix II
Toward Measuring Effectiveness: Pests' "Approach Rates"

We need to know the pest "approach rate" in order to carry out two vital determinations:
1) the importance of a specific pathway by which pests move relative to other pathways (This pathway might involve initial entry into, or dispersal within, the country.); and
2) the effectiveness of phytosanitary measures adopted to reduce pest use of that pathway.

By "approach rate," we mean the number of either organisms or species arriving at a "border". Depending on the analyst's purpose, that border might be either the U.S. border or some internal border – *e.g.*, that of a state or an ecoregion. First the analyst calculates the overall size of the pathway by quantifying the volume of articles of concern being moved across that border, *e.g.*, the number of crates, plants, trucks, containers, or firewood. Then s/he calculates the proportion of those articles which are likely to harbor a potential pest.

Depending on the analyst's purpose, s/he can choose from among a variety of parameters to define the articles, the geography, and the breadth of potential pests to be measured. These parameters must be specified and the reasons for selecting them explained.

Examples of possible combinations of parameters that could be selected for analysis of particular pathways include:

- the proportion of all plants entering the United States at a specific port that are infested by aphids (either all aphids or only those of quarantine significance);
- the proportion of rhododendron plants entering the country through all ports and from all countries of origin that are infested/infected by any kind of plant pest;
- the proportion of pallets entering the country from Asia that are infested by wood-boring beetles (either all beetles or only those of quarantine significance).

If the purpose of the analysis is to evaluate the efficacy of phytosanitary measures targetting a specific pathway, these analyses should be conducted using the same methodology both before and after the measures have been put in place.

Flaws in Data Limit Their Usefulness in Analyzing Measures' Efficacy

APHIS collects a massive amount of data on pest presence in various pathways. Most of these data are taken from "interception" records, which report pests detected by inspectors at the U.S. border. Unfortunately, much of this information cannot be used for analyzing pest approach rates or comparing various pathways' significance.[1]

First, APHIS targets certain types of baggage, shipments, or commodities for inspection. Data from these targetted inspections make up the agency's primary database (APHIS Pest Interception Database; acronym PestID). Because these types of incoming articles have been selected for their perceived high risk, they do not provide a statistically valid measure of the relative volumes of incoming shipments.

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[1] McCullough, E.G., T.T. Work, J.F. Cavey, A.M. Liebhold and D. Marshall. 2006. Interceptions of nonindigenous plant pests at U.S. ports of entry and border crossings over a 17-year period. Biological Invasions, Vol. 8, pp. 611–630; Haack, R.A. F. H´erard, J. Sun, and J.J. Turgeon. 2010. Managing invasive populations of Asian longhorned beetle and citrus longhorned beetle: a worldwide perspective. Annual Review of Entomology. Vol. 55, pp. 521–46 (2010).

Second, both the targetted commodities and inspection procedures change over time. Consequently, levels of effort and results cannot be compared from one period to another.

Third, only certain types of organisms are included in APHIS's database. Generally these are pests considered to be of quarantine significance, which are most often insects. The data do not include organisms that are dead upon arrival; organisms that colonize only dead plant material, such as lumber; native pest species; or nonindigenous species with so-called "cosmopolitan" distributions. The selective nature of species included undermines measurement of the overall importance of the pathway. Furthermore, since the species designated as "quarantine pests" (and, therefore included in the database) change over time, again, one cannot compare data from one period to another.

A second dataset, AQIM, provides a more powerful dataset that can be used to evaluate approach rates and programs' efficacy. The AQIM data are drawn from a statistically designed sampling program. However, the sampling program for some types of imports collects relatively few records, thereby opening analyses using these data to conflicting interpretations (see discussion of imported plants for planting in chapter 4).

Because of these problems, it is absolutely essential that, when APHIS adopts new programs to prevent introductions, the agency put in place a statistically valid sampling method. Without that, the effectiveness of the program cannot be measured.

Appendix III
Pests No Longer Regulated by APHIS per FRSMP
(those that attack forest trees are underlined)

Date	Names of Insects and Pathogens	
	Common Name	**Species Name**
December 31, 2013	Spiraling whitefly	*Aleurodicus disperses*
	White mango scale	*Aulacaspis tubercularis*
	Painted bug	*Bagrada hilaris*
	Carnation tortrix	*Cacoecimorpha pronubana*
	Brown garden snail	*Helix aspersa*
	Common emerald	*Hemithea aestivaria*
	Bayberry whitefly	*Parabemisia myricae*
	Black parlatoria scale	*Parlatoria ziziphi*
	Palearctic seed bug	*Rhyparochromus vulgaris*
	Yam nematode	*Scutellonema bradys*
September 5 2013	African seed bug	*Dieuches armatipes*
	nematode	*Hemicycliophora typica*
	Jumping snail	*Ovachlamys fulgens*
	Ehrhorn's palm mealybug	*Palmicultor palmarum*
	Asian Hydrilla moth	*Parapoynx diminutalis*
	Damson-hop aphid	*Phorodon humuli*
	Fig whitefly	*Singhiella simplex*
	Torpedo bug	Siph*anta acuta*
March 15, 2013	Alien scale	*Acutaspis aliena*
	Chinese wax scale	*Ceroplastes sinensis*
	Capparis sort scale	*Coccus capparidis*
	Sugarcane scale	*Duplachionaspis divergens*
	Winter moth	*Operophtera brumata*
	Winter Grain Mite	*Penthaleus major*
	a soft scale	*Philephedra lutea* (Cockerell)
	an armored scale	*Acutaspis scutiformis*
December 17, 2012	cabbage whitefly	*Aleyrodes proletella*

	banana weevil	*Cosmopolites sordidus*
	Malvastrum mealybug	*Ferrisia malvastra*
	cabbage cyst nematode	*Heterodera cruciferae*
	leaf spot of maize	*Phaeosphaeria maydis*
	Lantana mealybug	*Phenacoccus parvus*
	eucalyptus tortoise beetle	*Trachymela sloanei*
September 11, 2012	apple ermine moth	*Yponomeuta malinellus*
	albopicta scale	*Acutaspis albopicta*
June 16, 2012	banana thrips	*Chaetanaphothrips signipennis*
	sweet potato thrips	*Dendrothripoides innoxius*
	red-haired pine bark beetle	*Hylurgus ligniperda*
	Mexican bromeliad weevil	*Metamasius callizona*
	bigheaded ant	*Pheidole megacephala*
	ash whitefly	*Siphoninus phyllyreae*
	banana flower thrips	*Thrips florum*
	coconut whitefly	*Aleurotrachelus atratus*
April 12, 2012	palm whitefly	*Aleucerus palmae*
	mango bud mite	*Aceria mangiferae*
	green scale	*Coccus viridis*
	olive psyllid	*Euphyllura olivine*
	a rust	*Gymnosporangium confusum*
	teak moth	*Hyblaea puera*
	brown punctate weevil	*Otiorhynchus raucus*
December 5, 2011	Litchi scale	*Andaspis punicae*
	Seed ambrosia beetle	*Coccotrypes carpophagus*
	Common blossom thrips	*Frankliniella schultzei*
	aphids	*Greenidea psidii & G. ficicola*
	Coriander aphid	*Hyadaphis coriandri*
	moth	*Promalactis suzukiella*
	Mexican giant mealybug	*Puto mexicanus*, Mexican
	Apple grass aphid	*Rhopalosiphum insertum*
June 30, 2011	Schefflera whitefly	*Dialeurodes schefflera*,
	Banana rind thrips	*Elixothrips brevisetis*
	a thrips	*Neohydatothrips burungae*
	a moth	*Oecophora bractella*
	Dianella rust	*Uredo dianellae*

	seed bug red-banded whitefly	*Xanthochilus saturnius* *Tetraleurodes perseae*,
March 3, 2011	camellia bud mite 2 spp of eucalyptus psyllid Greenhouse mealybug juniper fiorinia scale small longhorn beetle longan scale	*Cosetacus camelliae* *Ctenarytaina eucalypti* &*C. spatulata* *Insignorthezia pseudinsignis* *Fiorinia pinicola* *Sybra alternans* *Thysanofiorinia nephelii*
February 4, 2011	jasmine whitefly kuno scale no common name Trilobite Scale	*Aleuroclava jasmini* *Eulecanium kunoense* (Kuwana) *Neolochmaea dilatipennis* (Jacoby) *Pseudaonidia trilobitiformis*
September 30, 2010	a psyllid bamboo rust firebug tuxedo bug	*Acizzia jamatonica* *Kweilingia divina* *Pyrrhocoris apterus* *Raglius alboacuminatus*

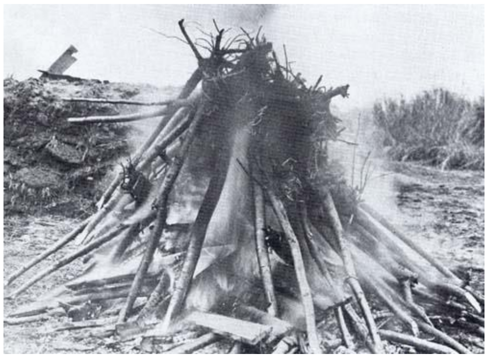
Appendix IV

THEN & NOW: A STRONGER FOUNDATION FOR ACTION

In 1909, a new fungal disease was found on eastern white pine seedlings imported from Europe. Called "blister rust," the pathogen had the potential to devastate some of the most valuable timberlands in the Northeast, Northwest, and Pacific Coast. Ironically, the contaminated imports were native trees. Because the American nursery industry could not keep up with demands for seedlings to restore deforested acreage, seedlings produced in Europe were being imported. The U.S. forestry industry pressed for federal legislation to protect it from diseased imports. The Plant Quarantine Act of 1912 was the result.

Previously, 39 states had already enacted laws to prevent pests being moved with nursery stock. As early as 1898, these states had pressed for a national plant quarantine law.[1] Until 1910, opposition to regulation from the horticulture industry stymied action. When 2,000 pest-infested cherry trees arrived in Washington, D.C. from Japan, President Taft himself authorized their destruction. Agriculture Secretary James Wilson and his staff used the confrontation to garner the President's support for new legislation. When the Plant Quarantine Act of 1912 was passed, the United States became the last major country to protect itself from importing infested plants.[2]

USDA officials inspect newly arrived cherry trees, January 19, 1910.



Diseased trees being burned, January 28, 1910 Source: U.S. National Arboretum, Washington, DC.

White pine blister rust became Quarantine Number 1.[3] Although the disease is still a problem, now threatening high-elevation pines and their ecosystems, a half century of resistance breeding by the USDA Forest Service has developed rust-resistant planting stock for the most important of the commercially-grown species, western white pine.[4]

With respect to the horticultural cherry trees, Japan sent another group to Washington. They passed quarantine inspection and were planted. Their descendants continue to inspire residents and tourists in Washington, D.C., each spring.

Today, a much broader base of stakeholders is interested in solving the problems created by non-native forest pests compared to a century ago.

1. Since the 1990s, a plentiful body of general, technical, and scientific literature has accumulated. It documents the extent and impact of invasions, and evaluates and suggests policy solutions.[5] [6]

2. Agencies charged with countering the pest challenge exist at the federal and state levels. These agencies have trained and dedicated staffs, regulatory and other powers, and infrastructure. Authorities and resources are not as strong as necessary, but they provide foundations to build on.

3. Hundreds of people are experts on pest-related topics, from top researchers within the government and at universities, to government officials at all levels, to volunteer staff at local groups;

   Common efforts to address invasive species have multiplied for more than a decade. At least 24 states have invasive species coordination councils.[7] The Continental Dialogue on Non-Native Forest Insects and Diseases, formed in 2006, brings together a range of stakeholders to reduce threats to North American forests.[8]

4. Now, a broader group of stakeholders is involved in a host of new ways. There are, for example, consortia to recover particular tree types, like the American chestnut and eastern hemlock; regional invasive plant councils; pest-specific research groups; city-based efforts to manage dead and dying trees; and individuals tracking pests on their smartphones;

   The American Chestnut Foundation www.acf.org
   Whitebark Pine Ecosystem Foundation www.whitebarkfound.org
   Alliance for Saving Threatened Forests www.threatenedforests.com
   Healthy Trees, Healthy Cities http://healthytreeshealthycities.org

5. Critics are increasingly vocal about the lack of action. For example, the Healthy Habitats Coalition [www.healthyhabitatscoalition.com] has called for drastically reshaping the way federal and state invasive species work is funded.

We seek to engage this broader constituency in pressing for effective actions to protect our forests from the pest threat described in this report.

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