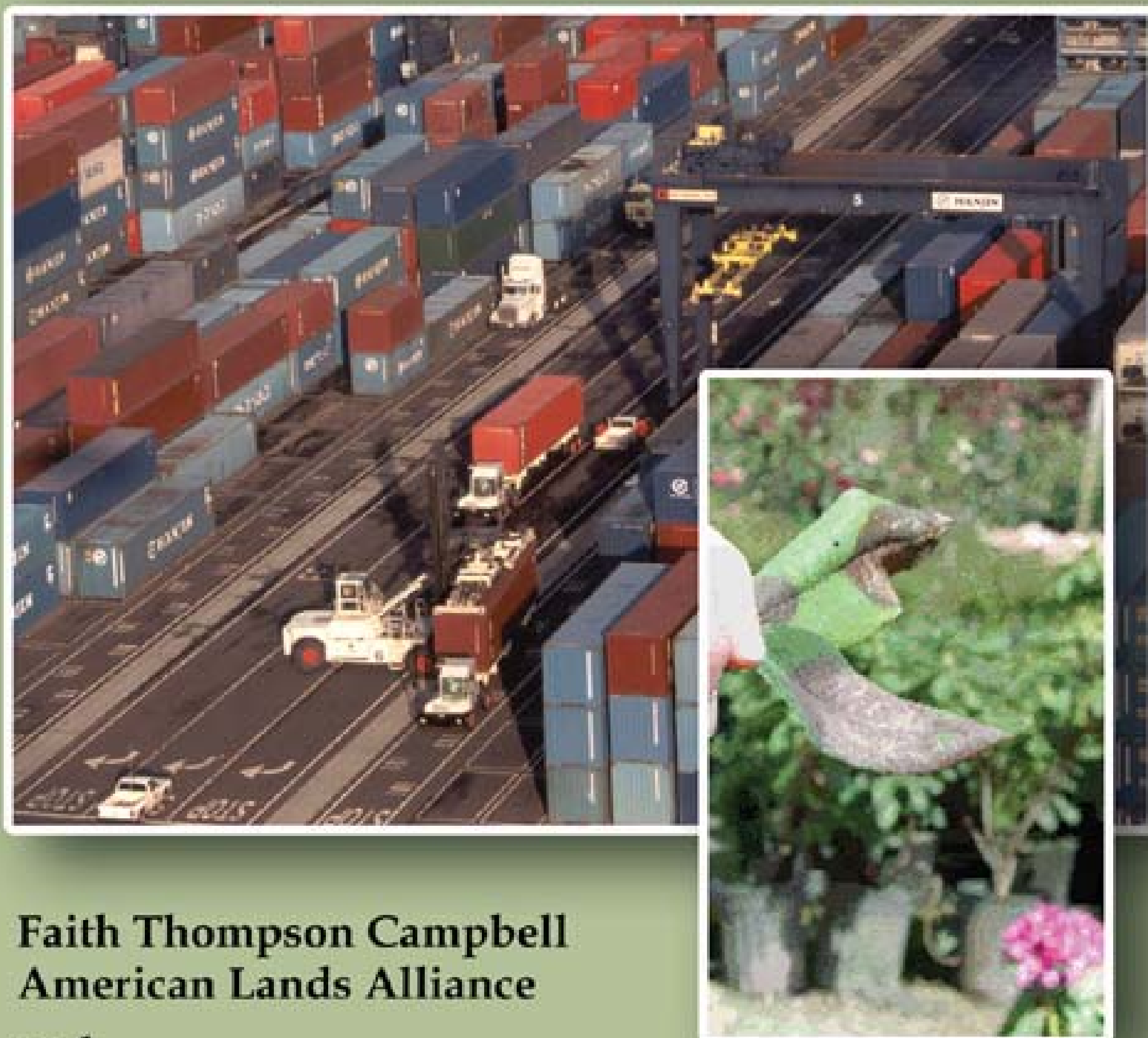
Fading Forests II

Trading Away North America's Natural Heritage



Faith Thompson Campbell
American Lands Alliance

and

Scott E. Schlarbaum
Department of Forestry, Wildlife & Fisheries
The University of Tennessee, Knoxville

Fading Forests II

Trading Away North America's Natural Heritage

Faith Thompson Campbell, Ph.D.
American Lands Alliance
726 7th Street, SE
Washington, D. C. 20003
http://www.americanlands.org/

and

Scott E. Schlarbaum, Ph.D.
Department of Forestry, Wildlife & Fisheries
The University of Tennessee
Knoxville, TN 37996-4563
http://fwf.ag.utk.edu/

Faith Thompson Campbell leads the Invasive Species Program for American Lands Alliance. She serves on the Invasive Species Advisory Committee created by Executive Order 13112. Dr. Campbell has been a nationally recognized leader on invasive species policy for a decade. In this capacity, she has served on advisory committees for USDA APHIS and the landmark study written by the Congressional Office of Technology Assessment. She earned a Ph.D. in politics from Princeton University.

Scott E. Schlarbaum is the James R. Cox Professor of Forest Genetics in the Department of Forestry, Wildlife and Fisheries at the Institute of Agriculture, The University of Tennessee, Knoxville. He is the current Leader of the University of Tennessee's Tree Improvement Program. The UT Tree Improvement Program was initiated in 1959 and is directed toward meeting the needs of the timber, paper, recreational and Christmas tree industries in Tennessee and to restore tree species that have been decimated by exotic forest pest species. Professor Schlarbaum was educated at Colorado State University [B.S. (College of Forestry) and Ph.D.(College of Agriculture)] and the University of Nebraska [M.S. (Institute of Agriculture)].

Acknowledgments:

The authors wish to acknowledge the assistance of the Healing Stones Foundation, which generously provided the majority of funds used for publishing this study. We also would like to acknowledge Renee A. Follum for graciously granting us permission to use her artwork on the inner title page and compact disc, and Gary R. Dagnan, The University of Tennessee, for assistance in developing the cover page.

Cover Page Photographs:

Shipping containers at the Port of Long Beach, California; courtesy of Robert Kanter, Director of Planning and Environmental Affairs, Port of Long Beach, California

Sudden Oak Death on rhododendron at a nursery in California: Bruce Moltzan, Missouri Department of Conservation

Published by the Healing Stones Foundation in cooperation with
the American Lands Alliance and The University of Tennessee, Knoxville.

2002

Table of Contents

Executive Summary……….…………………………………………………………………………1

Chapter 1: Introduction……………………………………………………………………...………6
- The Public and Biological Pollution………………………………………………....……8
- Environmental Concern About Exotic Forest Pests…………………………………....9
- Recent and Potential Problems……………………………………………………………..10
- The Costs of the Exotic Forest Pest Problem in North American Forest Ecosystems…..12

Chapter 2: Pathways to America……………………………………………………………...14
- Forest Susceptibility……………………………………………………………………...14
- International Trade and Exotic Pest Prevention………………………………………….14
- Primary Pathways of Introduction……………………………………………………….15
    - Nursery Related Materials……………………………………………………...16
    - Minimally Processed Wood…………………………………………………….17
    - Solid Wood Packing Materials………………………………………………….19

Chapter 3: Weaknesses in Laws, Policies, and Strategy in Prevention, Eradication, and Control of Exotic Pests………………………………………………….21
- Problems With International Trade Policy……………………………………………….21
- The Costs of Preparing Risk Assessments……………………………………………….26
- Treaty to Establish a Free Trade Area of the Americas…………………………………26
- Problems with APHIS……………………………………………………………………...28
- Inadequate Regulation of the Three Primary Pathways for Forest Pest Introductions….33
- The Plant Protection Act…………………………………………………………...…52
- National Invasive Species Council……………………………………………………….53

Chapter 4: Conclusion and Recommendations: What We Can Do to Protect America's Forests………………………………………………………………54
- Specific Steps……………………………………………………………………………….55
- Treaties, Policies, and Regulations - What Changes Can Be Made Today……………...56
- Agreement to Establish A Free Trade Area of the Americas………………………….....59
- National Policy and Regulation…………………………………………………………….59
- Focusing APHIS on Prevention…………………………………………………………….59
- Approaches to Prevention and Risk Assessment……………………………………...60
- National Invasive Species Council………………………………………………………....63
- Homeland Security and APHIS…………………………………………………………….64
- The Need for a National Center on Bioinvasion…………………………………………65
- Closing Statement…………………………………………………………………………..70

Gallery of Pests………………………………………………………………………………….71

Appendix 1: Common and Scientific Names of Plant and Animal Species……………………………84

Appendix 2: Summaries of Regulations, Laws, and International Agreements………………………89

Appendix 3: Proposed Amendments to the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures………………………………104

Literature Cited…………………………………………………………………………………..114

EXECUTIVE SUMMARY

The Challenge

North American forests have suffered enormous damage caused by insects and diseases introduced from abroad. Some tree species have been virtually eliminated as integral components of the forest, including the beloved American chestnut, while other species are currently suffering severe declines. The affect of an exotic species on forest ecosystems can be profound and extend beyond the host species. White pine blister rust has caused dramatic mortality in North American forests dominated by five-needle pines. This impact has extended to flora and fauna that depend upon host species for habitat and food. The grizzly bear depends upon the seeds of the whitebark pine for fattening up before its hibernation. Yet ninety percent of whitebark pines in the northern Rocky Mountains have been killed by the introduced pathogen white pine blister rust. In California, several species of oak in already stressed woodlands are dying from a recently introduced pathogen, Sudden Oak Death. These ecosystem impacts grow every year as more invasive species enter the country as a result of rising trade and trade agreements that have forfeited the public's right to protect our natural heritage.

Monetary costs are also significant. Public agencies have already spent tens of millions of dollars attempting to eradicate just one of several recently introduced pests, the Asian long-horned beetle. If this beetle escapes current containment efforts, it will cost an estimated $600 billion to replace city trees killed by it. Additional losses would take the form of reduced tourism built around viewing the colorful autumn leaves, maple syrup sales, and timber production.

This report focuses on describing the resulting heightened threat to just one vulnerable ecosystem, forests. The danger to many other ecosystems, however, is similar and will exist as long as strong protection measures are not adopted.

During the 1990s, managers of natural resources and agriculture have had to respond to numerous introduced pests, including three beetles that threaten a variety of hardwood trees across the continent (the Asian longhorned beetle, citrus longhorned beetle, and emerald ash borer) and a pathogen threatening oak trees in the West Coast as well as Middle West and East (Sudden Oak Death pathogen). Several other pests damaging to agricultural production have entered the country during the same period.

Experts have warned for at least a decade that the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) is falling behind in carrying out its responsibility to protect American natural and agricultural resources by preventing the introduction to the United States of damaging invasive species and responding rapidly and effectively when an introduction is detected. The principal reasons are that:

(1) international trade agreements impede adoption of effective safeguards;
(2) burgeoning import volumes overwhelm APHIS' resources;
(3) APHIS is torn between the conflicting goals of facilitating trade and preventing introductions; and
(4) the agency has not adopted the most efficient approaches to prevent introductions.

"Balancing" Trade and Protection

Over the past decade, the U.S. Government has led campaigns for international trade agreements that simultaneously promote trade and restrict APHIS' ability to prevent the introduction of pests hitchhiking on imported goods. Provisions in the World Trade Organization's (WTO) Agreement on the Application of Sanitary and Phytosanitary Standards (SPS Agreement), the 1997 amendments to the International Plant Protection Convention (IPPC), and the draft treaty to establish a Free Trade Area of the Americas (FTAA) have undercut sensible phytosanitary safeguards and will likely result in inordinate numbers of forest pests becoming established in the country.

The United States Department of Agriculture's (USDA) emphasis on trade promotion does not make sense from an economic point of view from the perspective of the general public. Introduced plant pests, weeds, and diseases of livestock cost the Nation $90 billion per year, 80 percent more than the $50 billion earned by agricultural exports each year. As illustrated by the Asian longhorned beetle case, these already substantial costs could rise significantly in the near future.

Exotic insects and diseases that threaten the tree species of North American forests enter the country primarily as hitchhikers on three kinds of imports: living plants, logs and lumber, and solid wood packaging. In attempting to balance the conflicting goals of promoting trade while preventing introductions of harmful exotic organisms, APHIS accepts what it terms a "negligible" risk of pest introduction. In practice, however, APHIS has embraced risk levels of three to five percent, as with logs and lumber imported from New Zealand and Chile, which is far too lax to be considered negligible. If this risk level is applied to imports of living plants, logs and lumber, and wood packaging, as many as 35 million pests could reach the country *each year*.

Low Priority Given to Forest Pests

While the relevant statutes assign responsibility for preventing introductions of forest pests to APHIS, the agency has given this task a low priority compared to excluding pests that threaten agricultural crops. For example, APHIS expends only approximately ten percent of funds dedicated to eradicating newly introduced forest pests. APHIS' stance reflects the priorities of the Congressional committees that oversee the agency; the House and Senate Agriculture committees and Agriculture Appropriations subcommittees.

The Need for Change

APHIS' regulations governing the primary pathways for forest pest introductions (living plants, logs and lumber, and wood packaging) are inadequate now and will become increasingly ineffective in the face of increasing trade. This will likely result in introduction of an excessive number of new pest species. For example:

- The U.S. imported nearly 700 million plants in 1999. Despite the many pests introduced on horticultural imports, APHIS is moving to relax the plant quarantine regulations for several types of plants. Meanwhile, the agency has not curtailed imports of rhododendrons from Europe to prevent the introduction to other parts of the country of the pathogen that causes Sudden Oak Death.

- The 1995 regulations governing imports of wood (including wood packaging) lack effective mitigation procedures to prevent introduction of deep-wood organisms found inside wood packaging, on or in hardwood and softwood logs and lumber from most suppliers, and in wood chips.

APHIS is moving slowly away from relying primarily on visual inspections toward greater reliance on a more effective systems or pathway approach. This approach utilizes a combination of independent treatments and rules governing preparation and handling of each imported commodity from origin through movement and processing after importation. However, APHIS undermines the effectiveness of the systems approach by adopting insufficiently stringent safeguards in order to avoid interfering with trade.

In accordance with trade agreements, the United States and its trading partners negotiate international standards that effectively limit the measures APHIS can employ. One such standard is the one adopted by the International Plant Protection Organization (IPPO) for wood packaging, one of the three pathways by which forest pests are introduced. This IPPO standard leaves acknowledged gaps through which pests can still reach the country. To close these gaps, APHIS should adopt more protective measures. Unfortunately, promulgating stronger regulations will be difficult because the IPPO standard requires APHIS to prove that the international standard is insufficiently protective. To meet this burden of proof, APHIS must either detect pests on incoming wood packaging that has been treated in conformity with the standard, or complete a risk assessment that demonstrates that specific quarantine pests associated with certain types of wood packaging from specific origins require additional regulation. Because of conflicting charges and resource limitations, APHIS cannot comply with these international agreements in all cases and in default, shipments that potentially harbor pest are allowed to enter the country. Moreover, the costs associated with this burden of proof are fostered on the general public, rather than the importer.

Improving the Efforts of the USDA Forest Service

The USDA Forest Service is responsible for addressing exotic forest pests once they become established in the country, but it has been hampered by severe funding and staffing shortfalls in its crucial research, genetic resources, and forest health protection programs.

Consequences

As a result of APHIS' priorities and underfunding of the Forest Service, no federal agency can act effectively to prevent new forest pests from entering this country or respond to the variety of established pests.

Solutions

The United States can minimize damage from both established exotic forest pests and those that might enter in the future by making fundamental changes in policies and programs at both the international and national levels. Equal priority should be accorded prevention of introductions compared to facilitating international trade. APHIS must adopt sufficiently protective safeguards to minimize the risk of pest introductions. Finally, the United States needs to devote substantially more resources to invasive species programs. Current federal expenditures on bioinvasion (also called biological pollution) now total about $1 billion, which is one percent of the estimated $100 billion in annual losses and costs associated with invasive species.

Trade Agreements: Changes That Can be Made Today

- U.S. trade negotiators should ensure that experts on invasive species that threaten natural areas are fully integrated into implementation of the WTO SPS Agreement and IPPC, especially in the development of IPPC standards.
- APHIS should more frequently use its right under the SPS Agreement (Article 5.7) to adopt provisional (temporary) phytosanitary safeguards.
- U.S. negotiators should ensure that the final text of the trade agreement to establish a Free Trade Area of the Americas (FTAA) at a minimum does not exacerbate the provisions in the WTO SPS Agreement that already hamper pest prevention.

Trade Agreements: Changes Over the Near Term

- U.S. negotiators should take advantage of the focus on agricultural trade issues during the next round of WTO negotiations to amend the SPS Agreement. Proposed amendments are included in Appendix 3 of the report.

Laws, Policies, and Regulations: Changes That Can be Made Today

- APHIS or Congress should mandate a "0 risk" "level of protection" as a *goal or target* -- a goal that we recognize cannot be achieved -- to affirm the importance of preventing introductions and promote adoption of more protective exclusion strategies and programs. APHIS should then amend its current phytosanitary measures in light of this new, more strict, standard.

- APHIS should adopt regulations rapidly phasing out unprocessed wood as packing materials by an early but reasonable deadline. After that date, APHIS should accept only packaging made from various composites, metal, plastic, or other materials. During the transition period, APHIS should require that all wood packaging be fumigated with acceptable, documented verification.

- APHIS should also seek outside expertise to re-evaluate the risk associated with wood wool, chips, and strips used as cushioning.

- APHIS should adopt regulations prohibiting imports of entire plants and living plant parts. The agency should allow imports only of small lots of seed or clones grown *in vitro* (grown in aseptic conditions free of contaminating agents such as bacteria or fungi) with stringent post-importation quarantine and regulations to ensure they are free of pathogens. The USDA National Plant Germplasm System and Plant Introduction Stations could help the nursery trade adjust to these new restrictions, including through developing native species that show landscaping potential.

- APHIS should adopt regulations requiring that logs, lumber and chips imported from all sources except Canada be first treated using heat or processed in a manner to eliminate all invasive species, including deep wood insects and pathogens.

- To minimize the impact of conflicting mandates, the National Academy of Sciences should periodically review APHIS' procedures and decisions.

- To assist APHIS in broadening its perspective to include forest pests, the agency should establish an advisory panel of scientists, resource managers, and stakeholders concerned about introduced forest pests.

Laws: Changes That Need Time

- To assist APHIS in broadening its perspective to include forest pests, the Congress should extend joint oversight of APHIS to Senate and House committees with responsibilities for natural resources, *e.g.*, the Senate Committee on Energy and Natural Resources and the House Committee on Resources, Subcommittee on Forests and Forest Health.

- The Congress should create a National Center of Biological Invasion (NCBI). The Center would provide a stable, permanent entity with responsibilities and authority to fund and carry out a national program encompassing prevention, rapid detection and eradication, integrated invasive species management and ecosystem restoration for all types of invasive exotic species and ecosystems, not limited to forest pests. The NCBI would carry much of the responsibility for implementing the national invasive species management plan adopted and periodically revised pursuant to Executive Order 13112. For example, APHIS would be transferred from USDA to the Center. The National Invasive Species Council would continue to coordinate efforts and embody high-level political support for invasive species efforts.

- The Congress should create a grants program, to be managed by the National Center of Biological

Invasion, to help communities and organizations respond to and recover from losses due to exotic invasive species problems.

Funding

Prevention efforts targeting forest pests currently receive a small fraction of the funds devoted to protecting agriculture from a similar threat. Funding must be considerably increased, and maintained, to carry out an adequate program that would range from prevention to restoration of impacted tree species. Industries and consumers that rely upon importations or utilize exotic species should pay a user fee to cover much of this increased expenditure. APHIS can greatly enhance the cost efficiency of its prevention efforts by moving more quickly away from inspection *cum* detection to pathway sterilization strategy supported by strong, functional early detection and rapid response programs. Significant funding increases are needed to reverse the decade-long deterioration of funding and staffing in the USDA Forest Service' research, genetic resources, and forest health protection programs, which provide the foundations for restoration of species and forest ecosystems damaged by invasive species.

Closing Statement

Invasive exotic insects and pathogens already harm the integrity of North American forests. The ecological, economic, and fiscal consequences threaten to rise substantially due to rapidly expanding imports and the weakening of phytosanitary safeguards prompted by international trade agreements and national trade promotion policies. Now is a crucial time: by changing relevant treaties, laws, regulations, and policies, and through providing additional funding, policy makers can minimize damage to forest ecosystems. Ensuring continued healthy forests for the future deserves the support of all who value the forests for the myriad values they provide. We urge our readers to support these needed changes.

Introduction

. . . In the United States, the ravages of imported insects injurious to cultivated crops, not being checked by the counteracting influences which nature had provided to limit their devastations in the Old World, are much more destructive here than in Europe.

The year was 1864, the book was *Man and Nature* (1864), and the author was George Perkins Marsh, one of the intellectual giants of the 19^{th} century or any century. At the time, Marsh was the United States' ambassador to Italy, but he had been an observer of man's use and misuse of natural resources over much of his 63 years. His book, *Man and Nature*, was the definitive book of his century for arousing environmental sensitivity among the general public in the United States and Europe and specifically mentioned the threat of exotic pests when unfettered in a new environment. At the time of publication, exotic pests were not a visible threat to any forest tree species for notation in Marsh's book, but within one-half century the stalwart of eastern forests, American chestnut, would come under attack by an exotic fungus.

American chestnuts in southwestern North Carolina. Photograph courtesy of The American Chestnut Foundation (http://chestnut.acf.org/).

One hundred years before the publication of *Man and Nature*, American forests were free from exotic pests and thriving. Naturalist John Bartram journeyed into the Pennsylvania wilderness to investigate the flora and fauna. In his diary (Bartram, 1751), Bartram wrote about the different kinds of trees he observed during the journey. The most frequently encountered trees were white and black oaks, followed by eastern white pine, American chestnut, a tree that he called spruce but probably was eastern hemlock, hickory, sugar maple, American linden, pitch pine, elm, American beech, and white walnut or butternut (Hicks, 1997). What has happened to these tree species since that walk almost 250 years ago, is a national tragedy. Exotic pathogens and insects, sometimes referred to as alien, introduced, or non-indigenous pests, have devastated many of these species (*cf*. Campbell and Schlarbaum, 1994) [see the Gallery of Pests in this report]. The magnitude of impact exotic pests have wrought upon North American forests can be illustrated by listing the prominent tree species mentioned in John Bartram's journal against the exotic pests that have affected them (Table 1). Nearly every species has been attacked by an exotic insect, pathogen, or a combination of both. Some species have been virtually eliminated as an integral component of the eastern forest, *e.g.*, American chestnut, while other species are presently being extirpated, *e.g.*, butternut.

Bartram most often mentioned "white" and "black" oaks, which probably referred to species in two subgenera, *Leucobalanus* (white oaks) and *Erythrobalanus* (black or red oaks), within the oak genus. Oak species currently are the preferred food of the European gypsy moth, an insect that was intentionally imported into this country. Gypsy moth can annually damage millions of acres of northeastern and Lake State forests and is progressively spreading into central and southern hardwood forests. Eastern white pine populations have been heavily damaged by white pine blister rust, which was imported on diseased nursery stock. The American chestnut, once comprising 25 percent of the eastern hardwood forest (Kuhlman, 1978), has been essentially removed from bottomland eastern forests by ink disease from a soil-born algal fungus, *Phythophthora cinnamomi*, and upland eastern forests by the chestnut blight fungus. Where American chestnut once grew to over 150 feet in height, only short-lived sprouts now exist, coming from the root systems of long-dead stems. Eastern hemlocks, important to plants and animals in mountain riparian zones, are currently being eliminated by the hemlock woolly adelgid. Sugar maple and American linden are subject to severe defoliation by exotic thrips species. The American elm, that once shaded our streets and houses, was removed from urban and forest settings by Dutch elm disease, a disease brought to this country on elm logs imported from Europe. Beech bark disease complex, a combination of an imported scale insect and native and exotic fungi, has killed approximately 94 percent of the beeches in northeastern forests, reducing this once proud species to thickets of sprouts. A once valuable hardwood species, butternut, is being eliminated from eastern forests, as butternut canker disease moves from southern forests into the Lake States, New England, and Canada.

Table 1. Frequency of species observed by naturalist John Bartram in a 1751 trip through Pennsylvania (from Hicks, 1997).

Species	No. Times Mentioned	Exotic Pest
White and black oak[1]	25	European gypsy moth
White pine	12	White pine blister rust
Chestnut	10	ink disease Chestnut blight Chestnut gall wasp
Spruce (=Hemlock)	10	Hemlock woolly adelgid
Hickory	8	-
Sugar maple	8	Pear thrips Asian longhorned beetle
American Linden (=American basswood)	7	Basswood thrips
Pitch pine	7	Pine shoot beetle
Elm	6	Dutch elm disease
American beech	6	Beech bark disease complex
White walnut (=Butternut)	6	Butternut canker

Exotic pests have been damaging American forests for over 150 years. Many exotic pests have arrived in this country on shipments of diseased nursery stock or on logs that were not properly sanitized. There are other avenues of importation, however, as shown by the recent arrival of Asian gypsy moths on ships transporting grain to the Pacific Northwest and military equipment to the South (Campbell and Schlarbaum, 1994). Some pests are species specific, *e.g.*, butternut canker kills only butternut trees, while other pests attack a broad range of species, *e.g.*, gypsy moth feeds on over 300 different plant species. Currently, there are estimated to be over 20 harmful exotic pathogens and 360 harmful exotic insects known to attack trees and shrubs in the United States (Mattson *et al*., 1994; Liebhold *et al*., 1995).

In general, eastern forests have been more heavily impacted by exotic pests than western forests. The East was colonized earlier by Europeans, and a number of intercontinental trade routes were established long before western trade routes were developed. Additionally, eastern forests generally are more diverse than western forests, with the exception of California, thereby providing more opportunities for establishment of pests to feed on closely related host species. Western forests have not been spared; white pine blister rust has severely damaged western white, sugar, whitebark, and limber pines. A root disease has decimated populations of Port-Orford-cedar. More recently, sudden oak death, a stem and branch disease, has killed more than 100,000 trees belonging to a number of oak species found in California and southern Oregon (http://camfer.cnr.berkeley.edu/oaks/). Exotic pests will likely increase in the future due to rising imports from formerly closed countries such as Russia and China, and importations of wood products (USDA Forest Service, 1991, 1992b, 1993). Northern, southern, and Pacific Coast forests are all near numerous ports-of-entry and correspondingly have a high potential for the introduction of new pests when compared to the Inland West and Alaska.

There is a stark contrast between the forests, swamps, and prairies viewed by John Bartram and other early naturalists/explorers, such as William Bartram, Lewis and Clark, and Edwin James, and their present appearance. The assault of agriculture, the industrial age and associated pollution, and urban sprawl on the American landscape have too often left the natural ecosystems that once graced the landscapes in a struggle for survival or identity. Yet the human race ***does*** share the planet with the fauna and flora, and the continued existence of all is intertwined. Studies have shown the resilience of plant and animal populations to rebound after being pushed to the brink of

---

[1]Latin names of trees and pests mentioned in this report appear in Appendix 1.

extinction. However, resilience ultimately depends upon the existence of surviving populations with enough genetic diversity to initiate successfully the rebuilding process. Therein lies the threat of exotic pests to North American ecosystems: the extirpation of host species that lack resistance to insects and pathogens that have evolved in isolation from these pests.

The overall impact to the ecosystem, however, is not limited to the host species; associated plants and animals also are affected. Each of the widespread pest infestations has permanently altered forest landscapes in terms of plant and animal species composition. In the eastern forests, the loss of American chestnut to the exotic chestnut blight fungus probably drastically reduced populations of black bears and turkeys (Pelton, personal communication). Reductions in whitebark pine populations due to white pine blister rust (another exotic fungus) have impacted grizzly bear and Clark's nutcracker populations in western forests (Kendall and Arno, 1989). According to Ledig (1992), "Introduction of exotic diseases, insects, mammalian herbivores, and competing vegetation has had the best-documented effects on genetic diversity [of forest ecosystems], reducing both species diversity and intraspecific diversity." The impact of forest exotic pests on North American forests has been greater than other more widely publicized, human-caused factors, including forest fragmentation, changed demographic structure, altered habitat, and pollution, which have been commonly ascribed to cause decline in health and integrity.

The Public and Biological Pollution

Exotic pest outbreaks have periodically concerned the American public. The devastation of American chestnut in eastern forests, white pine blister rust affecting five-needle pine species, the loss of American elms, and more recently, maples along city streets due to Dutch elm disease and the Asian longhorned beetle, have raised public awareness. However, in these instances the awareness was species specific and usually only for the duration of local devastation. This ambivalence toward exotic pests, coupled with no or limited inspections and quarantine of imported wood, logs, and wood-based packaging until the mid 1900s, has allowed occasional entry of exotic species. Heavy gypsy moth infestations occasionally aroused a public outcry in the areas affected, but overall neither the public nor elected representatives have been aware of the widespread impacts of a multitude of exotic pests on forest ecosystems. A glimmer of awareness came in 1977 when President Carter signed Executive Order 11987. This order instructed federal agencies to use their existing authorities to "restrict" the introduction of exotic species to natural ecosystems and encouraged the states to do likewise. The Carter Administration did not follow through aggressively, however, and interest waned completely with the change of Executive Branch administrations.

Public awareness of the exotic pest problems, in a general rather than species-specific sense, began to increase following the 1993 publication of *Harmful Non-Indigenous Species in the United States* by the Office of Technology Assessment (OTA report), which summarized the extent of exotic pest damage and costs to native ecosystems (OTA, 1993). In 1994, we wrote *Fading Forests: The Threat of Exotic Pests to North American Forests*, to inform the American public about the impact of exotic pests on forest ecosystems and the threat of introduction of additional pests—primarily through the importation of unprocessed logs. Unfortunately, few earlier publications linked resident exotic forest pests, recent introductions, or the growing risk of future harmful introductions with the rapid growth of international trade and associated trade agreements that have outstripped phytosanitary safeguards and resources.

Subsequently, there has been an increasing attention to ecological and economic damage caused by invasive exotic species (=exotic species whose introduction does, or is likely to, cause appreciable ecological or economic damage). Books have been published by The National Geographic Society (Devine, 1998), Worldwatch Institute (Bright, 1998), and Island Press (Cox, 1999; Mooney and Hobbs, 2000; Van Driesche and Van Driesche, 2001); reports have appeared in technical journals and books (Wilcove *et al*., 1998; Westbrooks, 1998; Schlarbaum *et al*., 1999; Pimentel *et al*., 2000; Campbell, 2001); influential articles have been published by the general media in magazines and newspapers such as *Harpers, Newsweek, Time, The Washington Post, the Chicago Tribune,* and *The*

New York Times. Most of the publications on invasive species since the OTA report, however, have given relatively little attention to the impact of exotic pests on forests. For example, native tree species essentially eliminated from the forest, such as American chestnut, or reduced in number throughout their ranges or in portions of their ranges are not included in statistics upon which are based statements that invasive species threaten 49 percent of America's "imperiled" species (Wilcove *et al*,.1998).

In response to the increased concern over biological pollution, President Clinton issued Executive Order 13112 on February 3, 1999, establishing a National Invasive Species Council (NISC) to formulate a national strategy (Appendix 2); a strategy we called for in the terminal essay of our 1994 paper. Over the next two years, the NISC, the Invasive Species Advisory Committee, and supporting technical committees met and developed the National Invasive Species Management Plan (National Invasive Species Council 2001, http://www.invasivespecies.gov/council/nmp.shtml). The National Plan set target dates for federal agencies to begin a coordinated effort to address the many facets of biological pollution, including exotic forest pests.

Environmental Concern About Exotic Forest Pests

The latter decades of the 20th century saw unprecedented growth in private citizen groups concerned with the environment, in particular forest ecosystems. Many of the issues pursued by these groups reflect public interest and concern. Yet these groups' concern has not extended to exotic forest pest problems, which is puzzling. We believe that various contributing factors are responsible for the public's ambivalence:

1) The filling of the host species niche with other arborescent species. The host species disappears, but the gap is rapidly filled by other tree species. Many people do not discern individual tree species, but rather just see a forested landscape.

2) The tendency, with a species-specific exotic pest problem, to view loss from a single species perspective, rather than the initiation of a cascade of ecological effects that will affect flora and fauna dependent upon or associated with the host species.

3) The lack of appreciation of the cumulative impacts of established and newly introduced exotic pests on the forest ecosystem.

4) The minimal involvement of forest tree pest experts in policy formulation at the political level as compared to pest experts representing agricultural and horticultural commodity groups. There are a limited number of tree species, *e.g.*, Douglas-fir, southern yellow pine, and western white pine, that are regionally important to timber or pulp companies and private landowners. When problems with these species occur, then there is a broad base of support for solutions, both political and biological. A good example is the $13 million allocated in 2001 for restoration of southern yellow pines to lands that have been devastated by the native southern pine beetle. Butternut, eastern hemlock, and American beech command no such lobbying efforts, as they are comparatively minor commodities.

5) A lack of awareness of the impact of new international trade agreements on government's ability to protect our forests from new introductions.

6) General ignorance of the types and quantities of imports that serve as pathways of introductions: wood products, wood packaging, and horticultural plants.

This apparent lack of public interest needs to be rectified if forest pests are to receive a meaningful "share" of the increasing allocations of resources to combat invading exotic species. Solutions to the difficult scientific and policy problems that expose our forests to ever-greater damage from established and newly introduced pests will become more expensive and less feasible the longer the problem is ignored. Additionally, there is good evidence to believe that the exotic forest pest problem will be much worse in the future.

Recent and Potential Problems

Our forests remain vulnerable, as is demonstrated by recent introductions of new exotic pests and the spread of native pests to previously isolated areas, *e.g*., eastern forest pests appearing in western forests, and an increase in host range of established exotic pests. Additionally, the "shrinking world," in terms of international trade, will only exacerbate this problem. We describe here briefly examples of these new threats to North American forest integrity; for more detail, see the Gallery of Pests.

Recent Introductions

Common (or larger) pine shoot beetle. The common (or larger) pine shoot beetle was first discovered in July 1992, near Cleveland, Ohio (Kucera, 1992). It entered the country on solid wood packing material (SWPM). Despite the United States Department of Agriculture, Animal and Plant Health Inspection Service's (USDA APHIS) 1995 regulations governing SWPM, this beetle continues to be detected on shipments (USDA APHIS and Forest Service, 2000). Established populations of this pest are spreading despite APHIS' restrictions on the movement of potentially infested material; the species is now found in 11 states and 2 Canadian provinces (USDA APHIS and Forest Service, 2000). The pine shoot beetle has the potential to cause billions of dollars in damage when it reaches southern pine plantations and western forests; it could severely damage lodgepole pine, the most common tree in the northern Rocky Mountains (Thomas Hofacker, USDA Forest Service, personal communication, 1999).

Common shoot beetle adult in damaged shoot. Photograph courtesy of Steve Passoa, USDA APHIS PPQ (http://www.bugwood.org)

Asian longhorned beetle. The Asian longhorned beetle has repeatedly entered North America (USDA APHIS and Forest Service, 2000), resulting in establishment of nine separate infestations in the Chicago and New York areas by the end of 2000. The species has been observed to feed on a variety of hardwood species, but prefers maples.

Asian longhorned beetle adult. Photograph courtesy of Kenneth R. Law, USDA APHIS PPQ (http://www.bugwood.org)

In an attempt to eradicate the Asian longhorned beetle, federal, state, and local officials had destroyed nearly 5,800 trees in New York and Chicago at a cost of approximately $25.1 million by March 2000 (USDA APHIS and Forest Service, 2000). USDA APHIS has estimated that the establishment of Asian wood-boring insects belonging to this and related genera could, if left unchecked, cause $41 billion in losses to forest products, commercial fruit, maple syrup, nursery, and tourist industries in the Northeast (USDA APHIS, 1998d). Nationwide, Asian longhorned beetle damage to urban trees could reach $669 billion (Nowak *et al*., 2001).

If the Asian longhorned beetle becomes established in North American forests, it has the potential to alter North American ecosystems across the continent. The impact would probably change dominant species composition and age structure in hardwood forests, particularly forests composed largely of maple and poplars, *ca*. 48 million acres primarily from New England to the Great Lakes (USDA APHIS and Forest Service, 2000). USDA scientists predict that the impact of Asian longhorned beetle will exceed that of any insect, including the European gypsy moth (Kucera, 1996).

Asian longhorned beetle larvae and damage in tree. Photograph courtesy of Larry R. Barber, USDA Forest Service (http://www.bugwood.org)

Increased Host Range for Established Exotic Pests

White pine blister rust. In the Western states, white pine blister rust has been found in one stand of limber pine in the central Rocky Mountains. Limber pine is a five-needle pine species that is not commonly harvested for timber or pulp, but it is a common component of western forest ecosystems. Devastation of this species would have significant impacts on the structure and function of these ecosystems as well as to recreational use of the forests.

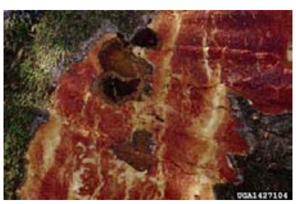

White pine blister rust canker on young eastern white pine. Photograph courtesy of Minnesota Department of Natural Resources Archive (http://www.bugwood.org)

Spread of Native Pests to Previously Isolated Forest Ecosystems

Pine pitch canker. The pathogenic fungus pine pitch canker is native to the southeastern United States, Mexico, and Haiti. Introduced into California, it is killing the narrowly endemic Monterey (=*Radiata*) and Torrey pines. The fungus might also cause serious damage to "[a]ll economically important native pine species" in California (USDA Forest Service, 1998a).

Possible Introductions of Exotic Forest Pests

Sudden oak death syndrome. Since 1995, a newly described pathogen (Werres *et al*., 2001) , *Phytophthora ramorum*, has been detected in the coastal hardwood forests of California and more recently, in southern Oregon. The disease has killed more than 100,000 oak trees in 10 coastal Californian counties. Major eastern oaks, particularly northern red and pin oaks, are also vulnerable (David Rizzo cited in Mary M. Woodsen, "If Oak Malady Moves East, Many Trees Could Die," *New York Times,* September 4, 2001). The sudden oak death pathogen attacks a wide variety of plants in addition to oaks (Werres *et al*., 2001; Rizzo et al., 2002), including rhododendrons, madrone, evergreen huckleberry, and California buckeye. To date, no solution to sudden oak death has been found.


Symptoms of sudden oak death disease on tanoak. Photograph courtesy of Joseph O'Brien, USDA Forest Service (http://www.bugwood.org)


Sudden oak death disease on coast live oak. Photograph courtesy of Joseph O'Brien, USDA Forest Service (http://www.bugwood.org)

Vulnerable oak species are distributed along 1,500 miles of the California and Oregon coasts; some are the dominant hardwood in large areas, growing in nearly pure stands in some forests. In the East, red and pin oaks dominate forests covering a combined range from northeastern Texas to Nova Scotia. These species provide habitat and acorns to a wide variety of wildlife. If the disease continues to spread, it will alter forest composition with significant implications for wildlife habitat and food chains. Additionally, the dead trees could pose a serious fire hazard in some areas.

While no one yet knows where the sudden oak death pathogen originated, evidence suggests introduction on rhododendrons imported from Europe. The pathogen was previously only known from Europe on rhododendron and *Viburnum* species until discovery on oaks and other species in California (Rizzo *et al*., 2002). Additional studies are needed to determine the true origin and vectors for this extremely dangerous disease.

Pests With an Increased Probability of Introduction and Establishment

European spruce beetle. The European spruce beetle is found across Europe and Asia (USDA APHIS and Forest Service, 2000), where it causes considerable damage. This beetle is one of the most commonly detected pests travelling on SWPM, even after adoption of the 1995


European spruce bark beetle adult. Photograph courtesy of Steve Passoa, USDA APHIS PPQ (http://www.bugwood.org)


Damage from European spruce bark beetle larvae. Photograph courtesy of William M. Ciesla, Forest Health Management International (http://www.bugwood.org)

regulations intended to prevent introductions of bark-associated insects (USDA APHIS and Forest Service, 2000). Several times, the beetle has been found in dunnage or warehouses after escaping detection by inspectors (Hofacker, 1993, LaGasa *et al*. 1997, USDA APHIS and Forest Service, 2000); the pest has apparently been eradicated before it became established. The European spruce beetle carries various fungi, some of which can be extremely pathogenic. If introduced beetles were accompanied by a virulent fungus, and native beetles also spread the fungus, "It could . . . be as disastrous to North American spruce as the Dutch elm disease was to elms" (USDA Forest Service, 1991).

Woodwasp-*Amylostereum* complex. The woodwasp *Sirex noctilio* and associated fungus *Amylostereum areolatum* are native to Eurasia and North Africa (USDA APHIS and Forest Service, 2000) and have been introduced in New Zealand, Australia, and South America (USDA Forest Service, 1992b). This insect-disease complex would threaten any pine in the "lower 48" states, especially Monterey pine and loblolly pine, as plantations of these species growing in foreign countries have been damaged (USDA APHIS and Forest Service, 2000). There is a high likelihood that wood wasp larvae will be in SWPM or other wood articles shipped from both its native and introduced ranges; the insect is commonly intercepted by APHIS inspectors. The wasp can spread rapidly by natural means (USDA Forest Service 1992b). However, an efficient biocontrol agent has been identified (USDA APHIS and Forest Service 2000).

European wood wasp adult female. Photograph courtesy of William M. Ciesla, Forest Health Management International (http://bugwood.org)

Mortality in pine plantations in Europe due to the European wood wasp. Photograph courtesy of William M. Ciesla, Forest Health Management International (http://www.bugwood.org)

Asian gypsy moth. The Asian strain of the gypsy moth, which belongs to the same species as the European gypsy moth, feeds upon more than 500 species of plants (USDA APHIS and Forest Service, 2000), including many conifers and hardwood species. Unlike the European strain, the female Asian moths have the ability to fly up to 40 miles (USDA Forest Service, 1991), and thereby would greatly accelerate dispersal and colonization. The Asian gypsy moth has been introduced to Europe and has reached North America several times as egg masses on ships. Each time, emergency control programs have apparently succeeded in eradicating the moth. New introductions of Asian gypsy moth appear inevitable; infestations would probably be extremely difficult to control.

Gypsy moth females laying egg masses. Photograph courtesy of William M. Ciesla, Forest Health Management International (http://www.bugwood.org)

The Costs of the Exotic Forest Pest Problem in North American Forest Ecosystems

The devastating impacts of exotic fungal pathogens and insects that attack trees and woody shrubs in the United States have been described by numerous sources (USDA APHIS, 1997; Niemela and Mattson, 1996), including in our first report (Campbell and Schlarbaum, 1994). Pimentel *et al*. (2000) estimate losses and costs associated with established forest pests introduced to North America at $4 billion annually. As previously mentioned, the impacts of exotic pests extend beyond their host species to flora, fauna, and sometimes the environment associated with the host. The true environmental and economic costs of forest damage by exotic pests is difficult to assess (*cf*. Oliver *et al*., 1997). Estimation of lost commodity values is easier than for non-commodity values. For example, lost timber revenues from exotic pest damage can be estimated. In contrast, how can a monetary figure be assigned to the loss of the aesthetic value of a mountain stream when the surrounding hemlocks die from hemlock woolly adelgid feeding?

Studies and risk assessments have shown the high level of damage that insects and fungal pathogens from forests or plantations in Europe, Mexico, Asia, or several countries in the Southern Hemisphere could potentially cause if introduced into the U.S. (USDA Forest Service, 1991, 1998a; Campbell and Schlarbaum, 1994; Niemala and Mattson, 1996; USDA APHIS, 1998c; USDA APHIS 1998d; USDA APHIS and Forest Service, 2000; USDA Forest Service, 2001). While technical tools for preventing introductions have improved, increased volume of trade and more rapid transport together provide increased opportunities for exotic organisms to reach our shores. Alarmingly, policy decisions focused on expanding international trade have already led to relaxation of phytosanitary safeguards and threaten further weakening despite the heightened risk.

What is at risk from a human perspective? Forests are valued in different ways; probably each individual treasures forested land from a unique perspective. Public debates over forest use illustrate just how differently people value forests and, unfortunately, how people can ascribe only a narrow set of values to a natural resource. We believe that the general public tends to view many exotic forest pest problems as "single issue" problems, *e.g.*, the Fraser firs are dying, and do not realize the niche each species fills in the ecosystem. For example, the loss of the American chestnut is widely bemoaned; however, little is said about the corresponding loss of mast for wildlife and habitat that the chestnut provided. Oliver *et al*. (1997) divided health-related forest values into two general categories: 1) values expressed as condition and function of the forest; and 2) values provided by the forest. The condition and function of the forest are important to many people. A forest that is relatively free from exotic pests protects the associated watershed and site, and sequesters carbon is very desirable. In addition, the forest is valued for commodities, recreational opportunities, and historical, cultural, and/or spiritual values. We believe that if the general public would think more broadly about the role each host species plays in the forest ecosystem, concern levels for forest health and integrity will rise.

Since we wrote *Fading Forests*, a scant eight years ago, we have increasingly recognized the relationship between world trade policy and a rising likelihood of introduction of exotic pests. We believe that economic globalization (international trade) is the principal cause of exotic species introduction into North American ecosystems—that unless significantly different, more effective, phytosanitary policies are implemented, increases in trade will be paralleled by increases in exotic pest problems. While the challenges posed by established and future exotic forest pest problems are varied — ranging from policy and the mechanics of prevention, eradication, and control to restoration of lost species and damaged ecosystems—it was the changes in international trade policy that prompted us to update our earlier paper. We seek, in this second edition, to inform the general public of the potential ramifications of these policy changes on prevention of exotic pests from entering this country. Correspondingly, much of this report will focus on international trade agreements and the provisions within these legally binding agreements that weaken our country's ability to defend against pest introductions. The report will also examine the weaknesses in federal laws, regulations, and policies that govern exclusion, quarantine, eradication, and control of exotic pests. Finally, given the increased public exposure of exotic pest problems and the establishment of the National Invasive Species Council, we expanded our discussion to suggest a comprehensive strategy to protect our natural heritage from destruction.

Pathways to America

Forest Susceptibility

Forests cover approximately one-third of the land area in the United States: 1.15 million square miles (USDA APHIS and Forest Service, 2000). These forests are comprised of approximately 500 species of trees plus thousands of identified species of terrestrial and aquatic animals and non-woody plants (USDA APHIS and Forest Service 2000) and likely thousands of undescribed species (http://www.discoverlife.org). Representatives of almost every type of vegetation that occurs worldwide can be found within the United States or its protectorates (*cf.* USDA APHIS and Forest Service, 2000). Additionally, many exotic plant species are grown for horticulture, Christmas trees, and other uses. Approximately 4,000 exotic plants are established outside cultivation in the United States [Kartesz, 1999; United States Geological Survey (USDI USGS), 1998]. This combination of native and exotic species across the United States provides ample opportunities for imported pests to find suitable hosts (USDA APHIS and Forest Service, 2000; Niemala and Mattson, 1996). The more than 400 exotic insects and pathogens that are permanently established in North American forests and woodlands demonstrate the vulnerability of these forests to exotic organisms (Mattson *et al.*, 1994; Liebhold *et al.*, 1995; USDA APHIS, 2000).

Forest ecosystems vary in their susceptibility to exotic pests. Forests comprised of relatively few trees, *e.g.*, forests dominated by Douglas-fir in the Pacific Northwest, would be more easily damaged by a species-specific pest than eastern forests, which have more diversity. Conversely, eastern forests provide greater opportunities for exotic pests to find suitable hosts. Damage to host species may range from negligible to potential extinction. The impact of some exotic pests is noticeable in a relatively short period after introduction, *e.g.*, Asian longhorned beetle, or can be delayed as with Asiatic oak weevil (Triplehorn, 1955; Roling, 1979; Stanton, 1994). Changes in host preference also can occur. Pear thrips were introduced to the country in 1900 and were spread throughout the country by the orchard industry. Only in the latter portion of the 20th century was pear thrips damage noted in a variety of forest tree species. Although some generalizations can be made, there is an uncertainty about how an exotic species will react in a new environment, what impact it will have on host species, and when it will be recognized as a problem species (USDA APHIS and Forest Service, 2000).

International Trade and Exotic Pest Prevention

To date, 72 and 18 percent of the established exotic forest insects are from Europe and Asia, respectively (USDA APHIS and Forest Service, 2000), reflecting past trade patterns and ecological similarities. In the 16 years 1985-2000, APHIS intercepted 6,827 bark beetles that were of potential concern as forest pests. While the intercepted beetles came from 117 countries, more than 43 percent of the beetles were in shipments from Western Europe. Another 8 percent (500 beetles) were from Russia and China. Other major source countries were Mexico, Jamaica, and India (Haack 2002). International trade is increasing rapidly with importations from a greater variety of countries. United States' imports in 2001 were 28 times greater than in 1970; they rose 82 percent just since implementation of the World Trade Organization in 1994 (U.S. Trade Representative 2002). Budgets for APHIS, the first line of defense against exotic pests, have not grown correspondingly. Nor has the agency rapidly adopted new, more effective approaches to excluding exotic pests. Therefore, the probability for importing additional exotic pest species and genotypes from European and Asian ecosystems and new pest species from the ecosystems of our expanded trade partners has significantly risen.

Primary Pathways of Introduction

Beetle cartoon by Steve Greenberg, 1999. Reprinted by permission of the Seattle Post-Intelligencer

Exotic forest pests can travel to the United States in many ways, ranging from importation of logs with bark to smuggled budwood for grafting. With very few exceptions (European gypsy moth was purposely brought to this country), exotic forest pests are transported as unwanted "hitchhikers" on imports of live plants or minimally processed wood, including wood used as packing materials. We will focus our discussion on three modes of introduction or "pathways" that have been shown to have a high probability for introducing forest pests: 1) nursery-related materials, 2) unprocessed wood (logs, lumber, railroad ties, and chips), and 3) crates, pallets, and dunnage. During the 16-year period 1985 - 2000, 20 percent of APHIS' interceptions of exotic bark beetles (*Scolytidae*) occurred on imports of plants or food; 0.05 percent on imports of logs or lumber; and nearly 72 percent on wood packaging (Haack 2002).

APHIS Interceptions of Bark Beetles on a Variety of Imported Goods

During the period 1985 - 2000, APHIS recorded 6,825 interceptions of exotic bark beetles (*Scolytidae*) from 117 countries (Haack 2002). The top 10 countries were

Italy	1,090	16%
Germany	756	11%
Spain	457	7%
Mexico	425	6%
Jamaica	398	6%
Belgium	352	5%
Russia	247	4%
France	261	4%
China	255	4%
India	224	3%

The most common vectors for these beetles were SWPM (72 percent of interceptions) and food or plants (20 percent of the interceptions).

crates	32% of the interceptions; from 57 countries
dunnage[1]	27% of the interceptions; from 57 countries
seed	11% of the interceptions; from 57 countries
unspecified wood	7.5% of the interceptions; from 50 countries
fruit	6% of the interceptions; from 51 countries
pallets	5% of the interceptions; from 31 countries

[1]Dunnage is defined by the UN Food and Agriculture Organization as "wood materials used in (*sic*) wedge or support cargo"; North American Plant Protection Organization, Draft International Standards for Phytosanitary Measures, Import Requirements for Non-Manufactured Wood Packing Material, April 1999.

(1) Nursery-Related Materials

Legal or illegal importation of nursery materials (*e.g.*, budwood, seeds, plants) from foreign countries has been repeatedly proven to transmit devastating pests (Kenney and Bagenski, 1998; National Plant Board, 1999). Since the late 1800s, several of the most damaging forest pests, *e.g.,* the chestnut blight fungus (Howard, 1898; Metcalf and Collins, 1909), as well as a wide variety of agricultural and horticultural pests (Haleamau, 1998; Regelbrugge, 1998; Office of Technology Assessment, 1993; Society of American Florists, 1998; Ostry, 2001) have been imported on nursery stock. Despite the early, specific warnings that importations of nursery stock are the most dangerous vector for transporting exotic pests (see, *e.g.*, Howard 1898) and the current best efforts of APHIS, this pathway remains very active. The citrus longhorned beetle, Japanese cedar longhorned beetle, and sudden oak death have probably entered the country on nursery stock during the 1990s.

Forest Pests Probably Introduced on Imported Horticultural Stock or Seeds

Pest	Host(s)
chestnut blight	American chestnut, Allegheny and Ozark chinkapins
Phytophthora cinnamomi	American chestnut, Allegheny and Ozark chinkapins, variety of other species in nursery and field situations
white pine blister rust	Five-needle pine species
Port-Orford-cedar root disease	Port-Orford-cedar
balsam woolly adelgid	Balsam and Fraser firs
larch casebearer	Eastern and western larches
beech scale	American beech
butternut canker	Butternut
dogwood anthracnose	Flowering and Pacific dogwoods
sudden oak death	Oaks and other hardwood trees and shrubs
Citrus longhorned beetle	Variety of hardwood species

United States plant imports are on the rise: from about 456 million plants in 1993 to more than 694 million plants in 1999 [APHIS Federal Register July 23, 2001 (Volume 66, Number 141)]. For example, imports of bonsai shrubs and trees have risen from fewer than 600 plants in 1993 to 54,749 plants in 1998 [Federal Register April 20, 2001 (Volume 66, Number 141)]. These growing imports represent a wide variety of plants; in 2000, the U.S. imported 863 genera of plants (Meghan Thomas, APHIS, personal communication). This growing variety shipped from a larger number of countries increases the variety of pests that could be introduced [Federal Register July 23, 2001 (Volume 66, Number 141)]. Even plants shipped from Canada, our largest supplier, can transport potentially damaging pests, since Canadian officials rely on their colder climate to control pests that can be harmful in warmer parts of the United States (National Plant Board, 1999).

Seed imports have also risen, from 8.7 million kilograms in fiscal year 1997 to 12 million kilograms in fiscal year 1999 [Federal Register July 23, 2001 (Volume 66, Number 141)]. Imported seeds also can transport invertebrate pests and pathogens (Roques, 2001), including such pathogens as pitch canker (Fraedrich, 2001).

During the ten-year period 1990-1999, 35-40 percent of all plant-feeding arthropods (that APHIS considers to pose a quarantine threat) intercepted by APHIS personnel at the ports were found on imports of plants, bulbs, roots, or stems or leaves used for propagation. Only some unspecified proportion of these arthropods were pests of trees or woody shrubs. These 14,878 intercepted pests were from 85 countries of origin (National Research Council, 2002a). A separate analysis of interceptions during the 16-year period 1985-2000 determined that APHIS intercepted 1,979 bark beetles on imports of food or plants: 38 percent of these beetles were in shipments of seeds, 20 percent on fruit, and another 12 percent were on stems, leaves, roots, or flowers (Haack, 2002).

(2) Minimally Processed Wood

A second high-risk vector for exotic pests is imports of minimally processed logs, lumber, and wood, including wood chips. Among the types of pests likely to be introduced via this pathway are larval and adult phases of wood borers and bark beetles, and deep-wood pathogens. The wood borers and deep-wood pathogens are especially hard to detect, as they reside within the imported wood. Bark beetles and some plant pathogens, *e.g.*, Dutch elm disease, are frequently transported on wood with some portion of bark attached. Once imported, bark beetles typically have a high capacity for dispersal, colonization, population increase, and spread (USDA APHIS, and Forest Service 2000).

Transport of pests has also been documented in shipments of wood chips. More than 100 species of fungi in 82 genera have been identified from piles of chips (Dwinell, 2001b). The pinewood nematode from North America has been repeatedly intercepted in shipments of North American wood chips to Nordic countries (Dwinell and Lehman In press; Magnusson *et al.*, 2001). There is dispute, however, as to whether large insects can survive chipping and transport; documentation of insects in wood chips is incomplete (Magnusson *et al.*, 2001).

Increased importation of logs, lumber, railroad ties, and wood chips.

Despite its extensive natural forests and plantations, the United States is the world's largest importer of forest products.[1] Most imports are of softwood (conifers): 96 percent of lumber, 86 percent of logs, and 99 percent of chips (Howard, 2001). Between 1989 and 2000, imports of softwood logs rose 17-fold, from 104,000 m^3 to 1,732,000 m^3; and imports of hardwood (usually deciduous) logs almost tripled, from 83,000 m^3 to 240,000 m^3. Imports of softwood lumber increased by 29 percent, from more than 35 million m^3 to more than 45 million m^3; and imports of hardwood lumber more than doubled, from 824,600 m^3 to 1,682,000 m^3.

Records of wood chip imports began in 1991. Imports of softwood chips were at 605,157 dry metric tons in 1991, peaked at 747,518 dry metric tons in 1996, then declined to only 85,837 dry metric tons in 2001. Imports of hardwood (usually deciduous species) chips increased by a factor of 25, from 3,500 metric tons in 1991 to 72,000 dry metric tons in 2001 [www.fas.usda.gov/ustrade]. While shipments of chips from Canada and Chile usually enter the country at Pacific ports, chips from tropical countries arrive at Gulf Coast ports (USDA APHIS, 1998b; Magnusson *et al.*, 2001), thereby facilitating exotic pests' access to the region of greatest commercial forestry in the United States.

The vast majority of these wood imports were from Canada: in 2000, Canada supplied 94-99 percent of imported logs (hardwood and softwood), softwood lumber, railroad ties, and wood chips. Canada also supplied more than 70 percent of the imported hardwood lumber. Wood imported from Canada carries little risk of introducing exotic pests, since U.S. and Canadian forests are largely contiguous.

Imports of minimally processed wood products from countries other than Canada constitute a significant pest risk. The risk to the continental United States is primarily from other temperate countries, although pests from high elevations in tropical countries could pose a risk to temperate countries. Imports from lower elevations in tropical countries pose a threat to forests in Hawaii and Puerto Rico.

Suppliers shift rapidly due to market conditions. These shifts make it difficult to predict either the quantities of wood that will be imported or, more importantly, the countries which will supply the wood. However,

[1]Unless otherwise specified, trade data cited in this chapter are from USDA Foreign Agricultural Service, www.fas.usda.gov/ustrade.

both New Zealand ["Hodgson Speaks to Forestry Conference" ForestPacRim: NZ Forest Minister addresses Forestry conference Date: 10/5/2000] and South American countries (USDA Forest Service, 2001) expect to greatly increase wood exports from existing plantations in coming decades. As long as APHIS continues to rely on country- or region-specific risk assessments to develop regulations, it must prepare such studies more quickly on the full range of suppliers, both those now shipping to the United States and those which might in future.

Softwood and hardwood logs. Imports of softwood logs from principal temperate trading partners other than Canada rose five-fold between 1989 and 1994 (from 21,600 m^3 to 111,000 m^3), then fell to 38,000 m^3 in 2001. The principal non-Canadian supplier is New Zealand: imports peaked at 102,542 m^3 in 1994, then fell steadily to less than a quarter of that volume. The lesser volumes imported from Chile peaked in 1989 and 1997. Even smaller-volume imports from Mexico peaked in 1995. Mexico had almost disappeared from the market by 2001. In contrast, imports from Europe spiked in 2000 to levels exceeding New Zealand's.

Imports of hardwood logs from temperate trading partners other than Canada grew from 3,444 m^3 in 1989 to 6,433 m^3 in 2001. Europe (including Russia) has been the principal supplier after Canada; Chile and, recently China, have supplied small quantities.

Softwood and hardwood lumber. The United States imported 3.6 million m^3 of softwood lumber from countries other than Canada in 1989; in the mid-1990s this volume fell to about 1 million m^3, then rose to 2.9 million m^3 in 2001. Europe has steadily supplied about one-third of the imports. Imports from New Zealand, Argentina, and Brazil grew rapidly during the period, while imports from Chile and Mexico fell.

The United States imported over 118,000 m^3 of hardwood lumber from Europe and Chile in 1989. These imports collapsed to just 4,600 m^3 in 1992, then rose to somewhat less than 20,000 m^3. By 2000, imports had reached 44,000 m^3, with Europe usually supplying about two-thirds of the total. Imports of hardwood lumber from non-Canadian sources in 2001 exceeded imports of softwood logs from non-Canadian sources in that year: this pathway deserves greater scrutiny.

Railroad ties. Railroad ties are large-dimension lumber and thus provide a haven for a variety of forest pests. Imports of railroad ties fluctuate from year to year. Peak imports—in excess of 70,000 m^3—occurred in 1993, 1996, and 1998; lows of 28,000 - 29,000 m^3 were observed in 1994 and 1995. Imports in 2000, 57,300 m^3, were in the middle of this range. Imports fell further to 38,703 m^3 in 2001. While most railroad ties are imported from Canada, other countries enter the market in years of relatively high demand. Most of the non-Canadian ties came from West Africa, but Mexico exported ties from 1994 to 1998; the peak was 30,000 m^3 in 1996.

Wood chips. While Canada dominates U.S. chip imports in most years, other countries provided significant quantities of softwood chips in the middle 1990s. Thus, Mexico supplied approximately half of U.S. imports of softwood chips in 1993 and 1994; Chile supplied more than 40 percent of imports in 1995 and 1996 and 28 percent in 1997. Brazil supplied 21,600 metric tons in 1995 and 10 percent of U.S. imports in 1998. Europe is a distant second to Canada in supplying hardwood chips, shipping between 2,000 and 4,000 metric tons each year.

Minimizing the pest risk

In the early 1990s, concerns about the risks associated with wood imports prompted APHIS to ask the USDA Forest Service to carry out several risk assessments with the goal of determining that risk and the appropriate phytosanitary measures to meet it. These studies analyzed the potential threat of pest introductions from Siberia (USDA Forest Service, 1991), New Zealand (USDA Forest Service, 1992b), and Chile (USDA Forest Service, 1993). Later risk assessments examined imports of pine and fir from Mexico (USDA Forest Service, 1998a) and plantation-grown *Eucalyptus* from South America (USDA Forest Service, 2001). Contrary to expectations, however, these countries have not become the dominant non-Canadian source of imported wood. Europe, Brazil, and Argentina have become increasingly important sources of softwood lumber, but APHIS has never conducted risk assessments on logs or lumber from Europe or pine from Argentina or Brazil. As noted above, rapid shifts in suppliers spurred by market forces have undercut the value of country-specific risk assessments.

Pests on softwood logs and lumber. North American forests have been demonstrated to be vulnerable to pests from Europe. Although many European pests have already been introduced to the United States, additional potentially troublesome organisms could be introduced from that continent. Among the damaging pests that could be introduced on softwood logs imported from Europe, including Russia, are the European spruce bark beetle and the associated fungi, and the Mediterranean pine engraver beetle. Imports of lumber from Russia might include lumber originating in Siberia that could transport Asian gypsy moth, nun moth, large pine weevil, and various Asian wood-boring beetles in the *Monochamus* and *Hesperophanes* genera.

New Zealand was the most important non-Canadian supplier during the decade, and it might become more important in the future, as New Zealand expects production to double over the next 20 years ["Hodgson Speaks to Forestry Conference," ForestPacRim: NZ Forest Minister addresses Forestry conference Date: October 5, 2000]. The most damaging pest associated with plantation-grown pines in New Zealand is the *Sirex* woodwasp and its associated *Amylostereum* fungus. A second potential introduction is the red-haired pine bark beetle, which has already been introduced into New York (Haack *et al.*, 2002). The *Sirex* woodwasp and associated fungus also could be introduced on coniferous logs or lumber imported from South America. Thirteen other pests of pines or firs posing a "moderate" or "high" risk to forests throughout the "lower 48" states have been identified as possible hitchhikers on logs from Mexico (USDA Forest Service, 1998a).

Pests on hardwood logs and lumber. Imports of hardwood lumber from China (*ca.* 6,000 m^3 of lumber in 1999) could transport various wood-boring beetles, including the Asian longhorned beetle. Fortunately, the volume of wood imported from China has since fallen, constituting only 1,109 m^3 in 2001 [www.fas.usda.gov/ustrade]. China also supplies a variety of smaller wooden articles. Pests have been found in baskets, bamboo garden stakes, and artificial Christmas trees shipped from China. Examples of damaging pests that could be introduced on wood articles imported from China include (*cf.*, USDA Forest Service, 1991b) Asian gypsy moth and nun moth, Siberian silk moth, large pine weevil, wood boring wasps in the *Siricidae* family, and (USDA APHIS 1998c) wood-boring beetles in the *Ceresium*, *Monochamus*, and *Hesperophanes* genera, including the Asian longhorned beetle.

(3) Solid Wood Packing Materials

Raw wood used as packaging material (called solid wood packing material, or SWPM), including pallets, crates, wooden spools for cable, and dunnage, is an especially dangerous vector for importing pests (USDA APHIS and Forest Service, 2000). No agency has attempted to quantify how much wood packaging comes into the country in any given year. Estimates of the proportion of U.S. imports contained in solid wood packaging vary from 15 percent (Berven, 1999) to 90 percent (Peters, 1999), although most official data suggest that approximately 50 percent of maritime shipments and 9 percent of air shipments use SWPM (USDA APHIS and Forest Service, 2000). The United States imports between 14 million ("William Booth, "Where Sea Meets Shore, Scenarios for Terrorists." *The Washington Post,* January 3, 2002; Bill Miller, "Customs Chief Seeks Checks Overseas of U.S.-Bound Cargo," *The Washington Post*, January 18, 2002) and 30 million (Robert Kanter, Port of Long Beach, personal communication) shipping containers; if only one-half contained SWPM, that represents 7 to 15 million loads of SWPM.

Exotic pest introductions via solid wood packaging are a serious threat due in part to the rising volume of imports, and in part to distribution patterns within the United States. Since the 1970s, SWPM has been the vector for 85 percent to 97 percent of the forest pests detected by APHIS during inspections (Williams and La Fage, 1979; Haack and Cavey, 1997; USDA APHIS and Forest Service, 2000). Over the 16-year period 1985-2000, 72 percent of the 6,825 bark beetles (*Scolytidae*) intercepted by APHIS were hitchhiking on SWPM (Haack 2002).

SWPM is imported from nearly every trade partner to every part of the United States. As international trade increases, there is a corresponding increase in the amount of wood packaging entering the country (USDA APHIS and Forest Service, 2000). The risk is highest for crates, intermediate for dunnage, and lowest for pallets. Haack and Cavey's 1997 reviews of APHIS interception data for all potential forest pests found that 45 percent of 6,952 insect interceptions were on crates; 33 percent on dunnage; and only 6 percent on pallets. Considering only bark beetles, but over the longer period 1985-2000, Haack (2002) found 32 percent in crates, 27 percent in dunnage, and 6 percent in pallets.

Construction of SWPM can occur in any country, and pieces with attached bark may be included. Unfortunately, some exporters have purposely constructed SWPM so as to conceal wood with attached bark from inspectors, *e.g.*, on the inside of spools (Dawson *et al.*, 1997). Durable SWPM products, *e.g.*, pallets, are often recycled after initial use. For example, a pallet built in China would be loaded with goods, enclosed within a shipping container, arrive in a United States port, and be transported to a factory in an interior city. After the pallet was unloaded, it would be stored with other pallets until collected by a pallet recycling company and eventually used in a shipment to another country. During these months, exotic pests can emerge.

Proper inspection of SWPM by APHIS is virtually impossible for a variety of reasons that are listed below (*cf.* USDA APHIS and Forest Service, 2000):

- The sheer volume of imports using SWPM prevents APHIS from inspecting individual pallets, crates etc.
- Containerization of shipments limits access to SWPM by inspectors.
- SWPM is not identified on the shipping manifest, so APHIS does not know if it is present, in what form, *e.g.*, pallets, crates etc., and if it has been sterilized.
- SWPM can accompany a wide variety of goods; one survey found SWPM with more than 250 different commodities.
- SWPM can be made from virtually any species of woody plant, and without sterilization information, an accurate assessment of risk is impossible.
- Solid wood can conceal deep-wood pests.
- Since SWPM often accompanies imported goods to their final destination, any associated pests can be taken to virtually any location within the United States.
- The practice of reconditioning and reusing damaged SWPM results in further distribution and opportunity for pests to mature and escape.

Weaknesses in Laws, Policies, and Strategy in Prevention, Eradication, and Control of Exotic Pests

The politics of trade policy are inherently tilted against the application of effective programs to exclude invasive exotic species introduced *via* the three primary pathways described in Chapter 2. Governments negotiate international trade agreements that promote trade while simultaneously constraining the ability of phytosanitary agencies to respond to pests imported with goods. When goods are imported, a specific, identifiable set of people benefits: importers, merchants, and the customers who buy the goods. If a pest enters the country on these goods and becomes established, it is usually impossible to identify exactly which shipments were responsible. Pest-related damage to agriculture or natural resources and costs to eradicate or control exotic pests and restore impacted natural resources are dispersed among all American taxpayers, who are an amorphous group lacking a coherent voice on this issue. Consequently, there is noone advocacy group to lobby for inclusion of appropriate pest-exclusion measures in trade agreements.

Exotic weeds and plant pests cause damage estimated at $80 billion annually (Pimentel *et al.*, 2000), which is 60 percent more than the $50 billion earned by United States agricultural exports in 1999 (Business Digest U.S. Farm Exports, *Seattle Post Intelligencer*, December 1, 1999). Yet United States' trade policy is dominated by efforts to expand agricultural and other commodity exports, even when those efforts lead to policies that result in an unnecessarily large number of damaging invaders entering the country. We have reviewed the major trade agreements accepted by the United States and believe that there are a number of revisions that need to be made to ensure protection of our natural heritage.

Problems With International Trade Policy

History has shown that importation of invasive species is an intrinsic risk of international trade (OTA, 1993). Each added shipment creates a new opportunity for exotic species to be carried to the United States. Attempting to increase the effectiveness of pest exclusion programs by increasing inspections and interdiction will not be effective for several of the forest pest vectors of concern, *e.g.*, nursery stock and wood packaging (USDA APHIS and Forest Service, 2000; National Plant Board, 1999; Powell *et al.*, 1984; comments by the American Nursery and Landscape Association and Society of American Florists on Docket No. 00-042-1). Unfortunately, the trade agreements that promote expansion of international trade have also imposed strict limits on a country's rights to adopt stringent phytosanitary safeguards. The World Trade Organization's (WTO's) Agreement on the Application of Sanitary and Phytosanitary Standards (SPS Agreement), as further elaborated by the 1997 amendments to the International Plant Protection Convention (IPPC), prescribes the phytosanitary measures that a country can apply and the information necessary to justify these actions (Appendix 2 contains summaries of these agreements; the text of the SPS Agreement can be read at www.wto.org; the text of the IPPC is available on www.pps.go.jp./english/agr_01/contents.html). In our view, aspects of these international agreements virtually guarantee a disproportional increase in future introductions of harmful forest pests over what could be expected if strong phytosanitary regulations were applied to importations.

Established Pests

Perhaps the most alarming provision in the SPS Agreement and IPPC is the severe restriction on the actions APHIS can take to prevent additional introductions of organisms belonging to any of the thousands of species of exotic insects, fungi, and plants already invading our natural and agricultural systems. The SPS Agreement says that if APHIS wants to prevent further introductions of an exotic pest species already in the country, it must treat the organisms inside the United States in the same way as it treats their conspecifics at the border. As elaborated by the IPPC, this means that APHIS may "exclude" this pest <u>only</u> when the species is not widespread <u>and</u> is the target of an "official control program" [emphases added].

The IPPC's definition of "official control program" requires that the program involve "active enforcement of mandatory phytosanitary regulations . . . with the objective of eradication or containment . . .." Under the definition adopted by the IPPC's parent organization, the United Nations Food and Agriculture Organization, an "official" program must be established, authorized, or performed by a nation's phytosanitary agency, *i.e.*, APHIS. As of November 2001, APHIS was trying to establish a procedure under which it could rely on individual states' quarantine programs to meet the definition of "official control".

Biological invasion of the United States is real and to use a current cliché, presents a "clear and present danger" to the landscape of the country. Thousands of exotic insects and more than 200 exotic plant pathogens have become established in the United States (USDA APHIS and Forest Service, 2000); not all are forest pests. Approximately 4,000 exotic plants are established outside cultivation (Kartesz, 1999; USGS, 1998), and according to our own compilation, more than 500 of these invasive plants are already known to have harmful impacts on the environment. Neither APHIS nor the federal government as a whole has sufficient resources to carry out an "active" program to "eradicate or contain" more than a few of these pest and weed species. Moreover, it is impossible to eradicate or contain a number of exotic pests. For example, despite billions of dollars spent to control gypsy moth, the area of permanent infestation continues to grow each year. The result of the combination of new international requirements and diminished funding for control programs is that the United States will use phytosanitary measures to prevent additional introductions of only a few of these species which are already demonstrated to be damaging invaders. We argue that the definition of "official control program" should be sufficiently broad to protect our ecosystems from additional introductions of these organisms, regardless of whether APHIS has sufficient funds to conduct an "active" program targeting each of these species.

In practice, APHIS solves this dilemma by ignoring the requirement that established pests be the target of official control programs. Many of the established pests remain on the agency's "action" list, and port officials continue to impose phytosanitary measures to prevent their entry. The risk is that a country exporting commodities subject to these actions might challenge the United States' right to act and would probably win the case. For example, if APHIS officials refused entry to a shipment of horticultural plants from China on the grounds that it was infested with hemlock woolly adelgid, China would have a very strong case for objecting to that refusal. The extensive federal and state efforts to address this pest do not include mandatory restrictions on moving potentially infested stock or supervision by APHIS, as is called for by the definition of "official program"; therefore, the shipment would have a legal right to be admitted.

Appropriate Level of Protection

The SPS Agreement recognizes a country's right to establish its own "appropriate level of protection", but with two constraints that undermine the ostensibly protective language. First, **Article 3.3** requires that countries justify their "appropriate level of risk" through a risk assessment evaluating some specific risk. Asserting that there could be *some* risk is not sufficient, (Victor, 1999; WTO AB-1998-5). Thus, the many unknowns confronted when conducting risk assessments undermine efforts to determine definitively an "appropriate level of protection".

Second, **Articles 2.3 and 5.5** require that "levels of protection" be consistent in different but comparable situations (WTO AB-1998-5). Comparisons can be made to the level of protection applied to the pest risk associated with a separate but somehow similar imported good, or to domestic regulation of the same or similar pests or commodities. For example, the United States must apply equally stringent regulations to prevent introduction of an insect from Europe and Asia. Victor (1999) believes that the comparison could also be made to other health or environmental measures. Under Victor's interpretation, the United States could not aim for greater protection from introduced pests than from an air pollutant that threatened crop productivity. Under this interpretation, any loopholes in protection found in environmental statutes can become "ceilings" which no phytosanitary "level of protection" may surpass.

Article 3.2 International Standards

Article 3.2 of the SPS Agreement states that a country "basing" its phytosanitary rules on international standards adopted by the International Plant Protection Organization (IPPO) is considered in conformity with the SPS Agreement. The SPS Agreement does not specify the process that the IPPO must follow or even whether it must justify the standard. The foundation for this work appears to be lacking, as the 1997 amendments to the IPPC have not yet come into force (too few parties have ratified the amendments); nor does the IPPO have an agreed definition of its "appropriate level of risk," which should be the foundation for any standard or a process for reaching it (Victor, 1999). Nevertheless, the IPPO has adopted several international standards, including one for wood packaging (see the summary in Appendix 2; the IPPO standard is analyzed below) and is negotiating the drafts of several other standards, including one to guide evaluation of impacts of plant pests on the natural environment.

Articles 5.1 - 5.6 Risk Assessment

The SPS Agreement requires that a country evaluate specific threats posed by specific organisms in a risk assessment before instituting phytosanitary controls. The SPS Appellate Body has ruled that the analysis does not have to be quantitative (WTO AB-1998-5), and that the country need not show that the damage will reach a certain threshold level (WTO AB-1997-4). However, the risk assessment must be very specific about the organisms to be regulated and the threat they pose. In one case, the dispute panel, supported by the Appellate Body, ruled that a risk assessment must evaluate the carcinogenic potential of specific hormones at the specific residue levels that would be found "*in 'food*,' more specifically, '*meat or meat products*,'" when the hormones are "used specifically for growth promotion purposes" [italics in original] (WTO AB-1997-4, p. 79). We doubt that scientists can obtain similarly specific information about the risk posed by potential pests that might be introduced into the country. Furthermore, the Appellate Body decided in another case that "it is not sufficient . . . that there is a 'possibility' of entry. A proper risk assessment . . . must evaluate the 'likelihood,' *i.e.*, the probability, of entry, establishment, or spread" (WTO AB-1998-5, p. 74). Again, we question whether scientists can predict the likelihood of introduction with any specificity.

How realistic can such assessments be when scientists experience great difficulty in attempting to predict which species might hitchhike on a shipment and whether those species might become invasive when introduced to a new environment? Among the challenges:

- A very incomplete knowledge about how many species exist and where they are found.
- Difficulty in identifying some life stages even when dealing with known species, especially juvenile forms of insects. About 20 percent of the arthropods intercepted on imported plants over the decade of the 1990s could not be identified to order (NRC 2002a).
- Insufficient familiarity with the ecological role of intercepted species in their native environment (if known) with a consequent difficulty in predicting host species.
- Scientists' inability to predict accurately what an organism will do in a new environment. According to Wallner (In press), "[e]xperience shows that the pestilence of an organism cannot be predicted from its status in its native country. For example, only 18 percent of immigrant insects and mites in the United States behaved exactly as one would have expected from their behavior in their country of origin."

Furthermore, introduced pathogens have new opportunities to hybridize, with the potential to accelerate the evolution and emergence of entirely new diseases. This process has been illustrated by the two elm disease fungi *Ophiostoma ulmi* and *O. novo-ulmi* (Brasier, 2001). According to Dr. George Carroll, past President of the Mycological Society of America (1998):

> Current regulations are based in part on pest risk assessments . . . However, most of the fungi that have caused devastating epidemics upon introduction to North America were previously unknown as significant pathogens and indeed were not significant pathogens in their native habitat. Today, it is estimated that 95 percent of fungal species in the world remain undescribed, let alone understood in terms of ecological function. We do not believe that pest risk assessments can adequately identify organisms which may cause severe damage in North America.

Phytosanitary agencies are more likely to identify pests that threaten major crops, such as citrus or wheat, that are grown around the world. Identification of potential forest pests would be much more difficult, as only a few United States species, *e.g.*, Monterey pine, loblolly pine, slash pine, or northern red oak are grown widely in other countries. The United States has a myriad of forest species and types reaching from boreal to tropical ecosystems. The number of potential invasive organisms that could affect the diverse forest ecosystems in this country is virtually incalculable. According to Wallner, " . . . forest ecosystems are highly complex, and most forest pests are not thoroughly understood. As a result, the answers to the key questions[1] often represent little more than speculation" (Wallner, In press). Not surprisingly, some risk assessments have concluded that a species represented a low risk, only to have that prediction subsequently proved incorrect. An example is the small Japanese cedar longhorned beetle (see Box 1).

Box 1

Smaller Japanese Cedar Longhorned Beetle

During the 1970s and early 1980s, the smaller Japanese cedar longhorned beetle (*Callidiellum rufipenne*) was intercepted frequently by APHIS in dunnage and casewood. However, after a 1982 risk assessment concluded that the beetle feeds only on dead or dying material, APHIS removed the species as a quarantine pest. In 1997-1998, the insect was discovered feeding on live arborvitae in Connecticut. By spring 2000, the beetle had been located in several sites from Rhode Island to New Jersey, and in North Carolina. APHIS restored the insect's status as a quarantine pest within days of the initial discoveries. Further study has shown that the beetle feeds on more than nine genera of conifers, including firs, junipers, and pines. It has also been introduced into Italy and Spain. Although APHIS has no interceptions records for the period 1982-1998 (when it was not considered a "quarantine pest"), the Japanese cedar longhorned beetle remains one of the most frequently intercepted species entering on SWPM. Other possible pathways of introduction include balled nursery stock, green logs, and pruned branches (USDA APHIS and Forest Service, 2000). See also APHIS' fact sheet at: www.aphis.usda.gov/npb/C.rufipenne%20alert.pdf.

Smaller Japanese cedar longhorned beetle adult female and male. Male is darker with longer antennae. Photograph courtesy of the Connecticut Agricultural Experiment Station Archives (http://www.bugwood.org)

Article 5.7 Provisional or Emergency Regulations

The SPS Agreement (Article 5.7) allows countries to adopt a "provisional" phytosanitary measure when information about a potential pest or pathway is inadequate to support a fully realized risk assessment. However, the text of the agreement and a decision by the Appellate Body make it clear that "provisional" measures are intended to allow response to a situation demanding immediate action. They are expected to be short-term and the

[1] These "key questions" were specified earlier as 1) What is the probability that the introduced species will be harmful? 2) How harmful is the introduced species likely to be?

exception rather than the rule. The country must actively seek the missing information and must review the provisional measure within a reasonable period (Victor, 1999). Thus, Article 5.7 does not enable countries to evade the unrealistic levels of specificity demanded for risk assessments. Instead, applying this provision results in APHIS subsequently expending scarce resources preparing full-fledged risk assessments to justify interim regulations, when the agency should better focus on addressing the many pathways of introduction that remain inadequately regulated.

Preamble, Articles 2.2, 5.4, 5.6, and Annex C: Minimal Impact on Trade

Another problem with the SPS Agreement is the explicit requirement in the Preamble, Articles 2.2, 5.4, 5.6, and Annex C that phytosanitary safeguards have a minimal impact on trade. Often when an organism that has not previously entered the country is found during inspection, available data on the host range, life cycle, *etc*., are ambiguous and open to interpretation as to how that organism will respond to a North American environment. In these instances, the staff has latitude over admission measures ranging from designation as a "quarantine pest" to concluding that the organism is benign and admitting the shipment without further interference. The SPS Agreement language clearly will affect how phytosanitary agency staffs resolve such ambiguous situations, particularly when political pressure is brought to bear for admission of a particular shipment. According to David McNamara, Assistant Director of the European and Mediterranean Plant Protection Organization, during the discussion on the American Phytopathological Society's "on-line" symposium in 2001, "Recently, [phytosanitary agency officials] have come to realize that our work has changed from 'preventing introduction of pests while not interfering unduly with trade' to 'facilitating trade while doing our utmost to prevent pest introduction.' The signing of the SPS Agreement was the moment when the switch was completely turned. And until we can convince our politicians that protecting plants is more important than international trade, that is the way it is going to stay." We fully agree with Dr. McNamara's comments.

The SPS Agreement and IPPC policy also does not recognize:

- the severity and often irreversibility of bioinvasion
- cumulative effects from the thousands of introductions
- the rising danger of introductions resulting from increased international trade
- practical limits on scientists' ability to predict behavior of organisms introduced to new environments
- the need for a margin of safety

Finally, the trade agreements appear to require that countries postpone applying phytosanitary measures until they actually detect a pest in a shipment, rather than acting on the basis of a risk assessment that documents that the pest is likely to hitchhike along a specific pathway. Roddie Burgess, of the United Kingdom Forestry Commission, said during the discussion on the American Phytopathological Society's "on-line" symposium in 2001, "Logic says we should act before a problem arises, but the SPS suggests we need to identify the problem first. Or . . . wait until the existing controls have been proved insufficient and then beef them up." We believe that the SPS and IPPC as now written virtually ensure the establishment of additional exotic pests, including forest pests, in the United States at a higher rate than would have occurred under more sensible international agreements that recognize the impact and associated costs of introduced pests.

In short, the SPS Agreement and IPPC appear to preclude APHIS from taking a more precautionary stance. Similarly, the SPS Agreement and IPPC appear to obstruct APHIS from abandoning its current emphasis on inspection and detection, which is directed towarddiscovery and mitigation of a sufficient proportion of hitchhiking organisms to prevent their establishment (*cf*. David McNamara, 2001). We favor an increased emphasis on regulation of probable vectors (= pathways) of introduction.

The Costs of Preparing Risk Assessments

When properly conducted, risk assessments are a valuable tool in phytosanitary decision making. There is, however, a finite number of risk assessments that a country can prepare due to cost and personnel limitations. The five pest-risk assessments the USDA conducted between 1991 and 1999 to examine the dangers associated with imported logs and lumber cost nearly $700,000, exclusive of the salaries of the federal scientists who participated (Wallner, In press). Meantime, APHIS has a backlog of about 400 risk assessments that it must complete to bring current regulations into compliance with the SPS Agreement (Deputy Administrator Richard Dunkle, personal communication). Many assessments need not be as expensive as the previous lumber assessments, but APHIS has had a very small policy staff charged with this responsibility. In 2001, APHIS began hiring additional staff to address the backlog of risk assessments.

Treaty to Establish a Free Trade Area of the Americas

All the nations of the Western Hemisphere except Cuba are negotiating a trade agreement to establish a Free Trade Area of the Americas (FTAA). This agreement will also further define the phytosanitary requirements set by the WTO SPS agreement. (The 2001 draft text of the agreement can be found at www.ftaa-alca.org; the phytosanitary issues are found in Section 5 of the Agriculture Chapter.) The draft provides alternative wording for many clauses; the negotiating countries will choose among these alternatives. Unfortunately, some of the choices would create additional difficulties in preventing pest introductions. Below are our thoughts on the important clauses in this draft agreement.

Excessive Emphasis on Consultations

There is considerable emphasis on consultations throughout the draft treaty. For example, under a version of proposed Article 17.a.2, when a Party finds that an international standard is not sufficient to ensure its appropriate level of protection, or even when no such standard exists, that Party must "engage in consultations with interested Parties to define and adopt the necessary standard for application in trade among them." Furthermore, consultations would be required for the most detailed aspects of implementation. Under proposed Article 17.c, the Parties agree to harmonize the systems they use for sampling, diagnosis, inspection and certification of animals, plants, their products and byproducts, as well as food safety. Mandating such frequent consultations will at least delay the U.S.' ability to adopt new phytosanitary safeguards and probably will result in approval of less rigorous phytosanitary measures.

Time Deadlines

Equally troubling are the numerous situations in which the draft treaty would impose time deadlines for completing risk assessments and other tasks required for setting both a country's appropriate level of protection and specific phytosanitary measures. The WTO SPS contains no such hard deadlines. Risk assessment should be a thorough process and allow for new discoveries that may necessitate unanticipated expansion of the work to be done. The United States, the most prosperous country negotiating this agreement, has experienced difficulties in completing risk assessments promptly. Under draft Article 17d.4., the exporting country could ask the FTAA forum to open trade in the subject commodity if the analysis were not completed by a particular deadline, thus giving trade interests a clear advantage over those seeking to prevent pest introductions.

Special Treatment of Developing Countries

At several points in the draft, countries with small or underdeveloped economies are granted special dispensations for complying with phytosanitary measures. For example, Article 17.c.6. allows countries with smaller economies and at lower levels of development more leeway in demonstrating to an importing country that its efforts to prevent pests from infesting exported commodities are "equivalent" to the importing country's requirements (see below). While we understand the social equity concerns that motivate such proposals, the result will be serious impairment of phytosanitary measures' effectiveness. Invasive species are as likely to originate in developing countries as in those with advanced economies.

Article 17.c.7

An area raising great concern is the draft treaty's treatment of the WTO SPS obligation to accept other countries' phytosanitary measures as "equivalent" if they afford the same level of protection. A poor choice of wording could force APHIS to accept other countries' efforts even when the result is an increased likelihood of introduction. Such a problem arises with the first of the alternative wordings for Article 17.c.7.1., which does not even conform to the WTO SPS requirement that the "equivalent" measure meet the importing country's designated level of sanitary or phytosanitary protection. The second alternative for Article 17.c.7.1. does specify that the "equivalent" measure must meet the importing country's level of protection. However, it is uncertain which of these alternatives the negotiators will accept.

It is also troubling that three alternative versions of this clause emphasize that the general objective of equivalence agreements is not just to facilitate trade but to "simplify" or even "eliminate physical controls" used "to verify" that products that come into the territory of the importing Party fulfill the requirements of the importing Party. We feel that this language is aimed at skirting countries' port inspection requirements.

Article 17d. Emergency Measures

Language in one version of Article 17d.6. requires a country imposing new measures to present a "scientific justification" "immediately" in an emergency situation. This provision should be amended to clarify that this "scientific justification" is not required to meet the standards laid out in the WTO SPS for "risk assessment." Otherwise, the allowance for emergency action (under Article 5.7 of the WTO SPS) would be meaningless.

Article 17.d.7

This clause is entirely unacceptable as written because it allows only "countries with small economies" to adopt a provisional phytosanitary measure. The WTO SPS allows all countries to adopt such a measure when available information is not sufficient to support a permanent measure. In contrast, Article 17.h. clearly permits all Parties to adopt provisional measures—as provided by Article 5.7 of the WTO SPS.

Article 17.e. Pest Assessment

One version of the proposed subpart Article 17.e.3. would require the Parties to accept automatically a determination by the IPPC that an area is pest- or disease-free or of low pest- or disease-prevalence. This is not acceptable. The WTO SPS clearly puts the burden on the exporting country to demonstrate that the "pest- or disease-free" area does indeed qualify for that designation. Even if alternative language conforming to the WTO SPS requirement is adopted, we remain concerned about the specification of a time period in subpoint 17.e.4.2.; at least in this case, the time period is subject to negotiation between the two parties involved.

Article 20.1.2.g Registration of Experts

Article 20.1.2.g calls on the FTAA Sanitary and Phytosanitary Committee to prepare and update a register of qualified specialists in the areas of food safety, plant protection, and animal health. This clause provides an opportunity to ask that the FTAA Committee compile a similar register of qualified specialists in the area of species invasive in natural areas.

Since almost the entire text of the draft agreement is still open to negotiation, scientists and concerned citizens might have an opportunity to correct some of the problems in the WTO SPS or at least to avoid language which might exacerbate exotic pest problems.

Problems with APHIS

No governmental agency is without problems, and APHIS is no exception. Incompatible goals for the agency, years of anti-government rhetoric, and reductions in authority and resources have severely curtailed APHIS' ability to prevent introductions (National Plant Board, 1999).

Conflict Between International Trade and APHIS Responsibilities

Congress expects APHIS to straddle the conflicting goals of promoting trade while preventing introductions of harmful exotic organisms. This Congressional stance fails to reflect studies by the Office of Technology Assessment (1993), General Accounting Office (1997), Congressional Research Service (Corn *et al.*, 1999), the National Plant Board (1999), and independent experts (Miller, 2000) that found attempting to balance trade promotion and pest exclusion poses a "challenge" for APHIS. In adopting the Plant Protection Act in 2000, Congress stated [Finding (3)]:

> (3) it is the responsibility of the Secretary [of Agriculture] to facilitate exports, imports, and interstate commerce in agricultural products and other 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 or noxious weeds.

In demanding this "balance" between trade and protection, Congress has effectively forfeited APHIS' ability to decide objectively on admission or rejection of shipments and thus has compromised our country's most protective stance against exotic pests. In 1998, then Deputy Secretary of Agriculture Isi Siddiqui told the senior author that the philosophy of "if in doubt, keep it out" was no longer appropriate in an era of trade promotion (personal communication to F. T. Campbell, meeting with Siddiqui and others, April 1998).

In seeking to balance its two contradictory obligations, APHIS does not strive for complete protection, but a "negligible" risk level of protection. APHIS has never explicitly defined what it considers to be a "negligible" risk, although a recent court decision requires that the agency specify that level (see discussion of risk assessment procedures, below). In analyzing the risk presented by imports of logs and lumber, the agency implicitly accepted a 95-97 percent protection level as adequate (*cf.* USDA APHIS 1997; USDA APHIS, 1998a). The Oregon Department of Agriculture has declared this level of protection to be inadequate. "We also do not concur that a 95 percent reduction is an "extensive treatment," especially when we are dealing with many thousands of tons of imported wood products per shipment . . . The 5 percent residual ... still leaves huge window of opportunity for pest escape and establishment," (Hilburn *et al.*, February 9, 1998; in USDA APHIS, 1998a). We strongly agree with the Oregon Department of Agriculture.

A “level of risk” of 3 to 5 percent is actually quite high. This risk is 10 to 14 times greater than the risk of dying from cancer incurred by a cigarette smoker (Botkin, 2001). In practical terms, a 3 to 5 percent risk applied to current import volumes results in the likelihood that tens of millions of damaging organisms would reach our shores. If 3 to 5 percent of the nearly 700 million plants imported in 1999 bore a quarantine pest, the result is transport of between 21 million and 35 million pests. If pests infested 3 to 5 percent of the more than 2.5 million cubic meters of logs, lumber, and railroad ties imported from countries other than Canada in 2000, it translates to 77,000-128,000 pests brought to our shores. Considering the more than 14 million shipping containers entering the United States annually, if half contain wood packaging, and 3 to 5 percent of that packaging harbors a quarantine pest, that is between 210,000 and 350,000 pests entering each year. In other words, in just one year, these three pathways potentially could result in arrival of 36 million pests into the United States under the terms of a strategy based on aso-called “negligible” risk. This staggering figure is of particular concern, as no one knows the real number of pests entering the country every year, given the limits of inspection and the absence of a concerted “early detection” program.

Minimal Efforts to Protect Natural Systems

Despite the broad wording of the Plant Pest Act and the earlier legislation which it replaces, APHIS has placed its priority on preventing introduction of pests of agriculture (GAO, 2001). This limited perspective reflects the priorities of the Congressional committees that oversee APHIS. The agency primarily reports to the House and Senate Agriculture committees and Agriculture Appropriations subcommittees, which are bodies that focus on crop species and have either minimal or no jurisdiction over forests and natural resources. In particular, the Agriculture Appropriations subcommittees often “earmark” funds to prevention or control measures targeting specific crop pests. Although the USDA Forest Service is responsible for addressing established exotic forest pests, it has no responsibilities in exclusion of pests. Effectively, this means that no federal agency places a priority on preventing new forest pests from entering this country.

Delays in Closing Pathways of Introduction

Scientists have warned about the risks of pests entering on SWPM and other wood articles at least since the late 1970s (Williams and La Fage, 1979), but it was not until 1995 that APHIS adopted regulations addressing these pathways. The 1995 regulations, however, give only limited protection in many respects. Consequently, articles known to vector damaging pests continue to enter the country and are subjected only to the insufficiently effective measure of inspection (see below).

The requirement in the WTO SPS that APHIS conduct a risk assessment to justify a new phytosanitary regulation causes additional delays in APHIS’ regulating newly recognized pathways. APHIS could reduce the impacts of these delays by utilizing its authority under Article 5.7 of the SPS Agreement to impose provisional regulations. However, the only time the agency has invoked Article 5.7 for forest pests was to target Chinese wood packaging after the widespread publicity surrounding the introduction of the Asian longhorned beetle and the likelihood of other introductions from China. In April 2001, APHIS claimed to be using Article 5.7 to speed adoption of measures to tighten restrictions on horticultural plants (see below), but the proposed regulation still had not been put into effect a year later.

Reliance on Visual Inspection

Visual inspection alone is widely considered ineffective in preventing introduction of exotic insects and pathogens (La Fage and Williams, 1979; Powell *et al.*, 1984; USDA APHIS, 1997; USDA APHIS, 1998a; Stone, 1998; USDA APHIS, 1999b; National Plant Board, 1999; USDA APHIS and Forest Service, 2000). APHIS cannot thoroughly inspect all incoming shipments, due to the nature of shipping containers and inadequate staffing and resources (La Fage and Williams, 1979; GAO, 1997; USDA APHIS and Forest Service, 2000). APHIS is moving slowly and hesitantly away from reliance on visual inspection toward more reliance on a “systems approach” that attempts to use mandates requiring shippers to take specified precautions to minimize the risk that pests will be present in the shipment. However, we think that an increasing number of hitchhiking organisms are virtually guaranteed to enter the country, because APHIS has been reluctant to impose sufficiently stringent requirements (see below). Until the agency does adopt the strongest possible regulations, it must still depend on inspectors' finding those pests that evade the less effective safeguards the agency has adopted. Yet, as we have already stated, inspection is widely recognized as being only minimally effective in preventing pest entry.

Specific Problems with the Risk Assessment Procedure

As indicated above, a difficulty in conducting risk assessments is how to treat the frequently encountered information gaps about pests and potential host species and uncertainty with respect to organisms' behavior in new environments. APHIS admits that a high level of uncertainty exists when staff attempt to evaluate risks associated with unknown pests. While APHIS claims that it does not equate this uncertainty with "low risk" (USDA APHIS, 1998a), concerns remain, as we outline below.

The National Plant Board (1999) has been extremely critical of APHIS' risk assessment process. As a result, APHIS has launched a review of its risk assessment procedures.[1] During this process, Craig Regelbrugge of the American Nursery and Landscape Association, speaking in his capacity as co-chair of the NPB's "safeguarding review" team, reiterated the review team's conclusion that "APHIS' risk analysis process . . . is unsustainable." The risk assessment process has been weakened by insufficient resources; the absence of clear priority-setting standards and ways to resolve differing perceptions of risk; and the lack of adequate feedback from ports of entry for use in refining assessments and mitigation strategies. Although a full scientific peer review of risk assessments would be desirable, it was considered to be impractical because of the unrealistic demands such a process would put on agency resources.

Two representatives from the citrus industry also spoke. Jean-Marie Peltier of the California Citrus Quality Council suggested that APHIS needed scientific policy papers to support its risk assessment processes. Ms. Peltier also called on APHIS to improve its mechanisms for developing empirical data, including by creating a committee representing affected industry to advise APHIS on import and export priorities. Ms. Peltier said APHIS needs additional resources to do risk assessments. Nancy Williams, representing the U.S. Citrus Science Council, expressed concern about APHIS' attempts to straddle the dichotomy between trade promotion and protection. She said APHIS had "a desperate need" for clear risk-assessment procedures.

The U.S. Citrus Science Council had invited Edmund Crouch to review a recent risk assessment from the perspective of his expertise in conducting risk assessments. Dr. Crouch had two principal criticisms of APHIS' risk-assessment process: the absence of a clear statement of the policy goal and "a notable lack of discussion of consequence" of the introduction. Dr. Crouch also stressed the importance of consulting with non-agency experts at all stages to ensure that no factors had been omitted.

In September 2001, the U.S. District Court for the Eastern District of California found that USDA APHIS had violated the Administrative Procedures Act when it issued a regulation allowing importation of citrus from Argentina.[2] The court found that APHIS had acted arbitrarily first by not specifying a negligible risk threshold for each of the four pests associated with the commodity. The court considered the failure to specify at what level the risk ceased to be "negligible" to be "of particular concern given that the risk increased significantly when APHIS reevaluated its risk assessment."

---

[1] See comments on Docket No. 99-079-01, available at the APHIS Document Room.

[2] Harlan Land Co., Limoneira Company, Pecht Ranch, R7 Enterprises; and U.S. Citrus Science Council vs. U.S. Department of Agriculture, Daniel Glickman, Secretary of Agriculture; and Craig A. Reed, Administrator, Animal and Plant Health Inspection Services [sic]. In The United States District Court for the Eastern District of California CV-F-00-6106 REC/LJO Order Granting Plaintiffs' Motion for Summary Judgment, Denying Defendants' Motion for Summary Judgment, Suspending Argentine Citrus Rule and Remanding to APHIS
Filed September 27, 2001

The Court also found the risk assessment itself to be faulty because it failed to link the regulatory decision to the data analyzed. "APHIS scientists failed to link the documents and data to each of the [steps in the growing and importing process]. One of the principles of risk assessment is the complete and transparent documentation of data used in the assessment. . . . Although APHIS refers to [more than 175 documents], the Risk Assessment does not state what information and data was [sic] used [to analyze the risk at each step in the growing and importing process]. Most of the input values were calculated without data and without reference to scientific or regulatory information."

The Court continued, "The uncertain nature of the Risk Assessment is illustrated by the fact that the risk of citrus black spot introduction increased [4.5-fold] under the revised Risk Assessment from one chance in 3.2 million to one chance in 763,000 for the mean and from one chance in 840,000 to one chance in 189,000 for the 95th percentile."

The court suspended the regulation and ordered APHIS to correct these errors.

This decision reflects the criticisms of APHIS' risk-assessment process raised by a variety of parties; indeed, the court cited Dr. Crouch's testimony. If this decision is not overturned by a higher court (it is unclear whether APHIS will appeal the decision), it should have profound effects on the agency's operations. We expect that the decision will force more rigorous application of science. However, the need to improve the risk assessments will probably result in further delays in adopting regulations governing now open pathways.

An analysis of APHIS' risk-assessment procedures carried out by the National Academy of Sciences [National Research Council (NRC), 2002a] reached similar conclusions. The NRC found that while APHIS bases its risk assessments on scientific concepts, the agency should better document the basis for its assessment, list and explain underlying assumptions, and provide for independent experts' review. The NRC recommends that the procedure should be transparent, repeatable, peer-reviewed, and updated to capture new information and enhance expert judgment. The NRC also recommended wider use of existing data on alien species' natural history, which is found primarily in the "gray" literature. The study provided a detailed set of recommendations on data collection and use and research to provide a more sound foundation for risk assessment.

The Need for Stronger Enforcement

The record demonstrates that shippers violate regulations fairly frequently, but there is little evidence that APHIS has penalized the violators. (We attempted to obtain a list of APHIS' relevant enforcement actions but were told that this information is not maintained in a way that would answer our questions.) In the mid-1990s, the Oregon Department of Agriculture complained (comment by Hilburn, Johnson, Griesbach, and Wright on Docket No. 91-074-3) that APHIS had not penalized shippers in two out of three cases when imported logs or lumber failed to meet existing regulations. In 1996, after the Asian longhorned beetle was identified feeding on trees in New York City, APHIS and its Canadian counterpart launched a campaign to determine the extent of the problem. They found many instances of Chinese and other shippers violating the agencies' requirements that bark be stripped from SWPM (see Box 2), and evidence of deliberately placing barked wood on the insides of spools and containers where it would be hard to detect. Forest Service personnel also found exit holes in wood that had been plugged to help escape inspectors' scrutiny (L. R. Barber to S. E. Schlarbaum, personal communication, August 19, 2001).

With regard to horticultural imports, in July 2001, APHIS published a notice in the *Federal Register* (*Federal Register,* July 23, 2001, Vol. 66, Number 141) announcing that, beginning in September, it would enforce the longstanding requirement that imported plants be accompanied by phytosanitary certificates issued by the exporting country. While APHIS data do not indicate the percentage of imported plants that currently enter the United States without phytosanitary certificates, the agency stated that it believed such imports to be primarily in small shipments imported by tourists, hobbyists, homeowners, small businesses, or importers who are newcomers to the plant trade. APHIS asserted that "consistent enforcement of the phytosanitary certification requirement . . . will help minimize the plant pest risks associated with these imports without subjecting affected importers and members of the general public to any costs that they are not already expected to bear" (*Federal Register*, July 23, 2001, Vol.

66, Number 141). Smuggled plant materials by individuals has been the source of at least one serious pest introduction. In the 1970s, a chestnut orchard owner from southern Georgia smuggled budwood of Japanese chestnut into the country and inadvertently introduced chestnut gall wasp (Payne *et al.*, 1975). Since introduction, the insect has rapidly spread north and westward *via* American chestnut sprouts and planted Asian chestnuts throughout more than one-half of the American chestnut's former range. This pest will pose an additional challenge in the effort to reintroduce blight-resistant American chestnut to eastern forests (S. A. Anagnostakis to S. E. Schlarbaum, personal communication, July 5, 2002).

Despite these assurances, within five weeks of issuing this notice, APHIS bent to pressure from importers and foreign exporters and postponed the effective date of the new policy from September 2001 to January 2002 [APHIS *Federal Register*, August 31, 2001 (Vol. 66, Number 170)].

Setting Priorities

While APHIS' safeguarding priorities should be based on objective scientific evaluations of relative risks, in reality, priorities are set by the various actors that determine the agency's budget, including other agencies within the U.S. Department of Agriculture, the Office of Management and Budget, and Congress (National Plant Board, 1999). One result is the low priority given to pests threatening forests and other natural areas. To APHIS' credit, it is struggling to improve this situation by contracting with the American Phytopathology Society, Entomological Society of America, and Weed Science Society of America to help identify high priority pests, *i.e.*, pests that have a greater probability of becoming established and having a widespread impact. However, as of October 2001, APHIS staff were hedging their statements on what actions they would take in response to the lists prepared by these societies.

The three scientific societies were asked to develop a list totaling 30 species, but all compiled much longer lists. The American Phytopathological Society posted its draft list on its web site for comments; among the 42 candidate priority species not yet found in the United States, 12 species were forest pests. Another three forest pests were included among the 20 species of "very limited distribution." The Entomological Society and Weed Science Society of America said that the terms of their agreement with APHIS prevented their sharing with us the lists they were developing.

We believe it is useful to compile such lists to set priorities in the development of rapid response plans in anticipation of possible introductions. They help in identifying organisms predicted on the basis of current knowledge to have a high probability of causing damage if they were to become established. However, these short lists should not be considered "complete" inventories of pests that might cause serious damage if they were to become established. APHIS must prepare to respond to a much larger number of organisms, given the uncertainty of exotic organisms' behavior in North America.

Data Base Contents

A major handicap in setting priorities is the highly biased nature of the principal dataset on which APHIS relies: the interception database. This database includes only those pests that are both intercepted on shipments <u>and</u> considered to pose a "significant" threat. Such a list does not truly reflect the organisms that are inadvertently imported into the country. Some hitchhiking pests are rarely detected by inspectors, *e.g.*, deep wood pathogens, and until recently, insects hidden inside wood (USDA APHIS and Forest Service, 2000). Second, even experts find it difficult to identify those pests that are detected, so they might record the wrong species. Inability to identify an organism or misidentification can result in an exotic species being mistaken for a related species that is already established in the country; in this case, APHIS would take no phytosanitary action. Incorrect identification also undermines attempts to use the interception database to quantify the rates at which particular pests enter the country and the effectiveness of the pest-mitigation measures. Third, detections are much more likely to be recorded for those types of imports on which APHIS concentrates its enforcement effort. This "sampling bias" then appears to confirm that these types of imports are the principal pathways of introduction, although they might not be. Thus, APHIS finds most quarantine pests in passenger luggage, on which it concentrates its inspection effort; whereas we believe it is probable that more hitchhiking pests that threaten forests are to be found in containers of goods, on imported living plants, etc. In fact, during the period 1990-1999, 35-40 percent of all arthropod interceptions were on imported live plants (NRC, 2002a). Similarly, if APHIS focuses inspectors on goods likely to transport agricultural pests, it has few resources to examine the probably quite different vectors that would be likely to carry forest pests.

Another source of "sampling bias" in the interception database comes from the inclusion of only those organisms determined to be "significant pests". Williams and La Fage (1979) warned about the weaknesses of interception data as a basis for analyzing pathways, since these data are skewed by both inspectors' choice of which types of cargo to inspect and the decision to not record interceptions of pests considered to be nonsignificant. This bias occurs in three areas.

1) Exclusion of nonsignificant pests from the database denies APHIS needed information on pathways a nonsignificant organism is using. As shown with the Japanese cedar longhorned beetle (Box 1), a pest deemed nonsignificant may actually turn out to be a significant pest.
2) The presence of nonsignificant pests also serves as evidence that living insects or pathogens are using the pathway. This should be a warning that the phytosanitary measure is inadequate and should be strengthened.
3) Data that include all hitchhiking organisms provides a way to measure the relative numbers of pests introduced *via* the various pathways.

Example of How Use of the Interception Database Could Disguise Problems

While the Great Lakes region does not rank high in either volume of incoming shipments (Williams and La Fage, 1979; USDA APHIS and Forest Service, 2000; Kanter, personal communication) or numbers of pests "intercepted" by APHIS staff (Haack and Cavey, 1997; USDA APHIS and Forest Service, 2000; Haack 2002), the Great Lakes ports have been the sites of recent introductions of Asian longhorned beetle, pine shoot beetle, an Asian insect that attacks ash trees (Hilburn, 2002), and several introductions (apparently without establishment) of the European spruce bark beetle. We believe that APHIS needs to conduct a thorough investigation on why introductions are occurring at these ports and take appropriate action.

Inadequate Regulation of the Three Primary Pathways for Forest Pest Introductions

Horticultural Imports

As noted in Chapter 2, the U.S. imports a huge volume of plants: nearly 700 million plants in 1999. Although imported plants represent a more significant risk of pest introductions than do fruits and vegetables, they are much less stringently regulated (National Plant Board, 1999). The "Q-37" regulations [see the summary in Appendix 2] are complex and confusing and they leave dangerous gaps in coverage. Increasing alarm arising from recent pest introductions on horticultural imports, expressed in the Safeguarding Report written by the National Plant Board (1999), prompted the Congress to insert into the Plant Protection Act an order that APHIS study better ways to prevent introduction of plant pathogens traveling on plants or plant products. APHIS was to work with scientists from state departments of agriculture, academia, the private sector, and the Agricultural Research Service. The report was completed in 2002 (NPB, 2002).

The "systems approach" was defined as employing a combination of restrictions and measures to prevent introduction or establishment of the target pathogens. Among measures that could constitute parts of a "systems approach" are treatment using chemical fumigation, heat, or cold; requiring pest-free planting stock; requiring prescribed cultural practices; requiring pest management throughout the growing area of the crop; pest monitoring as a trigger for action; standards for harvesting, sorting, packaging, and handling the produce; and post-harvest treatment.

The study's authors consider that plant pathogens pose a unique challenge, because a single infected plant or plant part may give rise to millions of propagative units. Consequently, phytosanitary agencies must consider such factors as:

- Whether potential host plants exist in those areas which might receive the potentially disease-bearing import?
- Whether environmental conditions in any of the potential receiving areas favor infection and disease development?
- Whether viable disease-causing propagules can reach the host to initiate a new infection?

Among the factors promoting adoption of a systems approach are trade promotion (which is undermining the historical reliance on prohibiting import of host material from infested regions) and environmental restrictions that limit the availability of effective chemical treatments.

The study concluded that the systems approach is effective as a phytosanitary strategy as long as certain conditions are met. First, at least two of the prescribed measures applied to any pathway must be *independently* effective. Second, the agency must specify the "appropriate level of risk" it is striving to achieve to provide the basis for determining what risk mitigation measures to apply. Furthermore, it must be possible to evaluate the effectiveness of the "systems approach" in either or both quantitative and qualitative terms.

While the study largely endorsed the systems approach as now applied by APHIS, we raise a number of concerns. First, we believe the study is factually wrong on several points. First, the study claims that most quarantine pathogens do not infest seeds. Nevertheless, references to damaging pathogens that have been transported on seeds, including pathogens that attack herbaceous as well as woody plants, are provided in, *inter alia*, Elmer (2001), Gordon (2002), and Wingfield (2002).

Second, the authors put great reliance on trading in host plants that are resistant to the target pathogen as a method for preventing transmission of the disease. However, forest pest experts, with whom we have consulted, say that a plant's "resistance" to a pathogen does not ensure that the plant cannot transmit that pathogen. Thomas Hall of the Pennsylvania Division of Forestry (personal communication) warned that non-symptomatic hosts pose a great phytosanitary risk as unsuspected reservoirs of infection. Importation of a tolerant host could also result in introduction of the pathogen, although the pathogen might be less vigorous. Even when the host is immune to the pathogen, there is still the possibility that it could be associated with the host as a surface contaminant or with soil adhering to roots, bark, etc.

We are also troubled that most of the conditions that the authors say are essential for Systems Approach to be successful are often missing in the case of forest pests. Such conditions as knowledge about the pathogen, its basic biology, and life cycle; the existence of systems for field surveillance and/or detection of pests in a shipment; and knowledge about harvest, packing, and marketing practices are rarely known for forestry. While it is often assumed that pests are absent from the commercial commodity, careful searches often reveal otherwise.

Nor did the study address how APHIS can ensure that any of the measures, or combination of measures, is effective against previously unidentified pathogens or pathogens that have minimal impacts in their native range but prove highly damaging once introduced to a new geographic area. As we have already noted, numerous pathogens that have caused significant damage to North American tree species gave no hint of their potential in their native ranges (Carroll, 1998).

Meanwhile, despite the demonstrated record of pest introductions on horticultural imports between 1991 and 2000, APHIS proposed relaxing the plant quarantine regulations to allow additional types of plants to be imported while established in growing media rather than "bare root," *i.e.*, without soil or other growing media. While the proposed new system would utilize a "soil-less" growing medium, that medium does not ensure pest protection. "Soil-less" media supporting growing plants is not sterile and could harbor larvae of insects with life cycles that include an underground larval stage. Leaves that have fungal diseases and that have fallen from the plant could be incorporated in the soil-less medium. These proposals have drawn considerable criticism, as detailed in the summaries below.

The APHIS proposals discussed here were put forward in the absence of clearly stated target risk levels, coherent goals, or an explicit underlying philosophy to govern exotic species management, contrary to criteria called for by the American Nursery and Landscape Association. We support the statement by the American Nursery and Landscape Association in its comments on Docket # 98-103-1 (see below) that APHIS has an obligation to specify its "acceptable level of risk" and that level of risk should not be set at "significant risk" or "current pest risk," as these standards are both unacceptably lax.

Rhododendrons

The first APHIS proposal to expand imports of plants in growing media concerned plants belonging to five genera: *Alstroemeria*, *Ananas*, *Anthurium*, *Nidularium,* and *Rhododendron* [APHIS *Federal Register*, September 7, 1993 (Vol. 58, No. 171) pp. 47074-47084]. While APHIS approved such imports for four of the genera in January 1995 [APHIS *Federal Register,* January 13, 1995 (Vol. 60, No. 4) pp. 3067-3078], the decision on *Rhododendron* was delayed by nearly five years [APHIS *Federal Register,* November 30, 1999 (Vol. 64, No. 229)]. APHIS had to obtain the approval of the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act, as the native *Rhododendron chapmanii* is listed as an endangered species.

This proposal generated virtually unanimous opposition from the more than 100 American scientists, horticultural industry representatives, and conservation organizations who submitted comments to APHIS.[1] In general, the critics objected that APHIS had not sufficiently acknowledged that importation of live plants is a high-risk pathway that provides potential pests an easily exploited means of transport both from other continents to the United States and, once here, into the natural environment. The critics pointed to a scarcity of scientific literature on pests that might be associated with these plant genera, particularly *Rhododendron*. According to the critics, APHIS had explicitly stated that a lack of information about a potential pest species in the (limited) literature meant that the organism would not be an important pest if it were introduced. One of the critics, Professor William H. Carlson of Michigan State University, said,

> In my opinion, . . . it is not acceptable to remove existing safeguards in order to facilitate trade simply because 'no information is available.' Such a policy is not scientific and ultimately poses a greater threat to our economy than the potential benefit of increased trade.

Many commenters questioned the efficacy of APHIS' proposed pest-mitigation measures. One theme was the inherent difficulty in detecting pests on the plants, especially root and crown rots, *Verticillium*, and nematodes (Powell *et al.*, 1984). The commenters pointed to various sources to show that such pests are quite capable of surviving in the growing media that APHIS had selected (Powell *et al.*, 1984; comments on the docket by Carlson, Chase and Osborne, and Regelbrugge).

Much of the controversy focused specifically on risks associated with imports of *Rhododendron* spp. According to those submitting comments, APHIS' own risk assessment team had concluded that the risk from <u>each</u> of two threats was sufficient that APHIS should not allow imports of rhododendrons in growing media. The two threats were: (1) the lack of information about a large proportion of the pests that might be associated with rhododendron plants; and (2) the difficulty in excluding or managing the quarantine-significant fungus *Chrysomyxa ledi* var *rhododendri.* According to Regelbrugge of the American Nursery and Landscape Association, APHIS was inconsistent in that it prohibits imports of spruce from Europe because of this fungus. APHIS responded that its requirement that the plants be observed several times during the lengthy growing period would ensure that infected

---

[1]These comments can be viewed at APHIS' reading room; specify Docket No. 89-154-1.

azaleas would be detected and banned from trade (*Federal Register* November 30, 1999, Vol. 64, Number 229). Despite the controversy, APHIS approved imports of rhododendrons in growing media from Europe in 1999 (*Federal Register,* November 30, 1999, Vol. 64, Number 229).

Rhododendrons are particularly worrisome because of the large number of related plants native to North America, including agricultural crops such as blueberry and cranberry, 37 native rhododendrons and azaleas found in forest ecosystems across the continent, and another 114 species or subspecies in the closely related genus *Arctostaphylos*, found primarily in the West. Six of the *Rhododendron* are considered "rare" by The Nature Conservancy and one, *Rhododendron chapmanii*, is listed by the U.S. Fish and Wildlife Service as an endangered species. Six species or subspecies of *Arctostaphylos* are listed as endangered or threatened species; 72 are considered to be "rare" by The Nature Conservancy (N. Benton, personal communication); and 57 *Arctostaphylos* are listed in the California Native Plant Society inventory of rare or endangered vascular flora (CNPS comments). Yet, APHIS confidently states that its measures will prevent any pests from reaching a suitable host (*Federal Register,* November 30, 1999, Vol. 64, Number 229).

In 2000, scientists discovered that the algal fungi causing sudden oak death in coastal regions of central California is a previously undescribed species in the *Phytophthora* genus (*Phytophthora ramorum*) and that a very similar fungus has been detected on rhododendrons growing in Europe. It is not yet known whether the fungus was introduced to California, much less whether it was introduced on imported rhododendrons. However, the Europeans had been struggling to contain the disease throughout APHIS' rulemaking (Devine, 2002), but the agency apparently never included information about this new pest in its analysis. It is ironic that, within a year after APHIS adopted the new regulation, scientists' linking of the California and European pathogens undermined APHIS' assurances that it was providing adequate safety.

APHIS issued interim regulations in February 2002 restricting interstate movement from California or Oregon of possibly infected nursery stock, wood, and foliage, but not soil (*Federal Register*, February 14, 2002, Vol. 67, Number 31). However, as of August 2002 APHIS still has made no change to the rules adopted in 1999 which allow imports of rhododendrons from Europe in growing media. According to an anonymous USDA source, APHIS believed that the WTO Sanitary and Phytosanitary Agreement required it to prepare a more complete risk assessment before restricting international trade.

We note that, to the contrary, Article 5.7 of the SPS Agreement allows countries to impose emergency restrictions. Clearly the oak forests in eastern North America are at risk. Regarding the domestic regulation, we are most concerned about the exemption for soil that has not been in direct physical contact with any article infected with the pathogen; this provision is too difficult to enforce.

***Phalaenopsis* Orchid**

While still considering the rhododendron decision, in 1998 APHIS proposed importation in growing media of orchids belonging to the tropical *Phalaenopsis* genus [APHIS *Federal Register*, September 1, 1998 (Vol. 63 No. 169), pp. 46403 - 46406]. In response, opponents raised similar concerns about the dangers associated with growing media and high levels of damage that could occur, particularly in Hawai`i where orchid production is an important industry.[1] The Society of American Florists noted that "[f]or the limited number of pests upon which a comparatively complete analysis is conducted, risk ratings are consistently 'high.'" APHIS' decision on *Phalaenopsis* is still pending as of August 2002.

Chinese "Bonsai" ("Penjing")

In September 2000, APHIS proposed allowing imports of "penjing" trees in growing media from China (*Federal Register,* September 20, 2000, Vol. 65, pp. 56803-56806). The underlying risk assessments (all prepared

[1]These comments can be viewed at APHIS' reading room; specify Docket No. 98-035-1.

in 1996[1]) fell far short of a minimal standard, in the view of those commenting on the proposal. These minimal risk assessments gave virtually all the pests (100 + taxa) an overall rank of "high risk," but contained no discussion of the criteria used for assigning pests to various categories of risk. Furthermore, each risk assessment noted the "special concerns associated with propagative material in growing media" and that the growing conditions in China exacerbate these risks. The proposal claims that these risks could be successfully minimized by imposing additional cultural and other requirements but failed to explain how this could be verified. The proposal made no reference to the 1999 discovery by APHIS that wood-boring longhorned beetles in the *Anoplophora* genus were hitchhiking in "penjing" shrubs (*Federal Register,* April 20, 2001, Vol. 66, No. 77).[2]

The organizations' comments on the proposal and risk assessments were scathing.[3] The American Nursery and Landscape Association (ANLA) and California Department of Food and Agriculture (CDFA) said APHIS should have waited for completion of its endangered species consultation with the U.S. Fish and Wildlife Service so that it could report the results of that consultation in seeking public comments. These organizations also criticized the risk assessments as not meeting the standards set out by the SPS Agreement and IPPC. The Society of American Florists said it was unacceptable to rely on a purportedly scientific risk assessment methodology when there was ". . . barely any pretense of presentation of scientific data." Both the ANLA and the florists expressed great disappointment that APHIS has not responded to the criticism of the agency's regulation of propagative material as an introduction pathway and several outside reports intended to strengthen safeguards. The Society of American Florists further said APHIS should implement the recommendations in the National Plant Board's Safeguarding Review (1999) before it proposes any additional amendments to Q-37. The ANLA found that the acceptable level of risk was not made explicit in the assessments. In the view of the ANLA, APHIS hints at a level of "*significant risk*" or current pest risk, but the American Nursery and Landscape Association said neither is acceptable, especially given the frequent introductions in recent years.

As to the specific proposal, the Society of American Florists commented: "The [pest risk assessment], as incomplete as it is, does not even appear to have been used by the decision makers." The mitigation measures outlined in the proposal are completely inadequate to offset the very high level of risk. " . . . [S]imply admitting that the action will pose a very high risk to U.S. agriculture and the environment, but then pushing all decisionmaking weight into the mitigation side of the equation is simply unacceptable." The ANLA also found problems with the proposal in that it lacked the necessary, credible monitoring system to evaluate whether the outlined measures are succeeding and is not open about APHIS' insufficient resources. Compliance is certainly an issue with respect to Chinese exporters, since they have often violated regulations regarding SWPM and have misled APHIS as to the nature of other articles they wished to ship to the United States (Richard Orr, APHIS, in a presentation to the Global Invasive Species Program workshop on "pathways," November 8-11, 1999).

The CDFA asked APHIS to explain why it chose to evaluate 5 species out of the 112 proposed by China. It pointed to discrepancies in treatment of individual pests from one plant risk assessment to another. CDFA urged APHIS to continue prohibiting imports of rooted cuttings in soil as high-risk.

The Florida Department of Agriculture asked for a ban on imports of both field-grown bare-root plants and greenhouse-grown plants that had previously been rooted in the field. Florida submitted lengthy attachments supporting its position that imports of bonsai plants carry serious risks and that those risks would increase if the agency allowed the plants to be established in growing media.

The voluminous negative comments on the proposal from reputable organizations point once again to APHIS' placing trade facilitation above homeland protection. We strongly concur that imports of bonsai plants carry a significant pest risk that is exacerbated by allowing imported plants to be in established in growing media.

---

[1]See Docket # 98-103-1.
[2]In summer 2001, several beetles belonging to an *Anoplophora* species were detected in a nursery in Washington State; the beetles apparently entered on bonsai plants imported from Korea. Www.wa.gov/agr/.
[3]These comments can be viewed at APHIS' reading room; specify Docket # 98-103-1.

We join in the criticism of the process used to prepare these proposals, specifically the agency's decision to proceed with the proposal despite the inadequate risk assessments, absence of a specified level of "acceptable risk," and the preponderance of the available evidence point to high risks. No decision on this proposal had been announced as of August 2002.

Bonsai Revisited

In 2001 APHIS published a proposed regulation (*Federal Register,* April 20, 2001, Vol. 66, No. 77) that would tighten requirements for imported artificially dwarfed woody plants. Imports of these plants have grown 90-fold between 1993 and 1998, to nearly 55,000 plants annually. Under the current "Q-37" regulations [Sec. 319.37-2(b)(2)], artificially dwarfed woody plants have been entering with a phytosanitary certificate and are subject to inspection and, if necessary, treatment.

Under APHIS' April 2001 proposal, imported artificially dwarfed plants would have to meet the following conditions: be bare-root (an exception would be made for plants grown in most parts of Canada); and be raised for at least two years in a nursery that is registered with the government of the exporting country and that fulfills certain prescribed conditions. Finally, in order to verify that these conditions are met, the plants must be accompanied by a phytosanitary certificate of inspection issued by the government of the country where the plants were grown, which would declare that all of the conditions had been met.

No risk assessment has been prepared as justification to buttress this proposal. According to Inder P. Gadh, (personal communication, May 10, 2001), APHIS is treating it as an "interim measure" under Article 5.7 of the WTO SPS Agreement. Usually, when issuing an "emergency" rule, APHIS specifies a date when the rule will take effect when it publishes the proposal, and provides only a short period for comments. The agency did not do so in this case, thereby creating a situation which might allow exporters to challenge the regulation under the terms of the SPS Agreement. However, APHIS did not issue a final regulation until August 2002.

In response to the proposal, the American Nursery and Landscape Association and Society of American Florists submitted joint comments[1] that praised APHIS' "important if fledgling progress." However, they questioned whether the proposed measures provide "adequate assurance" that risks would be reduced to an acceptable level. The ANLA and florists also criticized APHIS' "extreme and naïve reliance" on foreign phytosanitary agencies and continued reliance on visual inspection of naturally dwarfed shrubs and trees below a certain size. In conclusion, the ANLA and florists reiterated very strong support for this attempt by APHIS to address a serious problem with a regulatory, rather than an inspection-at-the-border, solution.

APHIS also received comments from two state departments of agriculture and the senior author of this report (APHIS *Federal Register* August 19, 2002, Volume 67, Number 160).

APHIS published the final regulation in August 2002 (*Federal Register* August 19, 2002, Volume 67, Number 160). Although the proposal had stated that the agency wished to "guard against the introduction of plant pests, <u>including</u> [longhorned beetles]" (emphasis added), in issuing the final regulation APHIS clarified that its purpose was to protect against the introduction of longhorned beetles, not other pests. The agency expects that by eliminating the widespread mislabelling of field-grown or field-collected plants as artificially dwarfed plants, the risk of deep wood insect pests will be greatly reduced.

In response to comments, APHIS tightened the final rule to require that the plants be grown not just in a registered nursery, but in a greenhouse or screenhouse. However, APHIS retained annual inspections, contrary to commenters' request that it require inspections every six months. APHIS will continue to allow plants to be started in the field and then moved into the greenhouse or screenhouse for the final two years.

---

[1]These comments can be viewed at APHIS' reading room; specify Docket No. 00--042-1.

In response to comments questioning the efficacy of the proposed mitigation measures pertaining to other pests, APHIS replied that if, in the future, the agency determines that imported artificially dwarfed plants pose a significant risk of introducing soil-borne pests and pathogens, the agency will address the issue at that time.

Despite the 90-fold increase in numbers of "bonsai" imported, the agency expressed confidence that inspections at the ports will be adequate to prevent introductions of pests other than longhorned beetles / deep wood pests on the artificially dwarfed plants as well as any pests on naturally dwarf plants. The agency also is still considering the pending proposal to allow imports of five genera of artificially dwarfed plants (penjing) from China (see above).

When asked to define the level of risk underlying its choice of mitigation measures, APHIS replied that "We believe that the requirements contained in the rule will significantly reduce the risk that imported artificially dwarfed plants could be infested with these longhorned beetles." (Emphasis added)

When commenters questioned whether it was wise to rely on foreign phytosanitary agencies to ensure compliance with the regulations, APHIS provided the following response: the agency would verify that the phytosanitary certificate accompanying the plants contains all the required declarations and would inspect the plants upon entry. Furthermore, the SPS Agreement and IPPC obligate APHIS to accept foreign certifications as equivalent to our own "unless there are documented reasons to consider them otherwise." APHIS expressed confidence that the proposed requirements will provide adequate protection.

In summary, artificially dwarfed plants imported into the United States must now be:

- free of any growing media (with the exception for plants grown in most parts of Canada);
- grown for at least 2 years in a greenhouse or screenhouse in a nursery registered with and inspected annually by the government of the country where the plants were grown; and
- grown in pots containing only sterile growing media during the 2-year period, on benches at least 50 cm above the ground.

The exporting country must certify compliance with these requirements. The plants remain subject to inspection by APHIS when they reach the U.S. border.

Wood Importations

The 1995 regulations [7 Code of Federal Regulations Part 319, subpart 40; see summary in Appendix 2] governing wood imports have numerous weaknesses that exacerbate our forests' vulnerability to exotic pests. APHIS is currently working on strengthening measures in only some of these areas. Below is a summary of what we perceive to be weaknesses, followed by a more detailed discussion.

Weaknesses in the 1995 regulations:

- Failing to require mitigation procedures for deep-wood organisms that might reside inside crates, dunnage, and pallets (SWPM).
- Failing to require phytosanitary treatment of logs and lumber from Mexican states that border the United States.
- Allowing softwood lumber and railroad ties from most temperate regions to be imported with bark and without treatment—as long as the importer promises to treat the articles within 30 days.

- Allowing imports of hardwood logs from tropical and most temperate regions after only fumigation and inspection.

- Continuing to rely on a treatment for wood chips that APHIS' own scientists have demonstrated to be unreliable.

- Rejecting scientists' findings and expert judgement that current treatment requirements for other types of wood imports are inadequate.

APHIS decided to adopt phytosanitary regulations governing imports of unprocessed wood in the early 1990s in response to the new interest of some United States firms in importing logs and lumber from such distant locations as Siberia. After ignoring earlier warnings from the scientific community, *e.g.*, Williams and La Fage (1979), APHIS responded in the 1990s probably because scientists concerned about the risk from Siberia managed to prompt expressions of concern by the Oregon congressional delegation (OTA, 1993). Because the agency was responding to concern about pests that might accompany voluminous imports of logs to the West coast, it failed to realize the risks associated with other types of wood imports or wood from other countries of origin. These other imports pose particular dangers to the forests of the East and Midwest, which are exposed to pests entering ports along the Atlantic and Great Lakes, as well as the extensive barge traffic into the Mississippi system. For example, APHIS' first request for public comments did not mention plans to regulate wood packaging (OTA, 1993).

As part of the rulemaking process, APHIS sought comments from the public on several occasions. The first solicitation came in September 1992, when APHIS published an Advance Notice of Proposed Rulemaking (ANPR) (57 *Federal Register*, No. 184, pp. 43628-43631). Later opportunities came with publication of the proposed rule itself and an environmental impact statement. All comments responding to these notices and proposals can be seen by visiting the APHIS reading room and asking for Docket Nos. 91-07-2; 91-074-01 through 91-074-03. We summarize these comments here.

Ninety-three people and organizations, among them 28 wood or wood-products companies and consortia, responded to the APHIS ANPR; 30 individuals and entities commented on the draft environmental impact statement; 27 commented on the proposed rule. Among those commenting on one or more of these documents were:

- The following wood-products companies or consortia: Boise Cascade, Champion International, Georgia-Pacific, International Paper, Weyerhaeuser; American Forestry Council, International Hardwood Products Association, Western Forest Industries, as well as the American Forest and Paper Association (AF&PA). More companies commented on the ANPR than on the later notices; among the major producers, only Boise Cascade, Georgia-Pacific, and Weyerhaeuser commented on the formal proposal in 1994. The other companies apparently chose to allow the AF&PA to speak for them.

- Non-timber businesses: a few shipping firms and ports; the American Association of Nurserymen.

- The following state agencies: California Department of Food and Agriculture, California Department of Forestry Resources, Maryland Department of Agriculture, Oregon Department of Agriculture, Oregon Department of Forest Products, Wisconsin State Forester.

- The following federal agencies or federal employees as individuals: USDA Forest Service, U.S. Environmental Protection Agency, U.S. Department of the Interior, some APHIS employees; and (then) Representative Ron Wyden.

- The following private-citizen groups: Association of Forest Service Employees for

Environmental Ethics, Californians for Alternatives to Toxics, Ecology Center of Southern California, Friends of Forest Park (Portland, OR), Klamath Forest Alliance, Headwaters, Mendocino Environmental Center, Natural Resources Defense Council [comments written by the senior author of this report], Oregon Natural Resources Council, Sierra Club Redwood Chapter, The Wilderness Society, and the Western Ancient Forest Campaign.

! Scientists: the American Phytopathological Society and the following academic or agency experts writing as individuals: Lonnie Williams (a researcher at the USDA Forest Service Southern Station); William Denison, Everett M. Hansen, and Jeffrey Morrell, all forest pathologists at Oregon State University; John D. Lattin, entomologist at Oregon State University; David Wood, entomologist, and Fields Cobb, pathologist, from the University of California at Berkeley.

! Major trading partners: Canada (both the Food Inspection Branch and Forestry Service), Chile, New Zealand, and the European Communities.

These comments are briefly evaluated below.

The forest products industry, through the American Forest and Paper Association (AF&PA) developed a unified position that supported efforts to prevent pest introductions but emphasized minimizing trade barriers and consistency with trade-policy objectives. We believe this is an untenable position for the forest products industry in that long-term gains from healthy forests, whether natural or planted, will be sacrificed for short-term financial gains. By adopting this position, the industry has unfortunately abdicated an opportunity for leadership on the exotic pest issue.

Many private citizen groups urged a ban on log imports and urged adoption of highly protective treatments in the country of origin for any wood that is imported. Detailed comments were submitted by only the Oregon Natural Resources Council and Natural Resources Defense Council. The European Union stated that the SPS Agreement (which went into effect in 1994) required the United States to evaluate the threat arising from specific wood species originating in specific countries, rather than adopt a broadly applicable rule. Europe also objected to the exemption for wood from Canada and parts of Mexico.

Several experts and agencies objected to the proposed treatments as inadequate. Williams said that none of the proposed treatments for logs had been sufficiently tested to be considered effective. Pathologists Denison, Hansen, and Morrell of Oregon State University, along with the Oregon Department of Agriculture and California Department of Food and Agriculture, stated that methyl bromide fumigation had not been proven totally effective at preventing pest infestations in coniferous logs. Denison, Lattin, Morrell, the Oregon Department of Agriculture and the California Department of Food and Agriculture urged APHIS to follow the recommendations of a committee of experts and require that heat treatment of logs meet a specification of 71.1 degrees C for 75 minutes (instead of the 56 degrees C for 30 minutes that APHIS had proposed). The Oregon Department of Agriculture, and California Department of Food and Agriculture criticized APHIS' reliance on visual inspection to determine that wood chips are "free from rot". Lattin said that APHIS had not assessed the risk to eastern forests. He believed that imports from South American pine plantations posed a significant risk to pines in the Southeastern United States. Lattin also objected to APHIS' proposal to allow importers to bring in untreated wood and wait up to 60 days before treating and processing it; he called this proposal "nothing short of disastrous."

There was concern expressed over compliance and reliability of exporter certification. Hansen, the Oregon Department of Agriculture, the California Department of Food and Agriculture, and the American Association of Nurserymen were among those raising concerns about these issues.

The USDA Forest Service asked APHIS to regulate imports of temperate hardwoods. In turn, APHIS requested the USDA Forest Service to conduct risk assessments associated with imports of logs and lumber from the regions that were expected to supply the majority of the wood: Siberia, New Zealand, and Chile. After the regulations were adopted, additional risk assessments were prepared for Mexico (1998) and *Eucalyptus* from South America (2001). We summarize the findings of these various risk assessments in the Gallery of Pests.

APHIS' regulations went into effect in August 1995. For a summary of these regulations, see Appendix 2. The full regulations are contained in 7 Code of Federal Regulations Part 319, subpart 40. APHIS' wood regulations represented one of the first attempts by any country to adopt "comprehensive" regulations as contrasted to rules that targeted specific imports from particular countries. As noted above, the regulations had initially come under criticism from European trading partners because they were neither country- nor pest-specific. However, European opposition has dissipated, and more countries are taking this approach (Hicks, 2001).

Critique of APHIS' Regulations Governing Logs and Lumber

The 1995 APHIS regulations require heat treatment (56 degrees C for 30 minutes) for logs, lumber, and railroad ties imported from Asia east of 60 degrees East longitude and north of the Tropic of Cancer (Siberia and most of China). Imports from these regions have been quite small, but they are growing. In 2000 the U.S. imported 680 m^3 of logs and 7,100 m^3 of lumber from China, plus 1,167 m^3 of logs and 27,000 m^3 of lumber from Russia [it is unknown whether the latter products came from western Russia or Siberia (www.fas.usda.gov/ustrade)].

Other sections of the 1995 regulations (summarized in Appendix 2) open other loopholes that expose America's forests to the risk of pest introduction on logs and lumber entering the country from other geographic regions.

Softwood Lumber From Most Geographic Regions

Softwood (coniferous) lumber (including railroad ties) from all other temperate regions, including South America, Europe, and New Zealand, may be imported if it meets either of the following conditions:

- It has been heat-treated (with or without moisture reduction) prior to importation; or
- It is imported untreated ("raw"), then shipped to an APHIS-approved facility, where it must be heat-treated within 30 days.

Allowing imports of raw lumber is extremely dangerous, since pests could easily hitchhike on this lumber and escape during the interval before the wood is processed. Raw lumber sometimes has some bark attached, which provides an even better haven for pests. The wood may be shipped anywhere during that 30-day interval. Indeed, one load of railroad ties from western Russia was sent from a port on the Atlantic coast to Oregon. Inspection of these ties revealed several types of insects and fungi (Hilburn, 1998) which had the potential to become established along the shipping route. The trade data do not indicate what proportion of the 2.3 million m^3 of lumber imported from Argentina, Brazil, Chile, Europe, and New Zealand in 2000 entered without prior treatment. The import volume is so large that a 3 percent risk of pests hitchhiking on these imports results in an expectation that 69,000 quarantine pests might have been transported to America on this lumber. While interception data show relatively few pests entering on imports of logs and lumber (Haack 2002), this might reflect the relatively low volume of importations when compared to wood packaging and living plant materials.

Logs and Lumber From Mexican Border States

Logs and lumber from the Mexican states bordering the U.S. can be imported without any phytosanitary precautions. In 1995, APHIS focused on the fact that both sides of the U.S.-Mexican border belong in the same Bailey ecoregion (USDA APHIS, 1998h). The agency apparently did not consider the ecological barriers (deserts) that separate Mexican high-elevation forests from their counterparts in the United States. Facilitating trade, again, appears to have taken precedence over safeguarding forests from pests. Consequently, more than 132,000 m^3 of lumber from the border states were imported without any phytosanitary safeguards in 1997. Given the delay in adopting improved regulations (see below), it is fortunate that, by 2001, imports of softwoods from all of Mexico had fallen significantly, to 208 m^3 of logs and 64,280 m^3 of lumber.

The California Department of Food and Agriculture had objected to unregulated imports from Mexico in comments submitted to APHIS during development of the 1995 proposal. APHIS then asked the Forest Service to prepare a risk assessment examining unprocessed pine and fir logs from the border states, which was issued in 1998 (USDA Forest Service, 1998). The risk assessment stated that the logs could vector potentially damaging pests that threaten forests throughout most of the contiguous 48 states. In response, APHIS began developing a proposal to tighten phytosanitary safeguards for coniferous logs and lumber imported from Mexican border states [APHIS, *Federal Register* June 11, 1999 (Vol. 64, No. 112), pp. 31512-31518]. At the time, APHIS declared wood imports from Mexico to represent one of the two highest-risk types of wood shipments entering the country (the other is solid wood packing material) (USDA APHIS, 1998a). The findings of this risk assessment are summarized in the Gallery.

The phytosanitary safeguards APHIS proposed were as follows:

- Logs must be debarked and heated, then handled so as to prevent re-infestation, as is now required for coniferous logs from other parts of Mexico.

- Pine or fir lumber could be treated by one of three options. The first two options were already allowed for lumber from other parts of Mexico: heat treatment with or without moisture reduction in Mexico before importation into the U.S.; or heat treatment with or without moisture reduction at an APHIS-approved U.S. facility within 30 days after importation. The third proposed option is new: to allow import of standard industry-cut lumber originating from anywhere in Mexico after debarking and fumigation with methyl bromide.

We consider that continuing to allow post-import treatment is dangerous, as pests can escape during the delay. We are particularly concerned because there is no limit on the size of the wood articles or even a requirement that they be debarked first. Publicly available data do not indicate what proportion of importers currently utilize the post-import treatment option.

The proposal to allow fumigation using methyl bromide represented a step backward with regard to a long-standing national policy to phase out use of methyl bromide. It also necessitated preparation of an environmental impact study, which has contributed to a lengthy delay in finalizing the more protective regulations (the final rule had not been issued as of August 2002). This delay means that imports of logs and lumber from Mexico continue in the absence of effective phytosanitary safeguards and are putting United States forests at risk.

Hardwood Logs

Hardwood logs shipped from tropical regions to the continental states and hardwood logs from temperate regions other than Asia east of 60 degrees E longitude and north of the Tropic of Cancer, can be imported subject only to fumigation and inspection. The same provisions apply whether or not bark remains on the logs. These "safeguards" had already been shown to be ineffective 15 years before the regulations were adopted (La Fage and Williams, 1979). It is unclear, however, whether APHIS is considering strengthening these provisions in any broad way. Brazil and other South American countries potentially could quickly outpace Europe as our principal non-Canadian source of hardwood logs, and these logs would be subject only to the present lax standards. APHIS might be considering adopting regulations specifically governing imports of logs and lumber from *Eucalyptus* grown as exotic species on plantations in South America; the Forest Service issued the risk assessment in April 2001 (USDA Forest Service, 2001). The findings of the risk assessment are summarized in the Gallery section. The assessors said that several factors suggest that logs and chips from *Eucalyptus* plantations in South America might be relatively free of most damaging organisms. Nevertheless, numerous potential pest organisms have a high likelihood of being introduced to United States *via* this pathway. The risk varies from country to country, depending on the types of *Eucalyptus* planted, variations in pest levels, variations in harvest practices, etc. Such imports might pose less risk than do imports of *Radiata* pine from plantations in New Zealand and Chile because the genus *Eucalyptus* is neither native to the U.S. nor widely planted. However, some pests might "cross over" to native North American species. The greatest concern focuses on those species native to South America that have adapted to attack *Eucalyptus*, suggesting a wide host range and adaptability.

Plantation-Grown Exotic Pines From New Zealand and Chile

Instead of insisting on heat treatment of these logs, APHIS is relying on a "systems approach" to minimize pest introductions *via* this pathway. The logs must be from healthy trees apparently free of pests. Once felled, the logs must be debarked and fumigated. During shipment, the logs must be kept segregated so as to prevent pests from moving onto the logs from other cargo. Once in the U.S., the logs must be shipped by the most direct route possible to an APHIS-approved processing facility, where they must be heat-treated and processed within 60 days. Lumber from these plantations may be either heat-treated before import or imported without previous treatment, then shipped to an APHIS-approved facility, where it must be heat-treated within 30 days.

Several academic scientists participated in a lawsuit challenging these provisions. The critics noted the nearly universal agreement that methyl bromide fumigation does not penetrate far into logs or other large pieces of lumber, and heat treatment is preferable for killing such pests (USDA Forest Service, 1992a; USDA APHIS, 1997; letters from J. Stone, J. Morrell, F. Cobb, and D. Wood reprinted in USDA APHIS, 1998a; Carroll, 1998). While the lawsuit forced APHIS to prepare a new environmental impact statement, it did not result in changes to the regulations themselves. APHIS maintained that the phytosanitary risk posed by plantation-grown timber from Chile and New Zealand was not sufficient to warrant heat treatment, and the SPS Agreement precludes requiring treatments that are more aggressive than justified by the risk (USDA APHIS, 1998a). Although the Oregon Department of Agriculture had found living organisms on every shipment brought in under APHIS' rule (Hilburn *et al.*, 1998), APHIS dismissed these pests as not meeting APHIS' definition of "significant" (Siddiqui to Campbell, April 1998). We believe that if "insignificant" pests can survive APHIS' protective measures, "significant" pests can survive as well. Given the demonstrated weaknesses of visual inspection, there is a good probability that some pests will escape detection on arrival and become established.

The pests from Chile and New Zealand that elicited greatest concern in the risk assessment were the wood wasp *Sirex nocotillo* and the associated *Amylostereum* fungus. An APHIS expert, Dr. Peter Witherell, recently confirmed that "[w]ood wasps (*Sirex* spp.) are probably amont (*sic*) the most difficult wood boring insects to kill. . . [M]oisture in the wood tends to impede the penetration of methyl bromide." Dr. Witherell recommended either extending the fumigation period or requiring kiln drying or heat treatment of the wood (personal communication from Peter Witherell, USDA APHIS, by email dated October 24, 2001). However, APHIS has apparently discounted the experts' opinion in retaining the existing regulations' reliance on methyl bromide.

Railroad Ties

Railroad ties (large-dimension lumber) coming from most temperate regions currently may be imported "raw" and treated up to 30 days after arrival. In June 1999, APHIS proposed amending the standard for railroad ties from all countries except Canada (*Federal Register,* June 11, 1999, Vol. 64, Number 112). We do not regard the proposed changes as reducing the risks significantly. First, the proposal does not curtail the practice of delaying treatment until after importation or of shipping the cross-ties any distance before treatment, although it does require that post-import treatment be done at an APHIS-approved facility. Second, this proposal would allow treatment of imported railroad ties using methyl bromide. As is the case with lumber from Mexico, finalizing of this regulation has been delayed for nearly three years.

Wood Chips

Under the 1995 regulations, wood chips from temperate countries other than Asia east of 60 degrees E longitude and north of the Tropic of Cancer may be imported after fumigation or heat treatment. Chips from plantations of exotic trees in tropical countries may enter without any phytosanitary treatments. Once in the country, the chips must be processed at an APHIS-approved facility within 30 days.

However, in 1997 APHIS researchers determined that methyl bromide fumigation does not reliably kill pests inside piles of chips that are larger than 120 cubic feet, *i.e.*, 5 feet by 5 feet by 5 feet (Hobgood *et al.*, 1997). In a partial response, APHIS has amended the regulations only for chips from plantation-grown *Radiata* pine from Chile (*Federal Register,* April 10, 2000, Vol. 65, No. 77). The new treatment calls for soaking the chips in a surface pesticide while they are being loaded for shipment. Whatever the merits of the new treatment regime, the United States has imported no chips from Chile since 1997. APHIS has not yet tightened regulations for chips from other sources. Since 1997 the U.S. has imported 40,400 metric tons dry weight of chips from Brazil, 200 metric tons dry weight of chips from western Europe, and about 110 metric tons dry weight from Mexico. Although the risk assessment examining *Eucalyptus* grown in South America does address a potential new source of wood chips, we believe that APHIS should revisit this situation and apply mitigation measures to all imports of wood chips from countries other than Canada. Chips from tropical countries could harbor potential pests, given the uncertainty of organisms' behavior in a new environment.

Wood Packaging (SWPM)

Regulation of SWPM is a very complex situation, with individual countries, regional organizations such as the North American Plant Protection Organization (NAPPO), and the International Plant Protection Organization (IPPO) all adopting standards simultaneously. After importation, SWPM is distributed across the United States. A widespread industry recycles some packing materials such as pallets. This industry, in turn, depends on the trucking industry to transport pallets, etc. Therefore, policy decisions on SWPM have broad external, as well as internal, ramifications.

Development of an International Standard by IPPO

The IPPO standard was adopted in March 2002. The IPPO standard is summarized in Appendix 2; the text can be found at www.aphis.usda.gov/ppq; click on "International Standards," then go to IPPC, final standards; click on ISPM 15.

The principal rationale for adopting a broad "pathway" standard for SWPM (as opposed to the usual pest- or country-specific standard) was that regulators cannot determine for any particular shipment the wood's country of origin, the length of time since the wood was harvested, in what other countries the SWPM has been, or whether any treatment has been applied and if applied, the date of application. Participants in developing the standard believe that few if any other imported commodities present an equal challenge for risk evaluation (McNamara and Kroeker, 2001).

The effectiveness of this "pathway" standard has been undermined by the IPPC parties choosing as their goal a distressingly weak "level of protection": "to **practically** eliminate risk for **most** quarantine pests and **significantly** reduce risk from **a number** of others" (emphasis added). This "level of protection" represents real progress as a starting point, a "floor" beneath which no country should fall. The problem is that it is also a "ceiling". Countries wishing to adopt more protective safeguards must prove the need to do so through the difficult and time-consuming processes of either detecting pests on SWPM that has been treated in conformity with the standard or by completing a risk assessment that demonstrates that "**specific quarantine pests associated with certain types** of wood packaging . . . **from specific sources** require more rigorous measures" (emphasis added).

The IPPO standard has been criticized by several USDA Forest Service scientists (anonymously) for not being based in good science. The principal flaw is the unsubstantiated claim that the heat treatment specified (56 degrees C for 30 minutes) has been shown by scientific studies to be effective in killing a wide range of pests. Actually, this regime has been verified only for eradication of pinewood nematode in coniferous lumber.

Whereas the original (June 2000) version of the standard had required treatments that change the character of the wood (*e.g.*, kiln drying) in order to prevent reinfestation, these requirements were substantially changed as a result of further negotiation. Specifically, the requirement for moisture reduction or kiln drying were dropped, at least partially in response to pressure by the U.S. wood pallet industry (C. Brindley, "How the Pest Issue Will Impact Wood Packaging and Lumber," www.palletenterprise.com/pests/pestissuearticle.asp) and an absence of strong scientific justification (Hofacker, personal communication). Instead, the IPPC parties called for adoption of "[a]ny treatment . . . **that is significantly effective against most pests** . . ." (emphasis added).

As noted above, scientists have also questioned the efficacy of the specific heat/time combination enacted in the standard. The standard for heat treatment would require that the center of the wood be raised to a temperature of 56 degrees C for 30 minutes. Even the IPPC parties concede that "some pests are known to have a higher thermal tolerance." During the negotiations, some scientists pressed for higher temperatures and longer times, *e.g.,* 67 degrees C for 60 minutes or 71 degrees C for 75 minutes. However, others believed that this higher standard would not be economically feasible at present (Dawson, 2001). In the end this view prevailed, although some continue to believe that most commercial kilns could attain higher temperatures without raising costs significantly.

The other approved treatment, methyl bromide fumigation, also provides no residual protection against re-infestation. Furthermore, evidence is mounting that methyl bromide fumigation is often not sufficiently effective. Both APHIS and the Canadian Food Inspection Service have found evidence that living pests survive fumigation of SWPM in China (http://www.pestalert.org/Detail.CFM?recordID=27; and www.cfia-acia.agr.ca/english/plaveg/for/evaluae.shtml). In October 2001, the senior author received a plea for help from a European fumigation firm that was experiencing difficulty killing Sircid wasps by fumigation (personal communication from Liliane Lathouwers, Desinfecta Croes BVBA of Belgium, by email dated October 12, 2001). In response, an APHIS expert, Dr. Peter Witherell, confirmed that "Wood wasps (*Sirex* spp.) are probably amont (*sic*) the most difficult wood boring insects to kill. As the fumigator suspected, moisture in the wood tends to impede the penetration of methyl bromide." Dr. Witherell recommended either extending the fumigation period or requiring kiln-drying or heat-treatment of the wood (personal communication from Peter Witherell, USDA APHIS, by email dated October 24, 2001). The IPPO standard explains this problem away by saying that **"**when properly applied," fumigation with methyl bromide will be effective.

The IPPO encourages countries to accept this standard. Those countries that do so are to impose no additional requirements on incoming consignments containing wood packaging unless either the packaging does not bear the approved mark indicating treatment or evidence is found of live pests. Only in these instances may a country require treatment or disposal of the wood packaging. In the earlier (June 2000) version, countries would have been allowed to require treatment or disposal of wood packaging accompanying a consignment if inspectors had previously found active quarantine pests in an equivalent consignment. These restrictions on protective measures are particularly troubling, given the acknowledged failure of each of the prescribed treatments.

The IPPC standard does allow individual countries to impose a more protective standard, but only after either intercepting pests on incoming shipments or completing a risk assessment. As mentioned before, the interceptions and/or risk assessment must show that "**specific quarantine pests associated with certain types** of wood packaging . . . **from specific sources** require more rigorous measures" (emphasis added). The countries are thus thrust back into regulating SWPM piecemeal, instead of as a global pathway. Unfortunately, the June 2000 suggestion that countries take emergency action in response to signs of live pests or bark, even when no quarantine pest is detected; or when dealing with consignments of a new commodity or from a new source was deleted from the IPPC standard.

From the beginning, those developing the standard believed that loose wood packing, *e.g*., sawdust and shavings, or raw wood cut into thin pieces (equal to or less than 6 mm) posed little risk. In the June 2000 draft, however, individual countries could exempt loose packing after concluding that the risk was indeed small. By November 2001, the burden of proof had been reversed: countries wishing to regulate this material would have first to complete a risk assessment that showed it to be an important pathway. The presumed safety of these small pieces of wood has been questioned by scientists who note that the United States and other countries regulate imports of wood chips because of the perceived pest risk.

Verification that the SWPM had been properly treated will be a problem. Since 1998, when Chinese exporters were obliged to fumigate SWPM, the only assurance that the SWPM was indeed fumigated has been a sheet of paper stapled to the SWPM that had "fumigated" written on it (Schlarbaum, personal observation). The draft standard provides for specific markings, although it will remain challenging to ensure their veracity.

The North American Standard for SWPM

APHIS and Agriculture Canada began working on a North American standard for wood packaging that aimed at preventing the introduction of wood-boring pests, in response to the 1996 detection of the Asian longhorned beetle in New York City. This standard was adopted by the NAPPO in November 1998 (see the summary in Appendix 2; the full text of the standard can be found at www.nappo.org). The North American standard will take effect only when the three party countries, Canada, the United States, and Mexico, adopt their own implementing regulations. The NAPPO standard is strong in requiring more effective treatments than simple removal of bark; and in allowing the party countries only two options for handling SWPM which has not been treated in the prescribed manner: treatment or refusal of entry. The NAPPO standard allows the routine use of methyl bromide fumigation. The standard does not address trade among the three member countries, so each can apply whatever measures it considers appropriate.

Box 2

Violations of United States and Canadian 1995 Regulations Requiring Bark Removal from SWPM

U.S. and Canadian officials discovered that their 1995 regulations' requirement that bark be stripped from SWPM was often violated by shippers. An APHIS survey conducted during 1996-1998 found that shippers using SWPM violated the no-bark requirement in 9 percent of maritime and 4 percent of air shipments (USDA APHIS and Forest Service, 2000). Canadian surveys found that 90 percent of wooden spools for cable imported from China, Korea, and Malaysia had bark present, usually hidden on the interior surfaces, where it could not be seen without disassembling the spool. The result, predictably, was transport of hitchhiking insects; 41 percent of wooden spools used to hold cable shipped from China to Canada were infested with some species of insect. Other interceptions of bark beetles under bark occurred on shipments from Spain, Switzerland, and Italy (Dawson *et al.*, 1997). A more recent study found 22-24 percent of examined SWPM infested with live insects; 37 percent of the damage was not visible during an external inspection. Among wood blocks used to brace granite, 32 percent contained live insects, 50 percent had bluestain fungi (Allen *et al.*, *teste* USDA APHIS and Forest Service, 2000). In a 1999 inspection blitz, Canadian Food Inspection Agency found that packaging from 36 of 63 countries had illegal bark (web site: www.cfia-acia.agr.ca/english/plaveg/for/evaluae.shtml).

APHIS' Regulation of Wood Packaging

The wood import regulations that APHIS adopted in 1995 do not require treatment of wood packaging to render it inhospitable to deep-wood pests. According to one (anonymous) USDA source, APHIS had wanted to require such treatments, but trade-promotion interests argued that there was insufficient evidence of a problem. This argument prevailed despite data in the interception database[1] and a study by Williams and La Fage (1979)

---

[1]CNN-Time reported on November 14, 1999, that the Asian longhorned beetle had been found in a shipment from China in Chicago as early as July 1990. Additional specimens were obtained in northern Ohio in 1992.

which demonstrate that deep-wood organisms often evade detection by inspectors. As a result, the 1995 regulations demand only a statement by the importer that all bark has been removed and that the SWPM is apparently free from live pests. Importers' pledges of compliance have been shown to be unreliable. When the Asian longhorned beetle was detected feeding on trees in the New York metropolitan area in 1996, APHIS and its Canadian counterpart conducted surveys to determine how often wood-boring insects are found in wood packaging. These surveys found two problems: 1) many wood-boring insects were present in SWPM; and 2) numerous shippers violated the requirement that bark be removed from wood packaging. Given this evidence, APHIS should not rely on assurances from importers that their shipments are in compliance with all regulations.

The outbreak of Asian longhorned beetles in New York and Chicago demonstrated a serious gap in the 1995 regulations, and APHIS responded by taking action on several different fronts. As noted above, APHIS and Agriculture Canada began working on two international standards for wood packaging: the North American standard and the IPPC standard.

Box 3

Methyl Bromide

The use of methyl bromide has been shown to destroy the stratospheric ozone layer which protects Earth from damaging ultraviolet rays. Pound for pound, methyl bromide is 50 times more powerful than chlorofluorocarbons (CFCs) in destroying the ozone layer. The Montreal Protocol on Ozone-Depleting Chemicals obligates countries to phase out use of methyl bromide, although phytosanitary uses are allowed to continue. While other, more effective, safeguards are often available, APHIS has several times proposed expanded use of methyl bromide fumigation, including for Chinese wood packaging in response to the Asian longhorned beetle emergency; logs and lumber from Mexico; railroad ties; and in the NAPPO and IPPC standards for SWPM. APHIS argues that use of methyl bromide fumigation on SWPM from China, logs from Mexico, and railroad ties constitutes a small increase with no significant impact on the "ozone hole." However, environmental impacts must surely rise with adoption of international standards requiring all countries to treat SWPM and approving methyl bromide fumigation as one of the treatments -- especially since the standards do not mandate a phase-out over time.

APHIS might believe it is obliged to allow the option of using methyl bromide fumigation under the combined effects of the 1998 amendments to the Clean Air Act and the SPS requirement that agencies impose that phytosanitary measure which is "least restrictive" of trade. In its draft environmental impact statement regarding use of methyl bromide to fumigate lumber imported from Mexico (USDA APHIS, 2000), APHIS stated

> . . . The availability of alternatives to [quarantine] uses of methyl bromide must be considered together with the requirements of prevailing trade agreements. Heat treatment . . ., an environmentally preferable alternative, could be prescribed by APHIS only if that alternative (1) is capable of fulfilling the agency's mandate to protect U.S. agricultural resources and (2) is consistent with prevailing trade agreements.

The Council on Environmental Quality believes, to the contrary, that the 1998 amendments to the Clean Air Act do not oblige APHIS to offer the fumigation option.

When APHIS adopted its emergency regulation on Chinese SWPM in Autumn 1998, the agency promised the Environmental Protection Agency that it would not propose any additional expansions of methyl bromide use until it had done a "programmatic environmental impact statement" examining the downsides of a cumulative total of APHIS' use of the chemical. Despite this promise, when the agency proposed using methyl bromide for Mexican lumber, it issued an environmental impact statement only after considerable delay. Furthermore, the study was not sufficiently broad to qualify as "programmatic".

APHIS and Canada adopted emergency regulations [APHIS *Federal Register*, September 18, 1998 (Vol.

63, No. 181) pp. 50099-50111; APHIS *Federal Register*, December 17, 1998 (Vol. 63, No. 242) pp. 69539-69543; Dawson, personal communication, May 2001], following discovery of a second cluster of Asian longhorned beetle infestations in Chicago in July 1998. These regulations require exporters in China to treat solid wood packing material using fumigation, kiln drying, or treatment with preservatives.

The China-specific regulations are flawed because they rely heavily on fumigation using methyl bromide. Methyl bromide provides only temporary protection. While the chemical kills organisms present on the wood or within a few inches of the surface, it provides no residual protection. The wood can become reinfested a short time after treatment (USDA APHIS, 1999b; *Federal Register,* January 20, 1999, Vol. 64, No. 12; Dedmon, 1998; Berg, 1998). Indeed, as noted above in the discussion of the draft IPPC standard, APHIS, the Canadian Food Inspection Service, and commercial fumigators have found evidence that pests survive fumigation of SWPM (http://www.pestalert.org/Detail.CFM?recordID=27; www.cfia-acia.agr.ca/english/plaveg/for/evaluae.shtml; personal communication from Liliane Lathouwers, Desinfecta Croes BVBA of Belgium, by email dated October 12, 2001; personal communication from Peter Witherell, USDA APHIS, by email dated October 24, 2001). These findings, coupled with the above observations by the junior author on exporters' "documentation" of fumigation and the observations of plugged exit holes by Chinese exports mentioned above, further demonstrate that importers should not be trusted to police their own actions. Additionally, the chemical has high environmental and health costs (see Box 3).

An additional weakness in the 1998 regulations is that the China-specific regulations do not address the threat of pest introductions on SWPM shipped from other trading partners to the United States (or Canada).

Improving APHIS' Broader SWPM Regulations

To curtail the risk of pest introductions on SWPM from all trading partners, APHIS has begun developing its own universally applicable regulations governing SWPM. In January 1999, APHIS issued an Advance Notice of Proposed Rulemaking for SWPM and asked for initial input [USDA APHIS, *Federal Register* January 20, 1999 (Vol. 64, NO. 112) pp. 3049-3052]. One hundred two people and organizations responded,[1] including several academic scientists, several state departments of natural resources or agriculture, the National and Eastern plant boards, several consortia of shipping or air cargo companies, makers of various kinds of pallets and containers, several environmental organizations, an association of professional fumigators, and the American Forest and Paper Association.

The responding organizations can be divided into three general groups.

(1) Organizations with an economic stake in wood pallets, or who feel they are likely to be greatly inconvenienced by a shift to packaging materials made of substances other than raw wood, urged APHIS to regulate SWPM on a country-by-country basis. These included a few wood-products traders, the American Forest and Paper Association, some transport consortia, and the National Wooden Pallet and Container Association. They were joined by the Quarantine Fumigation Alliance of America**.**

(2) Organizations supporting regulations that would require treatment of all SWPM regardless of origin included state departments of natural resources or agriculture in Iowa, Oregon, and Vermont; the Eastern Plant Board, American Nursery and Landscape Association, and the Canadian Food Inspection Agency (the latter referenced the draft NAPPO standard, which requires treating all SWPM). The Mycological Society of America supported requiring treatment of SWPM from all countries except Canada and Mexico.

(3) Organizations suggesting that APHIS prohibit use of raw wood and/or require shippers to use non-wood materials included several manufacturers of alternative packaging; a New Orleans barge operator; American Nursery and Landscape Association; the Vermont Department of Agriculture, Food, and Markets; the Oregon Department of Agriculture; California Department of Food and Agriculture; Federal Express; and the Sierra Club.

---

[1]These comments can be viewed at APHIS' reading room; specify Docket No. 98-057-1.

Comments from responding organizations were diverse. The National Plant Board and Canadian Food Inspection Agency thought substituting alternative materials might be most effective over the long term, in part to reduce reliance on methyl bromide. A shipping consortium whose members carry steel into Great Lakes ports, then carry grain out, said there is no substitute for wood dunnage. New Zealand also said it would be hard to replace wood dunnage. The Florida Department of Agriculture and Consumer Services noted the rising risk from growing world trade and called on APHIS to seek "ways to maximize protection as a singular goal." On the other hand, Global Transportation Services estimated the cost of requiring treated wood or alternatives at $15 billion to $30 billion per year and called for balancing these costs against the pest-related losses to U.S. agriculture and forestry. Virtually all statements noted that any shift away from raw wood will require a phase-in period. The National Wooden Pallet and Container Association said that the industry would need a phase-in period of at least 2 years for any treatment requirements, 10 years if wood were to be banned. The Quarantine Fumigation Alliance of America's long-standing position is that the U.S. should require treatment of suspect shipments at U.S. ports under APHIS' supervision; in the Alliance's view, relying on treatment in other countries would certainly result in more pest introductions.

Box 4

Interceptions of Forests Pest

APHIS Interceptions of Living Pests on SWPM, 1996-1998

During the period 1996-1998, APHIS intercepted 1,205 living pests on SWPM from 64 countries (USDA APHIS and Forest Service, 2000). While 39 percent of all SWPM interceptions were from China, 37 percent came from Europe, including:

Italy	189	16%
Spain	79	6%
Germany	56	5%
Other source countries or regions		
India	47	4%
Canada or Mexico	38	3%
South America	34	3%
Africa	30	2%
Oceania	4	<1%
unknown	15	1%

Canadian Interceptions

A focused inspection effort by the Canadian Food Inspection Agency from January-May 1999 at three ports found 23 quarantine pests intercepted from 12 countries (Belgium, China, North Korea, Germany, India, Italy, Japan, Spain, Sweden, Switzerland, Taiwan, Thailand). An additional 40 species of insects of undetermined quarantine status were intercepted from 12 countries (China, North Korea, France, India, Indonesia, Israel, Italy, Netherlands, Pakistan, Taiwan, Turkey, UK) [Canadian Food Inspection Agency, Evaluation of pest interceptions from imported non-manufactured wood packing materials (1991-1999) (July 5, 1999) (www.cfia-acia.agr.ca/english/plaveg/for/evaluae.shtml)].

APHIS' next step in the regulatory process was to release its risk assessment—which appeared in October 2000 (USDA APHIS and Forest Service, 2000). The study had 18 authors, the majority of which were employees of APHIS or the Forest Service. The document evaluated risks to forests throughout the country, including on tropical islands, from pests that could be introduced on SWPM from anywhere in the world except China. In brief, the risk assessment found that nearly all United States forest types provide ample host species for SWPM-associated pests. SWPM was regarded as an especially dangerous vector that goes to all parts of the country. Inspection was found not to be a reliable phytosanitary measure to prevent introductions on SWPM, so more stringent measures applicable to all source countries are justified. The study then examined 19 examples of the types of pests that could be introduced *via* the SWPM pathway. The study gave an overall pest risk potential of "high" to 17 of the 19 representative pests and a ranking of "moderate" risk to the 2 others. The team deliberately chose not to study any pests that they thought would pose a "low" risk. (For more detail about particular species evaluated, see the Gallery of Pests.)

The study attempted to project economic impacts that would arise should some of the particular pest species be introduced. These projections were not comprehensive; and the authors warned against totaling them. Nevertheless, the conclusions are startling. If the Asian longhorned beetle were to infest all vulnerable areas in the continental United States, it was estimated that replacing vulnerable urban trees would cost $522 billion (in 1997 dollars). Discounted monetary losses for timber resources around Chicago and New York would range from $1 million to $10 million 30 years after introduction. If the *Sirex* wood wasp and its associated fungus were introduced into Atlanta, the damage after 30 years would range from $48 million to $607 million. Introduction of the European spruce beetle into Minneapolis could result in damage up to $101 million. Introduction of a specific root rot into Charleston, South Carolina, could result in damage between $789,000 and $1,578,100.

Despite the importance of the issue and widespread repercussions that will arise from regulating SWPM, fewer than 20 groups and individuals commented on the risk assessment, including the Canadian Food Inspection Service; the states of California, Florida, Oregon, and Wisconsin; several environmental organizations; a trade association of air carriers; a professional association of fumigators; one forest products company (but not the trade association); a society of urban arborists; and some individual scientists.[1] Their opinions of the risk assessment were mixed. Predictably, there were differing views of the risk rankings, although there was little dispute that the named pests deserved some mention. Other topics mentioned ranged from concerns about the study's procedures to requests for an expanded discussion of the kinds and quality of woods used in SWPM, reconditioning/reuse of pallets, and the average lifespan of SWPM. Some asked for a more thorough analysis of how the 1995 and 1998 regulations had failed. From their comments, one senses general concern about additional introductions of exotic forest pests, but there is contention about the methodologies, including risk assessments, and which species pose serious threats.

China was the only country excluded from the APHIS SWPM risk assessment. We believe that omission is a mistake, as the current regulations concerning SWPM from China were adopted as provisional (emergency) regulations, not permanent ones. The 1998 risk assessment examined only four genera of wood-boring beetles to justify the 1998 regulations. It is unclear whether this assessment contains sufficient information to hold up under a challenge to the WTO dispute panel if the U.S. treats the regulations as permanent. Furthermore, the regulations for China rely on fumigating the SWPM using methyl bromide, a treatment which is both questionable as to efficacy and damaging to the environment. Fortunately, APHIS can still re-examine whether to include China in the final regulations.

While APHIS had earlier declared its intention to issue final regulations on SWPM by January 2002 (see National Invasive Species Management Plan), the agency has not met that timetable. APHIS now expects to adopt the IPPC standard while continuing to develop its own regulation (Michael Litsky, APHIS, personal communication, April 2002). Remaining steps include evaluating various options for mitigating the risk (perhaps

---

[1]These comments can be viewed at APHIS' reading room; Docket No.98-057-2.

with public input), putting forward a formal proposal for comment, and issuing an environmental impact statement. Thus, the new regulations will go into effect at best six years after the 1996 discovery of the Asian longhorned beetle demonstrated the failure of the 1995 regulations.

What would be the impact of applying stringent phytosanitary safeguards to solid wood packaging from all countries except Canada? We lack sufficient information at this time to judge. As we noted in Chapter 2, estimates of the proportion of shipments containing wood packaging vary from as low as 15 percent [Berven, 1999; Global Transport Service (comments on Docket No. 98-057-1)] to as high as 90 percent (Peters, 1999). Surveys by APHIS (USDA APHIS and Forest Service, 2000) and New Zealand (see comments on Docket No. 98-057-1) point to the presence of SWPM in about half of maritime shipments. Adoption of stringent rules clearly would have a significant impact on the terms and costs of trade. The Global Transport Service projected costs of $15 billion to $30 billion per year (comments on Docket No. 98-057-1). On the other hand, such pests have a serious and irreversible impact on resources and the economy when they enter the country. A cost of $15 billion to $30 billion appears reasonable when compared to Pimentel's (2000) estimate of $80 billion annual costs from exotic plant pests and weeds.

The Plant Protection Act (P.L. 106-224)

The Plant Protection Act adopted in 2000 is a mixed blessing (the law is summarized in Appendix 2). This type of legislation commonly contains a number of Congressional "findings" that have no legal force but which set the tone of the document. The "findings" in the Plant Protection Act often appeared contradictory. In some instances, the findings stress the need for strong programs; in other cases they stress the importance of facilitating trade. We are particularly concerned by finding number 3, which reads:

> (3) It is the responsibility of the Secretary [of Agriculture] to facilitate exports, imports, and interstate commerce in agricultural products and other 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 or noxious weeds.

We are concerned that a standard of "reducing" risks "to the extent practicable" does not set a sufficiently high standard for improving APHIS' performance in preventing introductions. As noted previously, the Office of Technology Assessment (1993), General Accounting Office (1997), Congressional Research Service (CRS, 1999), Miller (2000), and the National Plant Board in its Safeguarding Review (1999) have expressed concern that APHIS' attempts to "balance" its trade facilitation and protection roles result in lowered protection standards.

The procedures that APHIS uses to set priorities for approving importations of horticultural and other articles and to conduct risk assessments to evaluate conditions under which such importations should be allowed have created controversy. In response, the PPA required APHIS to issue, by summer 2001, a notice for public comment on the procedures and standards it will follow in responding to proposals to import new commodities, including how the agency will involve the public in the risk-assessment process, how it will determine which proposed import to evaluate given its limited resources, guidelines for soliciting relevant scientific and economic information, and guidelines for ensuring that its risk-assessment process will be understandable. APHIS published such a request for comments in June 2001 (*Federal Register,* June 19, 2001, Vol. 66, Number 118).

APHIS was also instructed to prepare a report, within two years, on the approval and risk assessment processes. The report, *Preventing the Introduction of Plant Pathogens into the United States: The Role and Application of the "Systems Approach,* was issued in 2002. It was written under the leadership of the National Plant Board, in consultation with scientists from state departments of agriculture, academia, the private sector, and the Agricultural Research Service. Above, we have already discussed the report's findings and weaknesses when discussing risks associated with imports of horticultural plants.

National Invasive Species Council (NISC)

The National Invasive Species Council (NISC) was established in 1999 to provide national leadership and oversight on invasive species and promote action at local, state, tribal, and ecosystem levels. As mentioned in Chapter 1, a national plan was issued in January 2001 (National Invasive Species Council 2001, http://www.invasivespecies.gov/council/nmp.shtml) that contained target dates for different steps of accomplishments by the participating federal departments. The Plan contains a good interagency strategy for addressing biological pollution in this country, including exotic forest pests, and has a welcome emphasis on the role that growing trade, tourism, and transport play in exacerbating the invasive species threat. It also calls for creation of a comprehensive communication strategy to build a foundation of public support for effective action on invasive species.

The Plan recognizes rapid response to newly detected pests to be crucial, but no agency has accepted responsibility to carry out this task for natural area pests, including those damaging forest resources. APHIS has the only comprehensive rapid response program and spends $125.8 of the total of $148.7 million that all federal agencies reported spending on "rapid response." APHIS spends 90 percent of its money on pests threatening agriculture and livestock because that is considered the agency's core mission (GAO, 2001). In FY 2000, APHIS spent only $12.1 million on rapid response to forest pests, with most of the funds spent on Asian longhorned beetle eradication. Although APHIS has amended its mission statement to include protecting natural systems, Congress has not funded its request for additional funds for "invasive species" (GAO, 2001).

The Forest Service says it is hindered in responding rapidly to newly introduced pests by a lack of funds and delay in obtaining funds when an emergency arises. In FY 2000, the Forest Service spent $16.1 million on "rapid response" actions, primarily programs aimed at eradicating the Asian longhorned beetle; as well as several "slow the spread" programs targeting such well established pests as European gypsy moth, hemlock woolly adelgid, and Port-Orford-cedar root disease. A recent example of the inability to obtain additional emergency funds quickly is the sudden oak death epidemic in California and Oregon. Although this apparently exotic disease has the potential to devastate both western and eastern forests, seven months passed between the Forest Service's request for funds and their becoming available. Furthermore, the Forest Service received only $1.1 million—less than one-third of the $3.5 million requested (GAO, 2001).

Unfortunately, the NISC staff and member agencies are lagging behind the timetable for completing the actions recommended in the Plan. One reason is that the Plan's activities have been added to the participating federal departments' workloads with very little or no new funding. Adding responsibilities without providing resources usually translates into implementation delays. The advisory committee of non-federal experts has also been unable to help effectively in implementing the Plan in part because of their own busy workloads. The change in Administrations inevitably also delayed action, while new leadership teams were appointed for the federal departments and decisions were made about priorities. At the date of this writing, it remains an open question on how effective the federal departments that comprise the NISC will be in implementing the National Invasive Species Management Plan.

Conclusion and Recommendations:
What We Can Do to Protect America's Forests

The United States is at a crossroads between facilitating international trade and protecting our natural heritage from invasions by exotic organisms. International treaties and agreements threaten APHIS' ability to prevent introductions of new damaging exotic forest pests. APHIS itself is in a quandary with a dual mission prescribed by Congress to protect our agricultural and natural resources while facilitating trade. Control of established exotic species that could damage forests falls under the responsibility of the USDA Forest Service, but this agency does not have the resources and, in some cases, personnel and infrastructure to successfully address many exotic species problems.

We can minimize damage from both established exotic forest pests and those that might enter in the future, but to do so we must make substantial, fundamental changes in policies and programs at both the international and national levels. Individual agencies' programs should be better coordinated. Furthermore, all stakeholders need to devote substantially more resources to invasive species programs. Much of the significant economic burden associated with preventing bioinvasion should be shifted from government agencies supported by taxes (that is, society generally) to industries and consumers that rely upon importations or utilize exotic species. A new balance must be struck that better sustains the integrity of our natural resources while maintaining the strong economy.

Our proposed changes would result in altering responsibilities and budgets of federal and state agencies and jurisdictions of Congressional committees, as well as amending international trade agreements. Furthermore, these changes in treaties, laws, and policies would impose significant but appropriate costs on industries that rely upon importations and industries that use exotic species. In most respects, our proposed tenets are similar to recommendations contained in earlier reports by the Office of Technology Assessment (1993), General Accounting Office (1997; 2000; 2001), National Plant Board (1999), and National Research Council (2002a), as well as the National Invasive Species Management Plan (National Invasive Species Council, 2001; http://www.invasivespecies.gov/council/nmp.shtml). In the area of trade policy and user fees, our proposed tenets are more strongly and specifically worded.

The establishment of a damaging exotic species is usually considered to be a rare event. Nevertheless, as shown in the preceding chapters and the Gallery of Pests, the consequences can be devastating, economically and ecologically. We feel that the sheer volume of imports now ensures that even a "rare" event will happen too often, given the present status of prevention and control efforts in this country. It is inevitable that this situation will only grow worse with increasing international trade and downgrading of phytosanitary safeguards. As discussed in the preceding chapter, the severe consequences of bioinvasion, numerous opportunities for introductions, and the many difficulties undermining the effectiveness of existing efforts demonstrate the need for a fundamentally new approach. In our view, policies to curtail new introductions must be based on the following nine tenets:

(1) Where a conflict arises between preventing introductions and priority over facilitating international trade, priority is given to the former.

(2) Appropriate sharing of the costs of mitigating bioinvasion threats by parties benefitting from trade and other activities that facilitate species introduction and dissemination.

(3) Reestablishment of the "guilty until proven innocent" policy when exotic species are intercepted.

(4) The use of a pathway sterilization approach, as opposed to a species-by-species identification and interdiction procedure, to prevent introductions.

(5) Establishment of strong, functional "early detection/rapid response" programs to support exclusion programs.

(6) Equal priority for exotic species that threaten natural resources as compared to invasive species that threaten agriculture and other economic interests.

(7) Assumption of the responsibility by the federal government for preventing movement of established invasive species within or between states.

(8) Adequate funding for complete resolution of exotic pest problems, ranging from prevention to restoration programs that include genetic conservation of threatened species.

(9) Stakeholder access to complete, current information on bioinvasion and its impacts.

Although adoption of the above tenets and specific changes described in the next section will go a long way to reducing the threat to America's forests and other ecosystems from invasive species they alone would not bring satisfactory resolution to exotic pest problems. In the long term, we believe a more comprehensive solution is needed: creation of a National Center for Biological Invasions (as described in the section beginning on p. 10).

Specific Steps

Funding Recommendations

There is widespread recognition that funding in the war against biological invasions has been inadequate. Overall, the present federal control effort, approximately $996.6 million in fiscal year 2001(NISC data), is less than one percent of the $137 billion in annual losses caused by bioinvasion, as calculated by Pimentel *et al.* (2000). To maintain effective protection and ultimately resolve biological invasions, funding must be considerably increased over current levels, even if more efficient pathway approaches are adopted. It is essential that funds also be stable, to prevent interruptions of long-term projects, as identification, testing, and application of mitigation and control measures for introduced invasive species requires years of dedicated effort.

APHIS receives the great preponderance of all federal funding on invasive species, *e.g.*, 80 percent in 2001 ($798 million). Indeed, funding increases for APHIS from 1999 to 2001 exceeded total funding increase for all federal agencies' programs. This welcome increase in funds has, however, not been allocated in the most effective manner. For example, increasing the numbers of APHIS inspectors is not as effective as instituting stringent regulations governing introductory pathways. Furthermore, increasing funding for one agency is also not the answer, as many federal and state agencies must play a role if a pest becomes established. Strengthening one agency outside a coordinated multi-agency program will not provide the protection and resolution needed by natural ecosystems in the United States.

The increased funding needed for the full range of invasive species programs, we believe, should come in part from those who benefit from importing goods that indirectly cause the exotic invasive species problems. We suggest imposing a fee on all importers to partially cover the costs of all aspects of the exclusion program, including monitoring, research, development of control methodologies, enforcement, and eradication costs, as well as of port inspection. The fee charged should reflect the level of risk represented by the imported commodity or packaging, rising with a higher risk, as does any insurance policy. Tying the fee to risk also gives the importer an incentive to have taken the necessary steps to ensure compliance with phytosanitary regulations.

Jenkins (2002) suggested that $200 million in additional funds could be obtained by charging a small tax or user fee (0.004 percent) on the estimated value of a certain segment of importers and travellers. Jenkins would target incoming cargo, ships, and planes, and arriving passengers that are coming from another continent (*e.g.*, not Canada, Mexico, or the Caribbean). We support the concept, although we consider an additional $200 million annually above current funding for federal agencies to be insufficient to encompass such aspects as ecosystem restoration, economic recovery, or other needed activities. We suggest that the fee be raised.

It may be necessary to amend the SPS Agreement and IPPC to allow this approach. The SPS Agreement [Annex C, para. 1 (f)] stipulates that "any fees imposed for the procedures on imported products [be] equitable in relation to any fees charged on like domestic products . . . and should be no higher than the actual cost of the service." The IPPC also requires that "the cost of implementing plant health regulation should not exceed the benefit" (Dawson, 2001). Given the figures for costs and losses arising from invasive species detailed in the Pimentel *et al.* (2000) study, there should be no problem in setting user fees at a rate to fund the proposed Center for Biological Invasions and associate activities.

Treaties, Policies, and Regulations - What Changes Can Be Made Today?

During the period needed for establishment of a functioning national center on bioinvasion, several actions can be taken that will substantially improve protection, eradication, and control of exotic forest pests and exotic pests in general. For example, the World Trade Organization (WTO) countries have agreed to address agricultural trade issues during the next round of negotiations, which is due to be completed within three years. This agenda presents an opportunity to press for amendment of the SPS Agreement. Below are specific recommendations we have developed to correspond with the problems presented in the previous chapter.

International Policy and Regulations

The international community needs to recognize the connection between international trade and the spread of species far beyond their native ranges throughout the world, and the resulting ecological and economic costs. This spread is rapidly increasing as more intercontinental trade occurs, spurred by adoption of new trade agreements. The very real, albeit often delayed, costs of biological invasions should be factored into policy negotiations, as are other costs.

The WTO SPS Agreement and IPPC

We consider the provisions of the SPS Agreement and IPPC to be significantly flawed with respect to protection against biological invasions. We feel that critical articles in the SPS Agreement, as outlined in the previous chapter, were written with the purpose of promoting trade, rather than to ensure effective sanitary and phytosanitary protection. Thus, the Preamble, Articles 2.2, 5.4, and 5.6, and Annex C explicitly require that any phytosanitary measures have the minimal impact possible on trade. Language in other articles that places a high burden of proof for risk on the importing country has the same effect. One result has been that APHIS no longer regards a hitchhiking organism as "guilty until proven innocent"; instead, the agency now considers such inadvertent introductions to be "innocent until proven guilty." When confronted with an organism that has not been evaluated previously, APHIS can no longer simply require treatments or other actions to block its introduction. Instead, APHIS must either carry out a burdensome risk assessment of dubious scientific value or invoke its rights under Article 5.7 to impose a provisional safeguard and then conduct the risk assessment.

As discussed in the previous chapter, we believe that it would be most effective to adopt a new approach. First, APHIS should shift the emphasis from assessing individual products to a more comprehensive look at each of the segments and components of potential invasion pathways or vectors. Currently, most risk assessments are done on a specific product coming from a specific country, *e.g.*, apples from Chile. This requires significant expenditures of time and money and probably looks at the problem too narrowly. We suggest a broader approach that looks at much larger classes of imports, pathways, and/or larger geographic regions, *e.g.*, all raw wood from South America. Second, APHIS should adopt measures intended to prevent any living organism from hitchhiking on the imported commodity. This pathway sterilization would simultaneously solve a number of common problems with an overall savings of time and money. We also suggest allowing the importing country adequate flexibility to set the level of protection that it determines to be acceptable and to specify phytosanitary measures to achieve it. Then the exporter and exporting country would bear the burden of meeting those requirements to ensure the safety of the incoming shipment. Finally, the importing country verifies compliance to its satisfaction.

Adopting our recommended approach (basing regulation on a premise of "guilty until proven innocent" and Integrated Vector Management (Carlton and Ruiz 2002)) will require amendment of the WTO's SPS Agreement and the IPPC. Because the SPS Agreement is linked to the enforcement mechanism of the WTO, we have focused on it first. We have drafted a set of amendments to the SPS Agreement that would achieve these goals as well as improve other aspects of international programs to minimize bioinvasion (the text of the proposed amendments is found in Appendix 3). These amendments are intended to make the SPS Agreement more flexible and more realistic in terms of bioinvasion and scientists' current levels of knowledge, while still promoting "smart" trade. Our proposed amendments seek to:

- Include an explicit recognition that increasing international trade facilitates the spread of invasive species and diseases.
- Change the balance to ensure adequate protection while promoting trade.
- Recognize the necessity of preventing additional introductions of exotic species that are already established within a country, so as to curtail their spread and facilitate more effective control programs.
- Ensure that international standards are developed utilizing the best available science and expertise and in coordination with other international bodies active in this field.
- Allow greater flexibility in accommodating data gaps and scientific uncertainties that hinder efforts to predict which species will be invasive if introduced.
- Allow countries to put the burden of proving that an import is safe on the entity proposing the trade—either the exporting country or the importer.
- Allow countries to utilize pest exclusion technologies that are more effective and efficient than the traditional reliance on detecting invasive species in individual shipments through inspections.

Preamble, Articles 2.2, 5.4, 5.6 and Annex C

These Articles or sections were written to facilitate trade by explicitly requiring that any phytosanitary measures have the minimal impact possible on trade. We propose new language to afford better protection. For example, we would specify that phytosanitary measures must provide adequate protection while minimizing their avoidable negative effects on trade.

Article 2.3

Article 2.3 strictly limits countries' ability to restrict additional introductions of exotic species that are already established on their territories. Under its provisions, a country may impose phytosanitary safeguards targetting such species only when it has instituted a parallel program within the country. The result of this requirement is that the United States will be unable to curtail additional introductions of hundreds if not thousands of exotic species already known to cause damage. We propose an amendment that would allow import restrictions targetting those exotic species that are subject to mitigation efforts carried out by natural resource agencies as well as agencies responsible for protecting human, animal, or plant health.

Articles 2 and 5

Together, Articles 2 and 5 strictly limit countries' ability to take protective action when faced with uncertainty about either the likelihood or magnitude of risk. We propose several amendments to these articles that would expand countries' freedom to impose phytosanitary safeguards in such circumstances. New language in Article 2.2 and Article 5.1 would reverse interpretations by the WTO dispute-resolution bodies that appear to require a level of certainty that is not achievable in many cases. We would instead allow countries to impose phytosanitary safeguards when there is a "well-considered risk of harm", as demonstrated by analogies to similar situations (*e.g.*, invasive species detected or suspected using a certain pathway) or expert opinion. For example, if insects had been introduced on logs with bark, then other forms of wood bearing bark could also be regulated. Similarly, since damaging plant diseases have been introduced on imports of horticultural stock from some countries, imports of similar horticultural stock from other countries could also be subject to phytosanitary regulations to prevent introduction of other plant diseases. Through additional changes in the language of Article 2.2, we would also allow the importing country to put the burden of proving the safety of trade in the proposed good, or using a particular form of packaging or trade route, on the exporting country.

Article 3

Article 3.2 encourages countries to base their phytosanitary safeguards on international standards adopted by certain international bodies. The efficacy and credibility of these international standards will depend on the scientific expertise consulted, integrity of the scientific input and minimization of political factors, and the transparency of the process used by these international standard-setting bodies. The SPS provides no guidance on a process for consulting outside experts, nor does it assure that the standard-setting process will be open to public scrutiny. As with all trade negotiations, decisions are subject to political pressures. The result can be adoption of standards that meet only the lowest common denominator. We believe the IPPO's standard on wood packaging demonstrates these flaws.

Our amendments propose a partial solution; we would add several international organizations which have expertise in evaluating and managing invasive species to the list of standard-setting bodies recognized by the WTO countries. These organizations include the Convention on Biological Diversity and the World Conservation Union. The IPPO is currently developing environmental criteria to be incorporated into invasive species risk-analysis standards, but we remain skeptical whether this body has sufficient expertise and commitment to natural ecosystems to develop and apply reasonable, adequate provisions for balancing trade and invasive species concerns.

Articles 3 and 5

A critical element in tightening protective safeguards is setting a high "level of protection." We suggest several amendments in these two interrelated articles to allow countries greater flexibility in determining the "level of protection" that they consider to be "appropriate". First, we eliminate the specific requirement in Article 3.3 that a country use the risk assessment process laid out in Article 5 in setting its "level of protection". Our goal is to accommodate the role that societal values play in these decisions (above and beyond strictly scientific factors). Second, we amend Article 5.5 to deny use of "inconsistency" as the sole grounds for overturning a country's phytosanitary measure. We would allow countries greater flexibility and time to reconcile differences between the "levels of protection" applied in varying circumstances. Under our amendment, countries would still have to comply with other provisions of the SPS Agreement intended to prevent an unjustifiable safeguard, *e.g.*, one that lacks scientific justification.

Article 5.6

We propose adding a sentence to this article that explicitly recognizes countries' obligations to reconcile WTO commitments with duties accepted under other international agreements, *e.g.*, the Montreal Protocol on Ozone-Depleting Substances. Under the Montreal Protocol, countries have pledged to work toward ending use of methyl bromide. However, under the WTO and other trade agreements, continued use of this chemical is favored because it is relatively inexpensive and more accessible than alternative treatments.

Article 5.7

We propose amendments that would allow countries to adopt permanent (rather than provisional or temporary) phytosanitary measures based on available information, even when that information is inadequate to resolve uncertainties about either the likelihood or magnitude of risk associated with an imported commodity or pathway. Our goal is to avoid forcing countries to waste scarce resources by seeking information that does not exist when they should, instead, be focused on closing other, still unregulated, introductory pathways.

Agreement to Establish A Free Trade Area of the Americas

In Chapter 3, we raised a number of concerns with the draft language under consideration for the agreement that would create a Free Trade Area of the Americas. At this time, it is difficult to further comment on specific articles in this agreement as it is still under negotiation and proposals may be incorporated into the draft which resolve our concerns. To protect the United States' natural resources, we do feel that the agreement should contain wording to ensure the following goals:

- Thwart political pressure for accepting shipments that do not meet a country's level of protection. Special dispensations should not be granted to developing countries, which are just as likely to export invasive species as are more developed countries;
- Protect importing countries' right to establish highly protective standards rather than accept less stringent standards developed through negotiations with other counties;
- Eliminate hard time deadlines within which countries must decide whether to allow imports of new commodities. Instead, adopt language that would provide a reasonable time for risk assessments with an appeals process to ensure the risk-assessment process will not be used as a barrier to trade.
- Prevent any restraints on phytosanitary measures that are more restrictive than the current wording of the SPS Agreement.

National Policy and Regulation

While pursuing needed modifications to international treaties and agreements, policy makers and stakeholders can act now to adopt more effective approaches to prevention and control allowed by existing international agreements. The previous chapter described a number of concerns about the ability of APHIS to give the Nation's natural resources appropriate protection in the increasingly seamless world of international and national trade. These concerns can be grouped into four general areas: 1) trade-promotion pressures that conflict with the pest-exclusion responsibilities of the agency; 2) the agency's approach to prevention; 3) the agency's approach to risk assessment; and 4) the breadth of APHIS' interception data base. In each area, there is latitude for change that would make APHIS more effective at preventing introductions and rapidly addressing newly established invasive species.

Focusing APHIS on Prevention

Expectations that APHIS will both prevent biological invasions and facilitate trade place the agency in an impossible position. Especially given the widespread lack of awareness about bioinvasion, pressure to facilitate broader trade results in APHIS accepting substandard levels of protection when evaluating either individual shipments or pathways. To correct this imbalance, we suggest that the Department of Agriculture adopt a "0 risk" “level of protection.” This mandate would serve as a goal, that is, a target that we recognize cannot be achieved. Its adoption, however, would affirm the importance of preventing introductions and lead to more protective exclusion strategies and programs. This goal could be adopted either by the USDA through administrative action, or by the Congress through amendment of the Plant Protection Act.

APHIS gives higher priority to protecting crop species, due in part to the oversight of Congressional committees that also focus on agricultural issues and not natural resources. These are the House and Senate Agriculture committees and Agriculture appropriations subcommittees. We believe that our country would best be served by granting joint jurisdiction over APHIS to Congressional committees with responsibilities for natural resources, *e.g.*, the Senate Committee on Energy and Natural Resources and the House Committee on Resources and Subcommittee on Forests and Forest Health. In addition, we believe APHIS can benefit from establishing an advisory panel of scientists, resource managers, and stakeholders concerned about introduced forest pests.

To assist the agency in adopting maximally effective pest-exclusion strategies, we suggest periodic review of APHIS’ procedures and decisions by a responsible, scientifically qualified, and independent organization or body.   Although different options exist for oversight, we believe that the National Research Council should be charged with this task. The National Research Council has access to sufficient expertise to conduct proper oversight and prestige enough to overcome political and business challenges to APHIS’ authority that are sure to occur. The National Research Council has frequently provided advice on natural resource issues (we cite three such studies in this report—one in 1975 and two in 2002).   The historical precedent is actually a century old: in 1896, President Grover Cleveland asked the National Academy of Sciences to study the use of the National Reserves, the precursor of the National Forests.

Approaches to Prevention and Risk Assessment

Prevention

We recommend that APHIS expeditiously diminish its reliance on inspection and detection and instead begin to regulate introductions using “Integrated Vector Management” (Carlton and Ruiz 2002). Scientists consider both the detection and evaluation processes to be error-prone (Carroll, 1998). Past and projected increases in international trade will undoubtedly increase the probability of more invasive species entering this country. Furthermore, APHIS cannot possibly inspect the increasing volumes of imports (USDA APHIS and Forest Service, 2000; National Plant Board, 1999; Powell *et al.*, 1984; comments by the American Nursery and Landscape Association and Society of American Florists on Docket No. 00-042-1). Under the “Integrated Vector Management” approach, the agency uses all available control and management techniques at the appropriate times and places to virtually eliminate hitchhiking organisms (Carlton and Ruiz 2002). In other words, APHIS would apply several independently effective phytosanitary safeguards in order to sterilize the pathway, so that no living organism could hitchhike or stow away on the shipment. Inspection and detection would serve as a check on the efficacy of the pathway sterilization measures, rather than as the first line of defense.

The use of Integrated Vector Management will allow APHIS to utilize its staff and resources more efficiently and to focus on the following important components of a prevention program that are now neglected:

- Enforcing phytosanitary rules aggressively.
- Reducing the backlog of 400 risk assessments needed to support pre-WTO regulations governing imports of various commodities.
- Devoting increased staff and funding to preventing introductions of organisms that threaten forests and natural areas compared to those that imperil agricultural and horticultural crops.
- Expanding coordination efforts with other agencies and a wider variety of “stakeholders,” *e.g.*,

private-citizen groups concerned about natural resources.

! Carrying out the research recommended by the National Research Council (2002a) to improve the scientific foundation for risk assessment, including researching, developing, and testing integrated prevention approaches.

! Collecting and evaluating more complete data on invasive species interceptions and actively searching for early evidence of new outbreaks.

! Responding rapidly to newly detected outbreaks.

Switching from inspection/detection to regulating pathways and vectors will not occur quickly, due to the magnitude of the change. APHIS should focus initially on the most dangerous of pathways, specifically the three pathways which pose the highest risk of transporting pests that threaten forests: nursery stock, raw wood, and wood packaging (SWPM).

Nursery Stock

We feel that importations of whole plants and portions of plants intended for propagation, *e.g.*, budwood for grafting, should be prohibited**.** Descriptions in previous chapters and the Gallery of Pests demonstrate that highly destructive exotic species still enter via this pathway. We feel that the safest option for introduction of exotic plants is through allowing imports of only small lots of seed or clones grown *in vitro* (grown in aseptic conditions free of contaminating agents such as bacteria or fungi) in compliance with existing importation regulations.

Seeds and *in vitro* materials can harbor invasive species, but these problems are more easily solved than the risks arising from imports of whole plants. Existing regulations focus protective safeguards on seeds that have a high probability of harboring insects, *e.g.*, acorns, and methodologies, *e.g.*, x-rays, can be used to check for seedlots with high insect damage. Pathogenic fungi pose a greater challenge. Several fungi have been reported in the scientific literature as transported on seeds (Elmer, 2001), including such forest pests as Diplodia shoot blight (Wingfield, 2002) and pine pitch canker (Gordon, 2002). Elmer (2001) goes so far as to say, "In fact, most plant pathologists would agree that any pathogen might be seedborne on at least one host." Infested seeds are often asymptomatic, so the infection is hard to detect by inspection. Seeds also provide an environment conducive to long-term persistence of the pathogen (Elmer, 2001). Until APHIS has developed rigorous systems approaches that have a high probability of success in ensuring that seeds intended for importation into the United States are free of pathogens, the agency must strictly limit the size of seed shipments in order to subject them to stringent inspection and post-importation quarantine with assessments of the germinated seedlots for disease.

Exporters of *in vitro materials* must be held responsible for periodic testing of parent stocks to ensure that they are free of pathogens (National Plant Board, 2002). There remains the problem that these tests are usually applicable only to a limited number of pathogens known to pose a threat and are likely to miss species that are "unknown" or are mistakenly thought to be benign. Exporters and importers must then ensure production occurs in a pathogen-free environment (National Plant Board, 2002). *In vitro* clones should come from certified laboratories that can attest that the plantlets are products of an *in vitro* process. Otherwise, shippers might try to substitute branches that have not been produced *in vitro*, etc., that can be propagated by rooting, and that could contain invasive species. Once the shipments arrive at the United States border, inspections would have to be expedited, since cultured material can die if it is not maintained in precisely defined conditions. As a final safeguard, post-quarantine inspections and regulation of *in vitro* plant materials during the growing-out period should be required**.**

Fairness Development of new types of cultivated plants for landscaping and floral use is the lifeblood of the nursery, and to a certain extent, floral industries. Limiting nursery and floral stock importations to seeds and *in vitro* clones will significantly impact these industries. There are viable alternatives, however, to maintain a flow of new cultivars to support these industries. For cultivars that have been developed overseas, importation of *in vitro* clones of cultivars is an option for species that can be propagated in that manner. Another option is to promote exotic, non-invasive plant materials that are already in the country. Collectively, Plant Introduction Stations, National Germplasm Repositories, the National Arboretum, and various state and private botanical gardens and arboreta have a considerable amount of materials that could be evaluated and developed for horticultural uses. Utilization and development of native species that show landscaping/floral potential is another avenue for providing new materials. In the long term, development of native species may better fit with a more populous country that will be placing more demand on water resources.

With respect to the above alternatives, we feel that the USDA should provide leadership in developing trees and shrubs through Cooperative State Research, Education and Extension Service (CSREES) programs, such as regional projects, that could provide funding for cultivar development to the universities. In addition, the USDA could redirect certain USDA Agricultural Research Service project emphasis, and develop program areas in the National Research Initiative for competitive grants relating to woody ornamental development.

There is another alternative: importation of plant materials exclusively through the existing federal infrastructure. Importing plant materials exclusively through the National Plant Germplasm System, in conjunction with the Plant Introduction Stations, may be the best and least disruptive option. Under this alternative, private importers would be restricted as above, but different types of materials, *e.g.*, scion wood, bulbs etc., could be imported through this System, with post importation quarantine and inspections occurring on the Plant Introduction Stations. The National Plant Germplasm System routinely sponsors trips to different parts of the world to collect seeds/clones of potentially valuable species and cultivars, and growers could target collections for certain species or cultivars. The germplasm would be grown under the oversight of a Plant Introduction Station, which could evaluate the material over time for hitchiking pests and invasiveness. Germplasm harboring pests or with invasive characteristics could be treated or destroyed. This would slow germplasm release due to the quarantine/evaluation period, but the released germplasm would not harbor exotic pests nor be invasive. Additionally, released materials could be deposited in National Plant Germplasm Repositories to ensure perpetuity. Additional Plant Introduction Stations would be needed under this alternative, as their numbers have dwindled to four (4) nationwide.

Raw Wood: Logs, Lumber and Chips

Current regulations governing importation of raw wood into this country have inconsistencies and loopholes, and treatments have been challenged by experts, as described in Chapter 3. Correspondingly, we believe that the importation of raw wood poses too great a risk. To ensure protection of United States' forests, the sanitation process should be conducted prior to the raw wood reaching the United States from other countries (with the exception of Canada, given that wood from our northern neighbor poses a minimal risk). Bringing unprocessed wood into the country, even into an APHIS-approved facility for sanitation, still affords invasive species opportunities to escape the unprocessed product during the inevitable delay until sanitation. Wood that has been processed in a manner to eliminate all invasive species, including deep wood invasive species, would be approved for import but under an incorruptible system that provides certification of correct processing.

Solid Wood Packing Material

The recent importations of Asian longhorned beetle and other insects on SWPM clearly demonstrate the need to rapidly phase out unprocessed wood as packing materials. APHIS should consult with shipping- and packaging-industry representatives and other interested parties, then issue regulations specifying the earliest possible deadline for switching from packaging made from solid wood to packaging made from various composites, metal, plastic, rubber, fiberglass, or other durable, more easily re-usable materials. In some cases, inflatable air bags can replace dunnage. During the transition period, APHIS should require that all SWPM be fumigated and institute secure systems to verify treatment. Enactment of a bar code system or equivalent such as those placed on railroad cars could be used for easy identification, tracking, and history of the movement of packaging.

APHIS should also seek outside expertise in helping it re-evaluate the risk associated with wood wool, chips, and strips used as cushioning. The agency should then either initiate a rulemaking requiring phase-out or treatment of these loose packing materials or publish a report that explains its decision not to take this step.

Risk Assessment

As noted in the previous chapter, APHIS does not now strive for complete effectiveness in excluding potential invasive species but opts for a "negligible" risk. While APHIS rarely specifies what it considers to be "negligible" risk, in the cases of logs and lumber imported from New Zealand and Chile, and wood packaging from China, it accepted a risk of 3 to 5 percent. However, a risk of 3 - 5 percent is actually quite high. We feel that APHIS should specify a much lower risk level for all types of importations and pathways and correspondingly re-evaluate its current phytosanitary measures. To spur the agency, we suggest that the Congress should amend the Plant Protection Act to establish "0 risk" as the nation's official level of protection. As we stated earlier, setting a target of "0 risk" would demonstrate the importance of this problem and the resolve of the federal government to address it.

We also reviewed the widespread criticism of APHIS' risk-assessment process. In a recent study, a National Research Council (2002a) panel reviewed this process and recommended that APHIS better document the basis for its risk assessments. The agency should list and explain its underlying assumptions, so that independent experts can evaluate the agency's conclusions about an organism's likelihood of arrival, establishment, and impact. The risk-assessment procedure should be transparent, repeatable, peer-reviewed, and updated to capture new information and enhance expert judgment. We concur with these suggestions and believe that adherence to these points will significantly strengthen the risk-assessment process.

Improving APHIS' Data Base

APHIS' ability to set priorities is hampered by inadequacies in the interception database, as noted in the previous chapter. We support the following recommendations by the National Research Council (2002a):

! Adopt statistically designed sampling methodology.

! Re-evaluate and revise port sampling protocols to ensure data are accurate and meaningful.

! Expand data collection to include vascular plants, in addition to those listed as noxious.

! Monitor data on a regular basis to detect and correct problems in data entry and maintenance.

! Make the data base accessible for analysis by external experts.

! Increase efforts to detect and identify pathogens.

! Include additional variables, such as

! Number of inspections that detect no invasive species,

! Some measure of abundance of invasive species,

! Interception of nonquarantine invasive species.

We again recognize the need for additional resources in APHIS to institute many of these changes.

National Invasive Species Council (NISC)

At least 23 federal agencies in seven departments are responsible for some aspect of the federal government's invasive species program. Other important players are state, local, and tribal governments, a wide range of businesses, associations, and individual citizens. Through Executive Order 13112, the federal government has created a body to coordinate the many agencies' efforts, the National Invasive Species Council (NISC). The Council is composed of the leadership of government agencies bearing responsibility for invasive-species management: the Secretaries of Interior, Agriculture, Commerce, State, Defense, Treasury, Transportation, and Health and Human Services; and the Administrators of the Environmental Protection Agency and Agency for International Development. All the agencies have appointed liaisons to represent them on a daily basis, although only the liaison staffs from the Departments of Agriculture, Interior, and Commerce actually work full time on these issues and are based in the Council's office.

The NISC and associated Invasive Species Advisory Committee have a disappointing record to date. One reason is that the Council has no authority over any agency, but can only seek to persuade the departments to cooperate. For example, if the Council feels that APHIS has not taken the appropriate steps to prevent an invasive species from spreading, it has no power to direct APHIS to modify its approach. A second reason is the decision to try to expand invasive species programs without providing additional resources. The NISC is hampered by its small staff, which consists of just five people plus liaisons to the three key departments. Partially for this reason, the NISC has lagged in carrying out is responsibilities under the national invasive species management plan. The individual agencies have also received no new staff or funds to implement the many tasks assigned to them by the Plan.

A third reason for slow progress has been unfortunate timing of Council activities relative to political events. The invasive species management plan was issued just when presidential administrations were changing; the new political leadership had to take office and decide its own priorities. When the policy makers made a commitment to continuing the coordinated invasive species effort, it was time to appoint a new advisory committee. Therefore, it was not until mid-2002 that the new advisors began conferring with federal agency staffs on developing detailed implementation strategies for each recommendation in the plan.

The National Invasive Species Management Plan developed by the Council and Advisory Committee has many strengths, but it is disappointing in its approach to international trade treaties and agreements. It foresees heavy reliance on cooperative and educational projects being carried out by the Global Invasive Species Programme (http://jasper.stanford.edu/gisp/home.htm). Such coordination will undoubtedly be useful, but it is not sufficient. The potential impact of effective invasive-species management programs on trade and important economic interests is too great to rely on cooperation and education alone. The National Plan does not mention other opportunities for developing a more cohesive approach to invasive-species issues, such as involving resource agencies in the on-going development of international standards that will determine what procedures agencies such as APHIS can follow to prevent additional introductions. Additionally, the National Plan has not proposed a fundamentally new approach to preventing introductions and minimizing impacts of established alien species. On the positive side, it has called for a collaborative effort with stakeholders to set priorities among introductory pathways. However, the Plan did not address such fundamental issues as constraints imposed by trade policies and eschewing regulations. The Plan does not address the conundrum of APHIS' longstanding emphasis on protecting crop species to the neglect of invasive species and weeds that damage natural ecosystems. Moreover, the Plan does not address APHIS' slow response to aggressively combatting newly detected introductions, particularly those that primarily damage natural systems.

Even after creation of a Center for Biological Invasion, personnel/offices in each of these agencies will continue to have responsibilities connected with biological invasions, and coordination will continue to be needed to improve efficiency and avoid duplication. If important responsibilities are transferred to a new Department of Homeland Security, the Executive Order should be amended to reflect those changes.

Homeland Security and APHIS

The nation's efforts to prevent renewed terrorist attacks could fundamentally change the way APHIS and other border agencies operate. President Bush has proposed combining APHIS, U.S. Customs Bureau, Immigration and Naturalization Service, and other border agencies into one agency (J. Sarasohn, "Agricultural Lobbyists Bend

Tom Ridge's Ear," *The Washington Post*, July 4, 2002, p. A21). It is difficult to predict how such a change might affect APHIS' ability to prevent introductions of biological organisms that might threaten natural resources. The reorganization process may open opportunities to address some of our concerns about APHIS. For example, Congressional action to create the new agency could provide an opportunity to broaden the range of Congressional committees overseeing APHIS' program. Furthermore, the new Department, in contrast to the USDA, would presumably place a low priority on facilitating international trade. On the other hand, preventing introductions that could harm natural systems might have to compete for funding and attention against an even greater number of concerns in an expanded agency and possibly slip to an even lower priority. In addition, the secrecy appropriate to an anti-terrorism campaign is counter to the open and rapid flow of information needed to improve invasive-species programs. While we support President Bush's determination to protect our country from attack, we respectfully believe that APHIS belongs in a CBI-type agency, rather than being combined with agencies such as the Immigration and Naturalization Service. It would be possible to create a division within APHIS that would have the necessary technical expertise to detect and address biological weapons and the appropriately trained law enforcement personnel to address criminal actions. This division could still work closely with external agencies and be readily available if traditional APHIS officers suspect a national security problem.

The Need for a National Center on Bioinvasion

Invasive exotic species issues affect vastly different constituencies, ranging from corporations to non-affiliated individuals concerned with the long-lasting health of natural ecosystems. As discussed, biologically-based decisions to address exotic invasive species have ramifications for natural ecosystems as well as international and interstate trade. The current and future demands on forest resources for multiple uses make it essential that a national program be developed and funded to encompass prevention, rapid detection and eradication of newly discovered introduced organisms, integrated invasive species management, and forest ecosystem restoration. Components of this program currently exist in individual agencies, as do several coordinating mechanisms. Demonstrably, neither individually or collectively is this effort accorded appropriate priority or adequate funds and staff, nor are the programs satisfactorily integrated into a coordinated effort. In addition to forested lands, natural, agricultural, and urban areas and waterways in this country have been impacted by biological invasions. Clearly there is a need for national leadership to prioritize and coordinate activities among the different federal and state agencies. A stable, permanent entity with broad responsibilities and authority to meet biological invasion challenges is needed that will transcend different Administrations and provide protection for our natural resources.

In ***Fading Forests I*** (1994), we called for a comprehensive national program that would promote interagency cooperation at the federal level and cooperation between the federal and state governments. At the time, we did not believe that a new federal entity would be necessary to address biological invasions. We now re-evaluate this recommendation because of the rising danger from changes in international trade agreements and rapid increase in international trade, exacerbated by domestic policies explicitly favoring trade over protection and the continuing low priority to combatting forest pests. Furthermore, the experience of the NISC causes us to doubt that the needed comprehensive national strategy can be effected through cooperation among existing agencies alone. We now believe that a Center for Biological Invasions (CBI), a concept first proposed by Schmitz and Simberloff (2001), needs to be created that will address exotic forest invasive species as well as established and potential invaders of other systems. We believe that APHIS should be an integral part of the CBI, but units addressing exotic invasive species issues from other agencies would generally be maintained in their home agency and would coordinate with the CBI, *e.g.*, research and Forest Health Protection in the USDA Forest Service. We further recommend that the National Research Council be charged with conducting periodic reviews of the CBI's performance, as it can assemble the necessary expertise to properly evaluate CBI activities and is the most respected, nonpolitical group of scientists in the country. The CBI would implement the national invasive species management plan adopted and periodically revised pursuant to Executive Order 13112.

We envision the CBI to have five major divisions: (1) Prevention, (2) Research, (3) Ecosystem Protection and Restoration, (4) Economic Recovery, and (5) Information. Within each major division, subdivisions of specialties would exist as follows:

(1) Prevention

Prevention efforts can be successful only if the responsible agency has a mandate to focus solely on preventing introductions through a combination of exclusion and rapid eradication. CBI-Prevention would have such a clear mandate. It would be comprised of regulatory staff from APHIS and other agencies now responsible for regulating introductions of organisms other than plants, plant pests, or animal diseases. This division would be charged with preventing exotic organisms from entering the country, spreading within the country, and early detection and rapid eradication of new introductions as below.

Preventing exotic organisms from entering the United States – CBI-Prevention would retain its emphasis on exclusion using a combination of integrated vector management and aggressive rapid response strategies to newly detected introductions. CBI-Prevention would use **improved** risk assessment analysis to set priorities and evaluate proposed deliberate introductions*, e.g.,* horticultural plants, and some reasonable number of other specific imports for which adequate information is available and amenable to species-specific exclusion efforts. Traditional inspections by visual or other techniques would remain largely as verification and back-up, although these procedures might still be the principal strategy for some pathways, *e.g.*, incoming passengers' luggage. While CBI would presumably have the lead in these areas, it would consult closely with the Forest Service and other agencies responsible for maintaining the health and productivity of natural resources within the country.

Preventing the spread of exotic organisms within the United States – Movement of established exotic organisms within the United States, either deliberately or as hitchhikers on commodities and vehicles, is a significant contributor to their spread to new areas. State animal and plant inspectors are charged with ensuring organisms are pest-free prior to interstate shipments; however, those inspectors are under tremendous pressure from in-state industries to avoid interfering with their shipments. We believe that this system should be entirely federalized and become part of the CBI in order to offer better protection to both natural resources and the inspectors. This should provide for more consistent enforcement of State and federal laws and regulations among the states and allow for implementation of quarantines where appropriate.

Early Detection and Rapid Eradication – The CBI-Prevention would provide leadership for a greatly expanded effort to detect quickly incipient infestations and rapidly implement eradication programs. Natural resource agencies, such as the Forest Service, would have a formal role in advising and cooperating with the CBI in these matters. Information from non-governmental scientists and knowledgeable amateurs should be sought and evaluated.

Monitoring – CBI-Prevention would establish and coordinate a nationwide monitoring system for biological invasions to detect species that cryptically enter the country, monitor the spread of newly established and resident species, and evaluate the effectiveness of eradication and control mechanisms. We believe the actual monitoring should be done by federal and state agencies, supplemented by information from non-governmental scientists and knowledgeable amateurs. The CBI would also evaluate and disseminate the information.

(2) Research

The need for research to address biological invasions is recognized in the National Plan (National Invasive Species Council, 2001; http://www.invasivespecies.gov/council/nmp.shtml). Six different research areas are identified: (1) Identification, prevention and early detection; (2) Monitoring; (3) Invasion biology and impacts; (4) Control; (5) Ecosystem restoration; and (6) Research Infrastructure. Different components of these research areas lie scattered across various government agencies, universities, and the private sector. Nationwide the emphasis on these research areas is variable. Generally, research in response to a problem, *e.g*., control, is more prevalent than prevention research, *e.g*., policy. We propose that the CBI Research Division be charged with addressing:

(1) Research needed to address all phases of a biological invasion ranging from prevention to restoration.
(2) Critical expertise needed in the Risk Assessment Analyses process.
(3) Integrating existing research in state (including universities) and federal governments and the private sector.
(4) Research that can be conducted by external experts through a directed grant program.

The CBI Research Division should provide a stable base, i.e., long-term research, to identify and address the varied and changing challenges of biological invasions where a solution is needed. In-house research should be coordinated with external programs and when additional expertise is needed, direct funding to scientists through contracts and grants that are administered by the CBI. Personnel would be drawn from APHIS and other agencies as appropriate to staff three functional units: biology, economics, and policy.

Biology. Provide biological information on exotic species, including taxonomy and invasion biology; impacts on rural and urban ecosystems; strategies for ecosystem restoration; characterization of genetic diversity in host or displaced species and corresponding germplasm collections; and detection, eradication, and control research.

Economics. Economic analyses of the impacts of currently established invasive exotic species; and species that could be introduced in the course of existing or proposed new trade relationships or as a result of changes in international treaties and accords and federal and state laws; and changes in regulations and policies that affect the ability to prevent, eradicate, and/or control exotic invasive species.

Policy. Examination of international, federal, state, and local laws, regulations, and policies that affect the ability to prevent, eradicate, and/or control exotic invasive species; recommend changes based on biological information and economic analyses of invasive species impact.

(3) Ecosystem Protection and Restoration

Ecosystem protection against newly detected invasive species, resident exotic invasive species that suddenly emerge as significant problems, and well established exotic invasive species should be an integrated effort between federal, State and private organizations and agencies, when applicable.

Control of Established Forest Invasive Species

The Forest Service would continue to lead research and application of control measures in the United States. Control measures can range from short-term mitigation procedures such as spraying GypChek® to suppress gypsy moth populations to long-term approaches such as breeding to incorporate resistance into host plants. As a federal agency, the Forest Service can provide the stability needed to develop the long-term solutions needed for resident exotic invasive species. The work should be in active collaboration with other federal agencies, *e.g.*, the National Park Service, state forestry divisions, and universities. Other interest groups that are affected by the decline of America's forests or contribute to the threat by importing items which could carry invasive species organisms should contribute knowledge, funds, public education efforts, and other resources to improving our understanding of and efforts to contain exotic invasive species of trees. These interest groups would include the nursery, wood products, shipping, and recreational industries; universities, state and federal natural resource and conservation organizations.

Unfortunately, the financial and staffing shortfalls for the Forest Service that we decried in our earlier report have grown worse. The Forest Service received only $35.5 million for invasive species programs in FY 2001 (NISC data). Funding for the Forest Service Research Branch, which examines questions ranging from basic investigations with broad application to highly targeted applied studies, has stagnated at $8.6 million for more than five years. Forest Service staff have documented funding needs of $30 million, almost four times as much. The effects of the funding shortfall are exacerbated by increasing costs, shifts in emphasis, and Congressional earmarking of the funds to specific projects. In constant dollars, Forest Service research funding has fallen 8.4 percent compared to 1980. Forest-protection research fell by 56 percent during this period (NRC 2002b).

Perhaps even more critical than a stagnant budget is the loss of expertise from Forest Service Research. Between 1985 and 1999, the number of entomologists has fallen from 70 to 31; the number of plant pathologists from 50 to 22. Similar trends are present in university forestry schools, thereby creating a shortage of trained personnel to replace retiring Forest Service entomologists or pathologists. This trend is further augmented by filling the open positions with scientists in more basic research, *e.g.*, molecular biology, in an effort to attract more funding from outside sources. We support the NRC's (2002b) recommendation that the Forest Service restore its expertise in the core areas/foundation disciplines of traditional biology.

The Forest Service also needs adequate funding to allow the agency to quickly research newly detected forest-invasive species. At present, the Forest Service's vital work targeting Sudden Oak Death and control measures for the Asian longhorned beetle are enabled by "emergency" funds, which are uncertain from year to year. Developing methods of eradication or control for newly emerging forest invasive species can take years of research. To end prematurely the necessary research that would lead to eradication/control of an exotic invasive species in an early stage of establishment will only exponentially increase the inevitable economic costs and ecosystem disruption. A strong Forest Service research presence in these areas is needed to assist the National Forests in addressing exotic invasive species and to transfer technology to state and private forestry and forest health protection personnel who assist state agencies; private industry and organizations; and individuals with exotic-invasive-species problems.

In testing and adopting control methods, all parties must balance the methods against the environmental impact(s) of the exotic pest. It is important to emphasize that environmental and financial costs are associated with both control measures and non-response to exotic pest damage. For example, biological control using an exotic organism may have an environmental impact greater than damage caused by the offending exotic pest. A difficult, careful balancing of these countervailing environmental costs should be inherent in any exotic pest strategy.

Ecosystem Restoration

Ecosystem restoration after an exotic-based disturbance usually receives little attention, in comparison to eradication and control actions (Schlarbaum *et al.*, 1999). Landscapes are resilient, so when trees die as a result of attack by invasive species, new vegetation quickly fills the gaps. Restoring areas damaged by invasive species to their natural state begins with management of the invading non-natural vegetation, management of natural regeneration of desired vegetation, and augmentation of desired species to the correct proportion in the landscape through planting or reintroducing the host species if completely decimated by a host-specific invasive species. If planting is necessary, it is desirable to use genotypes that are from the same locality to restore the local genetic architecture. This is particularly true if the affected land base is within a national park. Utilization of local genotypes is more difficult when a host-specific invasive species has extirpated the tree species from the landscape, and there are few surviving pockets of local genotypes.

Germplasm preservation of local genotypes through *in situ* preservation (preferred when possible), long-term seed storage, or establishment of an *ex situ* planting to bear seed is the answer to this problem, but unfortunately it is rarely incorporated into an exotic-invasive-species strategy. Actions toward ecosystem restoration should begin when eradication procedures fail to eliminate a newly emerging exotic invasive species that has the capability of reducing or destroying the genetic diversity in a species. The CBI Research Division should monitor all biological invasions, determine the genetic diversity in host species or organisms and recommend germplasm preservation when local gene pools are at risk. The traditional home of such activities for forest species has been within the Forest Service. The CBI should coordinate with Forest Service and local officials to ensure that collection of germplasm for storage is made to provide locally adapted genotypes for restoration when controls are developed or for use in developing host-plant resistance (*cf.* Schlarbaum *et al.*, 1999). Through collaboration with the National Center for Genetic Resources Preservation, seed storage can be made in the National Seed Storage Laboratory at Ft. Collins, Colorado. If storage is not feasible, *ex situ* or *in situ* seed production areas should be created. The same activities should be conducted for gene pools endangered by resident exotic invasive species, if the germplasm is still present. Creation of a land base for seed production is best tied to state or federal programs that can reserve land for this purpose and will work cooperatively with the CBI. Creation and management of seed production areas are expensive, long-term investments and should be funded as a line-item in the agency's budget supplemented by a CBI long-term grant.

Unfortunately, support for the Forest Service's Genetic Resources Programs has been deteriorating since 1992 (Schlarbaum, 1999) and some programs have closed. As the Forest Service shifted emphasis from timber management to ecosystem management, planting significantly decreased, and administrators and planners failed to recognize the significant role of the Genetic Resources Programs in responding to exotic forest pests.

Without strong Forest Service Genetic Resource Programs, ecosystem restoration will be difficult and very expensive. Essentially, there is no reliable fallback for this type of work in state and federal governments. Only approximately one-half of the states have tree improvement programs, and they vary in size and capabilities according to fluctuating state budgets (Schlarbaum, 1999). Thirty years ago, many land grant universities had tree improvement programs, but these have shrunk to only a handful of programs actively involved in traditional selection, breeding, and field-testing programs. There are several university-industrial tree improvement cooperatives, but they usually work only with a narrow range of timber species commercially important to the cooperators. Private industry is not a realistic option, as a number of species are not valuable for timber.

(4) Economic Recovery

Within the external grants program, the CBI should have the funds to make grants available to communities and organizations to help recover from losses due to exotic invasive species problems. Economic stimulus packages meeting criteria set by the CBI should be available to respond to such problems as changes in hydrology, watersheds, agricultural use, pastures, and loss of biodiversity. The packages should also encompass restoration of ecosystems if appropriate. The focus should be on a problem or problems at the county level or small, multi-county areas that will ensure involvement by the general public and thereby serve a dual purpose of problem resolution and public education. Communities could hire coordinators to assist private landowners in cost-share programs that would ultimately lead to restored ecosystems.

(5) Information

A significant responsibility of the CBI should be assembling and maintaining data bases related to exotic invasive species and linking them to a federally sponsored grid of information centers around the country. The data should be open and accessible to non-governmental scientists and the public. It should utilize information from the "gray" literature as well as peer-reviewed sources (National Research Council, 2002a). Following some of the suggestions of National Research Council (2002a), we feel that the data base(s) should include:

1. A central repository of information on resident North American exotic species and exotic species that could potentially cause problems if established, *e.g.*, species designated by risk assessments or other research.
2. Information and maps to show the distribution and progressive invasion of new and resident exotic invasive species.
3. A standardized literature synthesis on the natural history of resident and potential exotic invasive species.

We feel that new information should be summarized in the forms of news alerts and a periodic newsletter sent electronically to federal information centers; Agricultural Extension Service offices; appropriate offices in federal and state agencies; and private industry, organizations, and individuals who request the service.

Closing Statement

North American forests have suffered enormous damage caused by insects and diseases introduced from abroad. Already, several tree species have been virtually eliminated as integral components of the forest, and numerous others are suffering severe declines. Losses from introduced pests identified in the past decade could dwarf currently perceived impacts: the Asian longhorned beetle could cause more than $600 billion in damage over the next 30 years. Ongoing and projected expansions in trade greatly increase the risk that additional exotic insects and disease pathogens will be introduced. This danger is heightened by international trade agreements and national trade promotion policies that restrict application of effective phytosanitary safeguards.

Minimizing damage from exotic forest pests is already a great challenge, but it will become significantly more difficult and expensive unless steps are taken now to address both short- and long-term solutions. Relatively minor changes in specific APHIS regulations in the short term, can substantially reduce the risks of new introductions. Opportunities also exist for amending restrictive international trade agreements. American policy makers and other stakeholders should focus immediately on rectifying these flawed policies.

In the longer term, responsible agencies and the Congress must accept the importance of ensuring the health of our forests by adopting a much higher level of protection than APHIS' current target of "negligible" risk. Furthermore, the national effort needs to be expanded and better coordinated. For these reasons, we support not only an invigorated National Invasive Species Counci,l but also creation of a National Center on Biological Invasion.

Finally, programs to prevent the introduction of forest pests and to respond once pests are introduced require increased funding; they should be on a par with the funds now allocated to protecting agriculture from introduced pests.

Bringing about the needed changes, both amending specific measures and changing underlying policies and governmental agencies deserve the support of natural-resource professionals, industries that rely upon natural resources, and private-citizen groups concerned with the environment. As Gifford Pinchot, architect of the Forest Service, recognized a century ago,

"[The USDA Forest Service] . . . *rests upon the fact that in a government such as ours no movement can be permanently successful unless it is based on a general public recognition of its importance and utility".*

Proceedings of the American Forest Congress (1905)

America's forests provide a myriad of natural, economic, cultural, and philosophical values. We believe that ensuring continued healthy forests for the future deserves the support of all who value the forests, whatever their specific motivation. We urge our readers to support the changes that we propose in relevant laws, policies, and treaties.

In coming months and years, the American public has unparalleled opportunities to influence both international and national policies. Negotiators are still developing the text for the Free Trade Agreement of the Americas. Negotiations over new terms for agricultural trade could provide an opportunity to explore amendment of the World Trade Organization's SPS Agreement. The USDA Animal and Plant Health Inspection Service is strengthening its regulations of two of the most important pathways, imports of wood packaging and living plants. Individuals, associations, and natural-resource based industries should seize these opportunities to influence policies that will shape the future of our forests for generations to come.

Gallery of Pests

The dangers of exotic forest pests were evident by the latter 1800s, as gypsy moth quickly became a problem after its release in 1869 (cf. Howard, 1898). Over the years, hundreds of insects and a number of fungi have been introduced to North America (Mattson *et al*., 1994; Liebhold *et al*., 1995), but only a portion of these exotic species cause dramatic damage to forests or threaten specific species. Most exotic forest pests have relatively low profiles but are nevertheless damaging our natural resources. Below are short summaries for: 1) some of the most serious established exotic pests in North American forests, 2) newly discovered pests in North America, and 3) pests that could potentially pose problems if introduced and established.

Established Exotic Pests

Chestnut Blight
Phytophthora cinnamomi
Chestnut Gall Wasp

Chestnut Blight - Chestnut blight on American chestnut sprouts. Photograph courtesy of Gene Johnston, Tennessee Agricultural Experiment Station, The University of Tennessee.

The American chestnut and related Allegheny and Ozark chinkapins were once important components of upland forests in eastern North America. American chestnut was the stalwart of eastern forests, with estimates accounting for one-quarter of all the standing timber (USDA Forest Service, 1991), and provided Native Americans and European colonists with wood, tannin, food, and mast for wildlife and domesticated animals. Though dwarfed by American chestnut, chinkapins provided large crops of nuts that were comparatively smaller than chestnuts but were preferred by wild turkeys (Minser *et al*., 1995). Chestnuts and chinkapins have had the misfortune of being attacked in succession by three different exotic pests. Decline of these species probably began approximately 200 years ago with the introduction of the soil-borne algal fungi, *Phytophthora cinnamomi*, which causes brown-black lesions with ink-black exudate girdling the roots and root collar. This pathogen thrives in wet, poorly drained soils. The first recorded observation of this disease was in 1825, when a Mr. Jones of Riceboro, Georgia, observed Allegheny chinkapins dying in great numbers with no apparent reason (*teste* Clinton, 1912). Mr. Jones suspected that extremely wet conditions in the preceding two years had created a disease responsible for the chinkapins' demise. By 1877, the disease had apparently become well established in North Carolina, as State Geologist William C. Kerr reported, "The chestnut was formerly abundant in the Piedmont region, down to the country between the Catawba and Yadkin Rivers, but within the last thirty years they have mostly perished" (Hough, 1877). Throughout the 1800s, the disease gradually decimated chestnut and chinkapin populations on relatively wet sites (Crandall *et al*., 1945). Currently, a troubling development with *P. cinnamomi* is a possible expansion of host range or the realization that the pathogen's host range includes oaks. Robin *et al*. (1994, 1998) reported on oak species in Europe, including the North American red oak, becoming infected with this pathogen. Considering the importance of oak species in eastern forests, the impact of *P. cinnamomi* may not yet have been fully realized.

American chestnuts dying from Phytophthora root rot. Photo Courtesy of Sunshine Brosi, Department of Forestry, University of Kentucky.

Chestnut blight (=chestnut bark disease) was the next exotic challenge to surviving chestnuts and chinkapins on upland or well drained sites. The disease was first reported in 1904, when cankers were observed in New York City (Merkel, 1905), although it was most assuredly widespread in the northeast at that time (Anagnostakis, 2001a). Chestnut blight is caused by an exotic fungus that attacks twigs, branches, and bole, causing cankers that eventually girdle the tree. Metcalf and Collins (1909) believed that the disease was imported on Japanese chestnut nursery stock, and distribution of successive importations was the major factor in the spread of the pathogen. Introduced to North America in the late 1800s on shipments of Asian chestnut nursery stock

(Anagnostakis, 2001a), chestnut blight rapidly decimated upland chestnut and chinkapin populations throughout eastern hardwood forests (National Academy of Sciences, 1975) over the next 60 years. By the 1950s, virtually all chestnut and chinkapins had been reduced to short-lived sprouts from old stumps and disease-ridden shrubs (cf. Burnham *et al.,* 1986).

A considerable amount of research has been conducted on countering the effects of chestnut blight pathogen. Introduction of strains of the fungus containing a fungal virus that causes debilitation of the blight fungus has been attempted (MacDonald and Fulbright, 1991; Anagnostakis, 2001b). Molecular manipulations of this virus (Choi and Nuss, 1992) has made transmission easier, and field experiments are in progress to evaluate effects and transmission (Anagnostakis, 2001a). Breeding resistance into American chestnut from Asian species began at the Connecticut Experiment Station in 1930 and progress continues today (Anagnostakis, 2001a). Breeding for resistance has been conducted by other research programs and private foundations. The American Chestnut Foundation has completed a backcross breeding program involving transferring resistance from Chinese chestnut into American chestnut (*sensu* Burnham *et al.*, 1986) and is planning on field testing progenies by 2006. The American Chestnut Cooperators Foundation is working within the American chestnut gene pool to develop resistance (Griffin, 2000). In breeding programs that utilize Asian germplasm, trees are being selected for both blight and *P. cinnamomi* resistance.


Galls on chestnut induced by the chestnut gall wasp. Photograph courtesy of William M. Ciesla, Forest Health Management International

(http://www.bugwood.org).

Unfortunately, these efforts to reintroduce American chestnut will be hampered by a new pest, the chestnut gall wasp, which was first reported in 1974 (Payne *et al.*, 1975). This pest was illegally imported into the country on smuggled budwood and became established in a chestnut orchard in southern Georgia. Chestnut gall wasps lay eggs in bud and flower tissue; feeding by the larvae results in the tree forming a characteristic gall. Branch die-back can occur, possibly from toxics produced by the larvae, and tree mortality can occur with severe infestations. Although there are biological controls for the chestnut gall wasp, none has been evaluated in North America (Murakami *et al*., 1995; Yara *et al*., 2000). Chinkapins appear to be resistant or immune to chestnut gall wasp and may be a source of resistance for breeding programs.

European Gypsy Moth

The European gypsy moth has been one of the most destructive exotic forest pests introduced to North America. Gypsy moth larvae feed on the broadest host range of all established North American exotic pests in North America and prefer hardwood trees. Trees respond to defoliation from larval feeding by producing new leaves at the cost of draining energy reserves. Repeated defoliations will eventually cause decline and mortality in some cases. Oak species, particularly trees that are stressed or located on dry ridges, are preferred hosts. Other overstory and understory species important for timber, habitat, and/or mast production are also subject to attack (cf. Gottschalk, 1993). Gypsy moth damage affects timber and recreational industries and can have a significant impact on wildlife populations and the overall ecosystem (Allen and Bowersox, 1989; Corbett and Lynch, 1987; Swank *et al.*, 1981). Defoliation will cause declines in diameter and volume growth (Baker, 1941; Twery, 1987) and the quality of wood can be impacted (Twery, 1990). When populations reach epidemic levels, mortality can be as high as 90 percent (Herrick and Gansner, 1987).


Extensive defoliation in summer by European gypsy moth. Photograph courtesy of USDA Forest Service Archives (http://www.bugwood.org)


First instar (caterpillar) European gypsy moth larvae hatching from egg mass. Photograph courtesy of USDA Forest Service Achieves (http://www.bugwood.org)

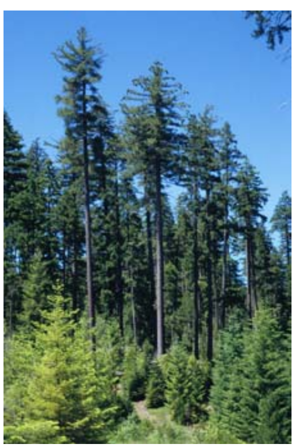
Gypsy moth was deliberately imported in 1869 to the U.S. by Etienne Leopold Trouvelot, an artist who was an amateur entomologist. Trouvelot was interested in identifying native silkworms that could be used for silk production, although his exact motive for importing gypsy moth egg masses is unknown (Liebhold *et al*., 1994). Trouvelot cultured the larvae on trees in his yard, but some larvae escaped. By 1898, gypsy moth (called “gipsy moth” in early publications) was considered to be a serious forest pest (Howard, 1898). Over time, the area of permanent infestation has spread west from the Northeast into Lake states and south into Virginia. Spot infestations are in many states and are treated with an eradication strategy. For a highly successful exotic pest, the spread has been relatively slow as the female gypsy moths do not fly. However, dispersal to uninfested locations has been greatly assisted by transportation of egg masses laid on vehicles, equipment, etc., at infested locations. During epidemic years, the number of acres defoliated can be staggering, e.g., 12.9 million acres nationwide in 1981.

European gypsy moth caterpillars feeding. Photograph courtesy of E. Bradford Walker, Vermont Department of Forests, Parks, and Recreation (http://www.bugwood.org).

Various strategies have been used to combat gypsy moth infestations. These strategies can employ insecticides, pathogens, e.g., *Bacillus thuringiensis* Beliner and *Entomophaga maimaiga* Humber, Shimazu and Soper, a naturally occurring virus, parasitoids, and silvicultural practices. The strategies selected to address a gypsy moth problem will vary with situation and can involve using several tools. States have county-level trapping programs for male moths using pheromone-baited traps to determine presence and population size. In 1991, the USDA Forest Service, in cooperation with APHIS and various states, initiated a pilot program, Slow the Spread, in 1991 that focused on slowing the spread of gypsy moth by using integrated pest management technology in areas that were in transition from uninfested to permanently infested. The pilot program was such a success that it was expanded in 1999 into a nationwide program. Through the efforts of this program and other similar efforts, the inevitable march of gypsy moth through North American forest can be slowed until a better solution is developed.

White Pine Blister Rust

White pine blister rust is a disease that rivals chestnut blight for impact on North American ecosystems. The pathogen attacks five-needle pine species in both eastern and western forests, causing galls that eventually girdle branches and stems. Gooseberry and currant species serve as alternate hosts. The pathogen thrives in a cool, wet-weather environment, and climate is a major factor in determining rust hazard areas. The rust fungus was introduced in multiple shipments of nursery stock from Europe to Kansas (1892), eastern Canada and New York (1906), and western Canada (1910) (Mielke, 1938; cf. Tainter and Baker, 1996). After introduction, the pathogen quickly spread west and north to eastern white pine populations in the Great Lakes region and Northeast and subsequently southward, to high-elevation eastern white pine populations in North Carolina. In western forests, the disease rapidly spread through western white and sugar pines, as well as impacting whitebark and southwestern white pines (USDA Forest Service, 1991; Hoff and Hagel, 1989). Mortality in western white pine stands can approach 94 percent (Hirt, 1948). More recently, infection of limber pine has been observed (G. I. McDonald personal communication to S. E. Schlarbaum).



Healthy sugarpines, host for white pine blister rust. Photograph courtesy of Richard Sniezko, USDA Forest Service.

Screening for white pine blister rust resistance at the Dorena Tree Improvement Center, USDA Forest Service. Resistant seedlings within different genetic families are obvious. Photograph courtesy of Richard Sniezdo, USDA Forest Service.

Different approaches have been used to address white pine blister rust. In eastern forests, a massive gooseberry/currant eradication program reduced populations of the alternate host for the pathogen. This strategy was particularly effective for intermediate hazard areas (cf. Tainter and Baker, 1996). Exploiting natural resistance, long-term breeding programs were initiated by the USDA Forest Service (Bingham, 1983). Rust-resistant western white, sugar pine and eastern white pine seedlings were developed and are available for planting (Bingham,1983; Garrett, 1986).

Susceptible and resistant sugar pines in a field test planted by the Dorena Tree Improvement Center, SUDA Forest Service. Photograph courtesy of Richard Sniezko, USDA Forest Service.

This a dramatic change from the late 1960s, when planting of western white pines was generally discontinued
(Ketcham *et al.*, 1968). Rust-resistance breeding programs continue today in the United States and Canada (Hunt, 2002; Neuenschwander *et al.*, 1999; Sniezko *et al.*, 2000).

Whitebark pine is not a commercially important species for timber and, therefore, has not received much attention in terms of resistance breeding. This is unfortunate, as Schmidt (1992) estimated that 80 to 90 percent of the whitebark pines in Glacier National Park and the Bob Marshall Wilderness area have blister rust. In British Columbia, a sampling of 54 stands revealed 21 percent of the trees were dead and as high as 44 percent of the remaining trees had blister rust (Campbell and Antos, 2000). Other whitebark pine populations have similar mortality and infection percentages. Whitebark pine occupies a critical niche in western ecosystems by producing large seeds that are extremely nutritious and important in food chains of 110 animals. Whitebark pine seeds are especially important components of grizzly bear, black bear, red squirrel, and Clark's nutcracker (Kendall and Arno, 1989; Schmidt, 1992; Reinhart *et al.*, 2001).

Dutch Elm Disease

The American elm is a large, vase-shaped tree that was a minor timber species used for furniture, cooperage, and construction of boats. Many cities and towns across America once planted American elms along streets to provide shade (Karnosky, 1979). The species was ideal for urban settings in that it was able to withstand soil compaction and drought. In 1930, however, urban American elms began to die from a disease caused by an introduced fungus, *Ophiostoma* (=*Ceratocystis*) *ulmi*. The fungus was introduced on shipments of unpeeled raw veneer logs from Europe and rapidly spread from three infestation centers (cf. Stipes and Campana, 1981). The fungus is vectored by the native elm bark beetle and the exotic smaller European bark beetle. When trees are infected with the fungus, they react by producing tyloses and gums that will eventually block the vascular system and cause demise. It can be passed from tree to tree by root grafts, which are common in urban settings. American elm is the least resistant of North American elm species to Dutch elm disease. Other native elms, e.g., red or slippery elm, have more resistance.

Mortality in roadside planting due to Dutch elm disease. Photograph courtesy of Edward L. Barnard, Florida Department of Agriculture and Consumer Services (http://www.bugwood.org)

The disease has spread to most of the contiguous 48 states with the except of a few southwestern states. The demise of urban trees, however, has given a misleading impression that forest trees are also dead. In United States forests, the disease is still radiating south and westward. American elms over 30 inches in diameter are still common in Tennessee. The disease has evolved in North American conditions, producing a more aggressive strain, *Ophiostoma novo-ulmi*, which was reintroduced to Europe and caused a second epidemic (USDA Forest Service, 1991).

Insecticides and fungicides have been used to protect urban trees with varying success. Breeding resistance into American elm from other elm species has been complicated by the tetraploidy of American elm, in contrast with the diploid of all other elm species. Nevertheless, resistant hybrid triploids have been produced (Sherald *et al.*, 1994). Another approach that has met with good success is crossing among surviving individuals, followed by clonal propagation of resistant progenies (Smalley and Guries, 1993; Townsend, 2000). This work has been led by Adrian M. Townsend of the U. S. National Arboretum and the Elm Research Institute, a private, nonprofit organization, and a number of resistant elm clones have been released.

Balsam Woolly Adelgid

The balsam woolly adelgid was introduced to New England in 1908 (Kotinsky, 1916) and western states in 1928 (Annand, 1928) on nursery stock from Europe. The pest attacks all North American true fir species, with the possible exception of the divergent bristlecone fir. Abnormal tissue development occurs due to salivary secretions during feeding, which change the balance of growth hormones and inhibitors (Balch *et al.*, 1964). It is believed that a combination of factors associated with salivary secretions kills the tissue (cf. Hay, 1978). The pest can damage and even kill western fir species and balsam firs in eastern forests (cf. Mitchell and Buffam, 2001). The greatest mortality, however, is in the southern Appalachian mountains where it kills mature specimens of Fraser fir. Fraser fir is restricted to mountaintop environments in the southern Appalachian mountains, where the species forms a unique forest type with red spruce.

Mortality in Fraser fir due to balsam woolly adelgid. Photograph courtesy of Rusty Rhea, USDA Forest Service.

The adelgid was first noticed on a northern population of Fraser fir in 1957, and it subsequently spread to all populations. Infested trees usually die within seven years (Johnson, 1980). A study on Mt. Guyot in the Great Smoky Mountains National Park revealed that Fraser fir declined from 80 percent to 2.5 percent of living crown trees in the time period of 1967-1985 (Alsop and Laughlin, 1991). This demise resulted in a dramatic change in forest composition and dynamics on former Fraser sites. With the forest canopy removed, the understory changed from primarily blueberry and fir saplings to dense blackberry, blueberry, and Viburnum populations. Increases occurred in the proportion of red spruce and yellow birch in the forest canopy. The spruce-fir moss spider that inhabits this unique habitat has now been listed as a federally endangered species. Changes in avian species and populations also have been observed in other studies (cf. Rabenold *et al.,* 1998).

Mortality of Fraser fir from balsam woolly adelgid in a red spruce - Fraser fir stand. Photograph courtesy of Rusty Rhea, USDA Forest Service.

Balsam woolly adelgid feeding on Fraser fir. Photograph courtesy of Rusty Rhea, USDA Forest Service.

Mortality is variable among mountaintops, with some mountain populations almost entirely decimated of mature trees. On some mountaintops, less than ten mature trees survived, although many immature trees still persist. However, the reproductive potential of this species could be in jeopardy. Smith and Nicholas (2000) studied Fraser fir size and age class distributions and found lower densities of young firs in stands severely impacted by adelgids. They attributed the lower densities to low numbers of reproducing adults, competition, and other environmental factors.

Control of the adelgids with insecticides has not been successful or practical, particularly in Fraser fir populations residing in the Great Smoky Mountains National Park. Biological controls have been attempted (Schooley *et al.*, 1984; Humble, 1994), but none has demonstrated satisfactory levels of success to date. It is hoped that biological controls that are being studied for the hemlock woolly adelgid (see below) also will be successful with balsam woolly adelgid. A planting of genotypes from different mountaintops was established in the Great Smoky Mountains National Park during the early 1990s to conserve the genetic resources of this fir species.

Butternut Canker

Butternut (= white walnut or oilnut) is a highly valued eastern hardwood species. The wood is prized for veneer, for lumber for cabinets, and especially for carving. Butternut also is an important mast species and can produce copious amount of nuts for a variety of wildlife species. The nut is very palatable for human consumption, and there are a number of cultivars that have been selected for nut production (Millikan and Stefan, 1989).

Presently, butternut populations are being decimated by an exotic fungal disease that causes multiple branch and bole cankers. The host tree is killed when multiple bole cankers join and girdle the tree. Although the disease was first discovered in 1967 in southwestern Wisconsin (Renlund, 1971), coring of infected trees in the southern portion of butternut's range suggest that the disease was introduced in the Southeast around 70 years ago (Anderson and LaMadeleine, 1978; Schlarbaum, unpublished). Over 80 percent of the butternut trees in the South are now dead.

Butternut canker has spread throughout much of the species' range, reaching Canada in 1990. Unlike American chestnuts and chinkapins, butternut will not sprout from the root crown when the top is killed by cankers. Seedlings and young sprouts are killed by the disease, in addition to mature trees (Prey and Kuntz, 1982). Therefore, when butternut canker disease destroys a population, that particular gene pool is lost forever, as there is no possibility for reproduction. The rapid demise of the species has caused the U. S. Fish and Wildlife Service to declare the butternut "a species of concern."

Butternut resistance test; insert shows cankers on saplings. Photograph Courtesy of Carol Young. Resistance Screening Center, USDA Forest Service

Despite the severe mortality from butternut canker disease, there is reasonable hope for returning butternut to eastern landscapes. Two groups of scientists and field experts from various organizations centered at the USDA Forest Service, North Central Experiment Station in St. Paul and at the University of Tennessee, have been working for a number of years on detection of resistance and genetic resource conservation (Ostry *et al.*, 1994, 1996; Schlarbaum *et al.*, 1997; van Manen *et al.,* 2002). Plantings to conserve the genetic diversity in surviving butternut populations have been established at various locations throughout the eastern states. Trees with putative resistance and immunity have been selected and are presently being evaluated for inclusion in breeding programs.

Larch Casebearer

Larch casebearer is a moth species that feeds on larch species and was probably introduced in Massachusetts on nursery stock from Europe in 1886 (Tunnock and Ryan, 1983; Otvos and Quedau, 1984). The pest spread throughout the range of eastern larch (tamarack), reaching the Great Lakes region in the 1950s and southeastern Manitoba by 1970 (Otvos and Quednau, 1984). Almost 70 years later, the pest was introduced to western forests as an infestation was found on western larch in Idaho in 1957. In western forests, the insect spread rapidly and was soon considered to be the species' most serious pest (Denton, 1979). The insect feeds the internal tissue of needles, causing defoliation . Repeated defoliations can kill the host tree or stunt it by reducing potential growth by as much as 97 percent (Tunnock *et al.*, 1969). The casebearer favors younger trees growing in the open or along forest edges (Tunnock and Ryan, 1983).

Damage from larch casebearer larval feeding. Photograph courtesy of Jerald E. Dewey, USDA Forest Service (http://www.bugwood.org)

Larch casebearer adult. Photograph courtesy of Scott Tunnock, USDA Forest Service (http://www.bugwood.org)

Control of this pest has relied upon environmental factors and parasitoids, both natural and introduced. Prolonged cold, wet Springs with frosts will cause mortality. There is an abundance of natural predators/parasitoids, but they are not efficient enough to stop outbreaks. Fortunately, a combination of natural predators/parasitoids and introduced parasites has been successful in eastern and central Canada and the northwestern U.S. (Otvos and Quednau, 1984; Graham, 1949; Ryan *et al.,* 1987). Two introduced European parasites, *Agathis pumila* and *Chrysocharis laricinellae*, have been able to aid in keeping the pest under control in western forests where it causes the most serious damage (Tunnock and Ryan, 1995; Ryan, 1997).

Dogwood Anthracnose Disease

Flowering and Pacific dogwoods are important components of the forest understory, as well as being valued by the American public for their natural beauty when flowering. Dogwood fruits are a valuable food source for migratory birds and mammals, and the twigs are browsed by a variety of animals (Mitchell *et al.*, 1988; Rossell *et al.*, 2001). In addition, the species provides habitat for nesting birds, and fallen leaves provide a significant amount of calcium to forest soils (Hepting, 1971).


Leaf blotch symptoms of dogwood anthracnose disease. Photograph courtesy of Robert L. Anderson, USDA Forest Service (http://www.bugwood.org)


Mortality in understory dogwoods from dogwood anthracnose disease. Photograph courtesy of Robert L. Anderson, USDA Forest Service (http://www.bugwood.org)

Both dogwood species are in the process of being extirpated from North American forests by a relatively new exotic fungal disease. Dogwood anthracnose disease is migrating through eastern and western forests and killing entire dogwood populations (Britton, 1993; USDA Forest Service, 1999). The disease was discovered almost simultaneously in Washington (1976) and New York (1978) (cf. Daughtey and Hibben, 1994). The fungus is particularly virulent in cool, moist conditions, and dogwood populations proximal to water are at the greatest risk. Trees are killed by annual cankers that girdle the bole. Areas subjected to acid rain may predispose dogwoods to attack and increase the severity of the disease (Anderson *et al.*, 1993). In flowering dogwood, there are surviving trees in populations that have decimated, and natural resistance has been detected (Windham *et al.*, 1998). To date, there have been no reports of putative resistant Pacific dogwoods.

Port-Orford-Cedar Root Disease

Port-Orford-cedar is a valuable forest tree that has a limited distribution along the Pacific coast from southern Oregon to northern California. The species has a highly aromatic wood and is widely used as a landscape plant. Unfortunately, Port-Orford-cedar populations have been decimated by a root disease caused by the exotic algal fungus *Phytophthora lateralis*. The disease was first reported in 1923 near a Seattle nursery (Hunt in Zobel *et al.*, 1985), which is outside Port-Orford-cedar's natural range. In 1938, the disease was again discovered in Oregon's Willamette Valley, where it virtually halted nursery production of ornamental *Chamaecyparis*. The disease was discovered in the naturally occurring Port-Orford-cedars in 1952 and has since spread throughout the host's range. How *Phytophthora lateralis* entered the country or even the exact country of origin are uncertain. Partial resistance in Asian *Chamaecyparis* species suggests an eastern Asian origin (Roth *et al.*, 1987).

The fungus invades fine roots and subsequently colonizes the entire root system. Multiple root infections will spread to the root collar, and the tree will die from girdling. Aerial infections of branches that come into contact with infected litter or soil can occur during wet weather. The infection will eventually migrate to the bole, and girdling will occur. Pathogen spores are spread by surface water or rain splash, usually in the wet Spring. It can be transferred in spore-contaminated soil by machinery and animals but does not occur independently in soil (Ostrofsky *et al.*, 1977). The pathogen will attack seedlings as well as mature trees. Seedling mortality can occur within a few days, while mature trees may take two to four years to die. The disease also can be spread by movement of infected Port-Orford-cedar nursery stock, including other *Chamaecyparis* species. Zobel *et al.* (1985) believe that the disease "probably never would have emerged in epidemic form without the widespread planting of ornamental Chamaecyparis in northwestern Oregon and Washington."


Resistant tree to Port-Orford-Cedar root disease next to dead, susceptible trees. Photograph courtesy of Chuck Frank, USDA Forest Service.

The USDA Forest Service at the Dorena Tree Improvement Center, in conjunction with the USDI Bureau of Land Management and Oregon State University, have been working many years on detection of resistance to this disease. Over 9,000 trees has been screened for resistance, and controlled pollinations are now being made to develop resistant genotypes and to understand the mechanisms of resistance. Meanwhile, surviving trees and stands are being protected by management practices, including restriction of movement of people and machinery during wet periods where spores are abundant.

Hemlock Woolly Adelgid

The Asian hemlock woolly adelgid was first reported in the 1920s, where it was attacking western hemlock in the Pacific Northwest (Annand, 1924). A separate introduction established the pest in Virginia, from where it spread to attack eastern and Carolina hemlocks (USDI NPS EIS, 2000). The insect feeds on the contents of parenchyma cells that comprise the xylem rays, and a toxin may be involved in causing the needles to prematurely drop (Young *et al*., 1995).

Eastern and Carolina hemlock populations can die from severe infestations. Extensive decline and mortality has occurred in Virginia, Pennsylvania, New Jersey, and Connecticut within ten years of the first detection (Orwig and Foster, 1998). At Shenandoah National Park in Virginia, where HWA has been present since 1988, only 8.4 percent of hemlocks sampled still have 90 to 100 percent of foliage intact; very few stands are entirely free of adelgid. Hemlock populations in Connecticut were infested in 1985, and mortality ranged up to 95 percent in the sample stands studied (Orwig and Foster, 1998).

Hemlocks play an important ecological role in riparian communities by creating distinctive microclimates, which are important habitats for a variety of wildlife. In northern New Jersey, 96 bird and 47 mammal species are associated with hemlock forests (USDI NPS EIS, 2000). Amphibians, particularly salamanders, also depend on the unique habitat under a hemlock canopy (Brooks, 2001). Hemlock glades and the streams in them are especially important habitats for smaller organisms. These forests shelter more than 14 species of amphibians, more than 12 species of small mammals, at least 152 species of terrestrial invertebrates. Hemlock-lined streams also keep water temperatures cool enough for brook trout.


Mortality in eastern hemlock due to hemlock woolly adelgid. Photograph courtesy of Rusty Rhea, USDA Forest Service.

According to the National Park Service (USDI NPS EIS, 2000) decline of hemlock in the Delaware Water Gap NRA is likely to have "massive adverse effects on the ecological, aesthetic, and recreational values of the park." Affected streams would be warmer, have lower water flows, and be more likely to dry up during summer droughts. Overall species diversity in hemlock-dominated habitats would probably decline by 35 percent or more. Decaying and downed trees would increased debris flow, interfere with water flow, and cause channel scouring that would raise the chance of extreme flood damage. Nurtient cycling would also be disturbed (Jenkins *et al.*, 1999).


Infestation of hemlock woolly adelgid. Photograph courtesy of Robert L. Anderson, USDA Forest Service.

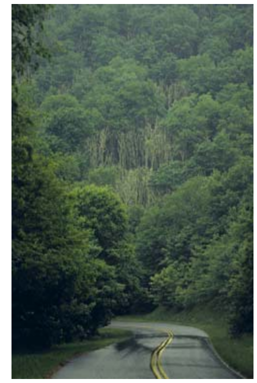
Spraying of insecticides to control hemlock woolly adelgid will not be effective in many cases, possibly because of the riparian habitat. In the last decade there has been a significant amount of research conducted on biological control of the adelgid through introductions of predators from Asia and natural predators (McClure, 1995; Wallace and Hain, 2000; Lu and Montgomery, 2001; Zilahi-Balogh *et al*., 2002). However, the greatest challenge may be to reintroduce hemlock into former sites. Little is known about hemlock genetics and diversity, and there are no seed orchards of eastern or Carolina hemlocks to provide seed, unlike many other forest species that are utilized for timber. Reintroduction efforts will be forced to use non-local seed with no information on the effects of seed movement on growth and survival. In addition, virtually nothing is known about post-planting requirements of hemlock seedlings. While the present work is encouraging, a complete solution to this exotic pest problem appears to still be distant.

Beech Bark Disease

American beech is a common component of eastern North America. The species is utilized for lumber and pulp, and it periodically produces hard mast (beech nuts) for wildlife. Beech was not commercially utilized until the 1950s when drying problems were solved (cf. Tainter and Baker, 1996). By that time, an exotic insect-disease complex had become established in northeastern beech populations that was causing extensive mortality. Beech bark disease is due to the activities of the exotic beech scale and an associated exotic fungus, *Nectria coccinea* var. *faginata* (cf. Mahony *et al.*, 1999). Beech scale was imported in the late 1800s into Halifax, Nova Scotia, probably on nursery stock of European beech (Hawbolt, 1944). However, it


Beech Bark disease in Great Smokey Mountains National Park. Photograph courtesy of Glenn Taylor, Nation Park Service.

was not until around 1920 that an outbreak of beech bark disease was recorded. The disease spread rapidly and was commonplace in Nova Scotia by 1930. In the United States, the first report of beech bark disease was in Massachusetts in 1929. By the early 1970s, the disease had spread throughout New England and into eastern Pennsylvania. The scale and associated fungus are easily transported over long distances by animals and humans, which has resulted in isolated outbreaks and establishments in West Virginia (1981), Virginia (1983), and more recently, in the Great Smoky Mountains National Park (Tennessee) far ahead of the advancing front in Pennsylvania. The scale penetrates the bark during feeding, letting the associated fungi enter the tree. The tree is girdled from the resulting multiple cankers (Houston and Valentine, 1988).



Beech Bark disease in Great Smokey Mountains National Park. Photograph courtesy of Glenn Taylor, Nation Park Service.

There is no practical chemical control of the beech scale in natural forests. The scale has several natural predators, but none has been sufficiently effective to stop the spread of beech bark disease. Resistance to beech scale attacks has been discovered in some beech trees (Shigo, 1964; Cammermeyer, 1993; Houston and Houston, 2000) and can be integrated into breeding programs to produce beech bark disease-resistant trees for restoration of the species.

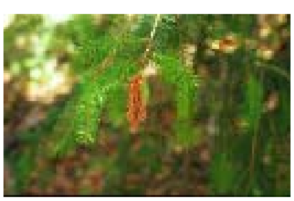
New Exotic Forest Pests in North America

Established populations of new exotic forest pests are now being discovered all too frequently. In the Introduction, we describe various pests that have become established in recent years, around the last 15 years. While each of these pests poses serious challenges to North America's natural resources, widespread publicity in the popular press did not occur until Asian longhorned beetle was discovered in two of the largest cities in the country, New York and Chicago. As a result, we feel that the general public and natural resource professionals became more cognizant of the increased possibilities of additional exotic pests emerging as problems. We have already mentioned the Asian longhorned beetle and Sudden Oak Death pathogen. However, the announcement of Sudden Oak Death disease attacking redwood and Douglas-fir prompted us to include details about this serious exotic pest.

Below are four additional examples of pests that have been recently discovered. Two pests, the brown longhorned spruce beetle and the red-haired pine bark beetle, are estimated to have been in North America for over ten years, while the newly discovered emerald ash borer has been resident for approximately five years. We feel the detection of the citrus longhorned beetle and rapid response to eradicate the pest before it becomes established represent a good example of how an exotic pest should be addressed.

Sudden Oak Death disease

After the printed version of Fading Forests II went to press, in September 2002, Drs. Dave Rizzo and Mateo Garebelotto of the University of California announced that redwood and Douglas-fir are susceptible to the pathogen that causes Sudden Oak Death, *Phytophthora ramorum*. Infected redwood saplings have been found at several sites, while infected Douglas-fir saplings have been found at only one site to date. Both field studies and laboratory tests indicate that Douglas-fir might be more susceptible (California Oak Mortality Task Force News Release, September 4, 2002. UC RESEARCHERS CONFIRM COAST REDWOOD AND DOUGLAS FIR AS HOSTS FOR SUDDEN OAK DEATH PATHOGEN).



Sudden Oak Death on Douglas fir foliage. Photograph Courtesy of Faith Thompson Campbell, American Lands Alliance.

Sudden Oak Death on redwood foliage. Photograph Courtesy of Faith Thompson Campbell, Ph.D., American Lands Alliance.

Movement of living and harvested redwood and Douglas-fir trees from counties with Sudden Oak Death will now be subject to state and federal quarantine rules. The quarantine rules require that infected logs be debarked in the same county where they are felled. Together, redwoods and Douglas-fir account for more than half of the $3 billion generated by

California's timber industry. According to an expert from the California Department of Forestry and Fire Protection, 95 percent of the redwood and 45 percent of the Douglas-fir harvested in California come from counties where Sudden Oak Death disease is present (Peter Fimrite, "California rushes to protect redwoods; Davis seeks Bush aid as tests confirm sudden oak death," San Francisco Chronicle, September 5, 2002). Timber spokespeople
disagree over whether these rules will disrupt commercial lumber production in California. The California Department of Food and Agriculture and USDA APHIS are reported to be reviewing the restrictions on movement of wood (Peter Fimrite, San Francisco Chronicle, September 5, 2002). The impact could be even greater if SOD spreads farther north in Oregon and Washington, where Douglas-fir is even more important as a timber resource.

Tanoak dying of Sudden Oak Death. Photograph Courtesy of Faith Thompson Campbell, American Lands Alliance.

Nursery and Christmas tree growers and those who have sold bark for garden mulch are much more likely to be affected in the immediate future. The regulations require annual inspections of nurseries in the quarantine counties that wish to ship plants belonging to host species. Furthermore, each shipment containing host plant species must also be inspected immediately prior to shipment. If either inspection detects the SOD pathogen, the nursery is barred from shipping host species. The huge trade in cut greens is also regulated. Wreaths, garlands, and greenery may be shipped out of the quarantine area only after being dipped for hour in water that is held at a temperature of at least 160℉.

If contamination were to spread to Christmas tree-producing regions of Oregon or Washington, sales of infected trees could be limited to local clientele. Oregon produces more Christmas trees than any other state; sales were $131 million last year. Oregon also ranks among the largest producers of nursery stock in the nation. Oregon's $696 million nursery industry was reported to be "on high alert" (Michael Rose, "Fir, redwood may house fungus; Sudden Oak Death is linked to Douglas firs, Salem (OR) Statesman Journal, September 5, 2002). Washington State is the fourth-largest producer of Christmas trees nationally (Lisa Stiffler, "New disease infects Doug firs; Spread of 'sudden oak death' along coast alarms researchers", Seattle Post-Intelligencer September 5, 2002). Such restriction would seriously impact these industries.

Brown Longhorned Spruce Beetle

An infestation of the brown longhorned spruce beetle has been found in and around a Halifax, Nova Scotia park, where it was causing mortality to red and white spruce (Smith and Hurley, 2000). The pest is thought to have been imported around 12 years ago on SWPM through the port of Halifax. The beetle is native to Europe and Asia, ranging from Lapland to Japan. In its native habitat, the pest primarily feeds on dead, felled, or stressed spruce species but will also attack pines, fir, larch, and some hardwood species. Trees are girdled by larvae tunneling under the bark in the cambial layer. Living, non-stressed trees have been successfully attacked in Nova Scotia, suggesting that there may be less resistance in the North American red spruce than European species (Ontario's Forests, 2000). Canadian authorities are presently attempting to eradicate the insect by cutting and chipping up infested trees and proximal trees that could provide habitat. Chemical insecticide applications have not proven to be a successful strategy to combat this pest. North American spruce forests and perhaps other conifer-dominated forests are at risk from this serious pest.

Red-haired (=Golden-haired) Pine Bark Beetle

Red-haired pine bark beetle adult. Photograph courtesy of Steve Passoa, USDA APHIS PPQ (http://www.bugwood.org)

The red-haired pine bark beetle has been trying to gain a foothold in this country since the early 1990s. The species is native to Mediterranean areas and Africa but has been introduced to South America, Japan, Sri Lanka, Australia, and New Zealand. The species can be imported on SWPM made of pine, *e.g.*, cargo crates (Ciesla, 1993), and infested logs (Sato, 1975) and is occasionally intercepted by APHIS at United States ports. More recently, an infestation of the species was discovered in November 2000 at a Christmas tree plantation in Rochester, New York. Subsequent surveys in 2001 detected two additional infestations in the same county, as well as small infestations in two adjacent counties. Adult beetles can be vectors for pathogenic fungi (Ciesla, 1988; Zhou *et al.*, 2001). Silvicultural controls include removal of tree stumps and slash to limit breeding habitat and delay in planting of seedlings for six to nine months after harvest.

Emerald Ash Borer

Dead ash tree from girdling by emerald ash borer larval galleries. Photograph courtesy of James W. Smith, USDA APHIS PPQ (http://www.bugwood.org)

Widespread damage by the emerald ash borer has been recently recognized in Michigan and neighboring Ontario. The species was probably introduced in SWPM, as APHIS has intercepted the insect 36 times, primarily on dunnage. Larvae feed in the phloem and outer sapwood, producing galleries that damage and can eventually kill the host. Adults have been observed to feed on host foliage. In North America the borer has been found only on ash species, but the pest feeds on elm and *Juglandaceae* species (walnuts and hickories) in its native, east Asian range (McCullough and Roberts, 2002a and 2002b). The pest is thought to have been established in Michigan for at least five years. Although the infestation is now thought to be confined to Michigan/Ontario, the insect has been intercepted in ten other eastern states. This is particularly ominous, as a phenomenon known as ash decline has been observed in at least 14 eastern states. Ash decline has been ascribed to several or a complex of causes but now warrants careful examination to determine if emerald ash borers are involved. An interagency task force has been formed and is in the process of characterizing tree damage, determining the distribution in the United States, and gathering information on the insect (Millsap, 2002).

Emerald ash borer adult and larval galleries. Photograph courtesy of Dave Roberts, Michigan State University (www.msue.msu.edu/reg_se/roberts).

Citrus Longhorned Beetle

Although the name of this Asian pest implies attacks on fruit trees, the citrus longhorned beetle attacks and kills a wide range of hardwood species, including maple, oak, willow, and poplar in addition to apple and citrus trees. The species is closely related to the Asian longhorned beetle and attacks living trees. The larvae are very large, around 2 inches in length, and bore numerous tunnels in the bole that sever internal transport and can eventually kill the tree, in addition to making it susceptible to wind breakage. The insect was intercepted in Chinese shipments of bonzai plants to Georgia in 1999. An infestation of citrus longhorned beetles was first discovered in 2001 on quarantined, imported maple trees in a plant nursery in Tukwila, Washington. Examination of the damage raised suspicions that up to five beetles had escaped. Correspondingly, the Washington State Department of Agriculture imposed a quarantine of properties within one-half mile of the point of introduction. As of summer 2002, APHIS and the Washington State Department of Agriculture were cutting and chipping up to 1,000 trees in hopes eradicating this dangerous pest (USDA APHIS, 2002; Washington State Department of Agriculture News Release, June 26, 2992). The risk rating for this beetle is very high, and professionals consider that the impact of this insect could be greater than the more widely known Asian longhorned beetle, if it becomes established.

Citrus longhorned beetle adult. Photograph courtesy of Washington State Department of Agriculture (http://www.wa.gov/agr/CitrusLHBeetle.htm)

Newly Discovered Beetles in Mississippi and Texas

In summer 2002, exotic forest pests were also discovered to be established in Mississippi and Texas. In Mississippi, an ambrosia beetle *Xylosandrus mutilatus* first detected in 1999 was identified after becoming more numerous in 2002. The beetle appears to be well established in at least 10 counties in eastern Mississippi, although it has not yet been found in Alabama. The economic and ecological damage that this species may cause is still unknown. In its native Asia, it has a broad host range on hardwood trees and shrubs, including some ornamentals. In addition, many ambrosia beetles indirectly impact host trees by vectoring fungal pathogens.

Another exotic tree-feeding insect, *Xyleborus similis*, has been found in Memorial Park, Houston. These traps were placed as part of the joint APHIS-Forest Service Rapid Detection of Exotic Scolytidae project. This beetle is widely distributed in Africa, Asia, Australia, and several Pacific Islands. It has an exceptionally broad host range in these tropical countries.

Potential Exotic Pest Threats to North American Forests

Two of the most serious pests, Asian gypsy moth and woodwasps with the associated *Amylostereum* pathogen, that are potential threats to North American forests were mentioned in the introduction. Entry by either pest through the different importation pathways could be directly from their respective natural ranges or indirectly from established populations in countries/continents/hemispheres that have been previously invaded (Tribe, 1995; Garner and Slavicek, 1996; Zlotina *et al*., 1999). Asian gypsy moth infestations have been found on a number of occasions on both western and eastern seaboards, but eradications have been successful. To date, woodwasp infestations have not been found. Below are examples of additional pests that have a high potential to become established in North America.

Larvel galleries of the Mediterranean pine engraver beetle. Photograph courtesy of William M. Ciesla, Forest Health Management International (http://www.bugwood.org)

Mediterranean Pine Engraver Beetle

Mediterranean pine engraver beetles primarily attack pine species but also can occur on Douglas-fir, spruce, fir, and cedar species. Reproduction, however, is limited to infestations in pine species (Mendel and Halperin, 1982). The species infests recently fallen trees, slash, and stressed living trees. As with other bark beetles, one of the major dangers from these engraver beetles is the transmission of pathogenic fungi, including blue stain fungi. This pest is native to Europe, the Middle East, northern Africa, and possibly China and has been introduced with certainty to United Kingdom, Fiji, and Chile. The entry potential to the United States is considered high, as it is the second most commonly intercepted bark beetle. The species is usually intercepted on logs. Biological controls are being used in South Africa to address this pest (Tribe and Kfir, 2001).

European Oak Bark Beetle

Introduction of European oak bark beetle into North America would probably have the greatest impact on eastern hardwood-dominated forests. In Europe, this bark beetle feeds on branches and secondary shoots of various hardwood species, including oaks, chestnuts, beech, birch, poplars, willows, and elms. The insect targets recently dead, felled, and stressed trees. The beetle has been found to vector a wide variety of fungi, including pathogenic species. Dunnage is the primary vector for the European oak bark beetle, and establishment potential is considered high if introduced (USDA APHIS and Forest Service 2000).

Newly hatch larvae of nun moth on pine bark. Photograph courtesy of William M. Ciesla, Forest Health Management International (http://www.bugwood.org)

Nun Moth

The Eurasian nun moth is in the same genus (*Lymantria*) as European and Asian gypsy moth and is similar in host utilization and behavior. The host range is wide, consisting of conifer and hardwood species. Nun moth causes more damage in continental Europe than any other forest defoliator, including gypsy moth. The Siberian risk assessment (USDA Forest Service, 1991) stated that if nun moth would become established, 172 million acres could be affected in the United States. Entry potential is considered to be high, as nun moth females can lay egg masses in crevasses ranging from pallets to ship structures. Extensive research has been conducted on detection and biological control of this potential pest if it is introduced into North America (Morewood *et al.*, 2000; Gries *et al*., 2001; Fuester *et al.,* 2001).

Pine Flat Bug

Pine flat bug is a Palearctic Region pest of coniferous and hardwood trees. The pest is distributed from the United Kingdom to Siberia and feeds on the tissue of seedlings and young trees and can cause serious damage in nurseries, Christmas tree plantations, and seedlings/sprouts naturally regenerated or artificially regenerated (planted seedlings). The likelihood of introduction and subsequent establishment in the United States is high, as the species is easily overlooked, transportable in low temperatures, and unlikely to be dislodged during transport. Infestations of pine flat bug in North America have not been observed to date (USDA APHIS and Forest Service 2000).

Chilean carpenter worm

The Chilean carpenter worm is endemic to South America and occurs naturally in central to southern Chile and Argentina. The species feeds on various hardwood timber species and fruit trees. In 1992 the pest was observed to attack eucalyptus plantations in Chile. Larvae feed in living trees and bore relatively large holes in the bole, making them susceptible to wind breakage. Adults can fly over considerable distances, and the pest could quickly spread if established. The insect has a long life-cycle, with the larvae taking two or more years to complete development. Transportation of late instar larvae, pupae, and adults to North America in bole galleries within imported logs is considered to be a moderate risk (USDA Forest Service 2001).

Appendix 1

Common and scientific names of plant and animal species mentioned in Fading Forests II: a) deciduous tree, shrub and plant species (angiospermous), b) coniferous tree species (gymnospermous), c) pathogen species, d) arthropod species, e) mammalian species, and f) bird species.

a. Deciduous tree, shrub and plant species

Common name(s)	**Scientific name**
red maple	*Acer rubrum* L.
sugar maple	*Acer sacharrum* Marsh.
mountain maple	*Acer spicatum* Lam.
California buckeye	*Aesculus californica* (Spach) Nutt.
tree-of-heaven	*Ailanthus altissima* (Mill.) Swingle
lady fern	*Althyrium felix-femina* (L.) Roth
Peruvian lily	*Alstroemeria* L. spp.
serviceberry	*Amelanchier* L. spp.
pineapple	*Ananas* P. Mill.
Anthurium Schott.	
madrone	*Arbutus* L. spp.
manzanita	*Arctostaphylos* Adans.
Japanese barberry	*Berberis thunbergii* DC.
birch	*Betula* L. spp.
yellow birch	*Betula allegheniensis* Britton (=*B. lutea* Michx. f.)
black/sweet birch	*Betula lenta* L.
hickory	*Carya* Nutt. spp.
chestnut	*Castanea* Mill. spp.
American chestnut	*Castanea dentata* (Marsh.) Borkh.
Japanese chestnut	*Castanea crenata* Sieb.& Zucc.
Chinese chestnut	*Castanea mollissima* Bl.
Allegheny chinkapin	*Castanea pumilla* Mill.
Ozark chinkapin	*Castanea ozarkensis* Ashe.
eulophia	*Eulphia* R. Br. ex Lindl.
citrus	*Citrus* L. spp.
flowering dogwood	*Cornus florida* L.
Pacific dogwood	*Cornus nuttallii* Audubon
hazlenut	*Corylus* L. spp.
hawthorn	*Crataegus* L. spp.
hay-scented fern	*Dennstaedtia punctilobula* (Michx.) T. Moore
eucalyptus	*Eucalyptus* L=Her.spp.
beech	*Fagus* L. spp
American beech	*Fagus grandifolia* Ehrh.
European beech	*Fagus sylvatica* L.
ash	*Fraxinus* L. spp.
Juglandaceae	taxonomic family containing walnuts and hickories
walnuts	*Juglans* L. spp.
butternut; white walnut	*Juglans cinerea* L.
black walnut	*Juglans nigra* L.
tanoak	*Lithocarpus densiflorus* (Hook & Arn.) Rehd.
apple	*Malus* P. Mill. spp.

Japanese stilt-grass	*Microstegium vimineum* (Trin.) A. Camus
bromeliad	a variety of ornamental genera
Oxalis	*Oxalis* L. spp.
moth orchid	*Phalaenopsis* Blume spp.
poplars	*Populus* L.
white oak	*Quercus alba* L.
pin oak	*Quercus palustris* Muenchh.
northern red oak	*Quercus rubra* L.
black oak	*Quercus velutina* Lam.
gooseberry; current	*Ribes* L. spp.
rhododendron, azalea	*Rhododendron* L. spp.
Chapman's rhododendron	*Rhododendron chapmanii* Gray
blackberry	*Rubus* L.
willow	*Salix* L. spp.
American linden; American basswood	*Tilia americana* L.
elm	*Ulmus* L. spp.
American elm; white elm	*Ulmus americana* L.
red elm; slippery elm	*Ulmus rubra* Muhl.
blueberry	*Vaccinum* L.
cranberry	*Vaccinium macrocarpon* Ait.
evergreen huckleberry	*Vaccinium ovatum* Pursh
Viburnum	*Viburnum* L. spp.
hardwoods	tree species and genera that are angiosperms
conifers	tree species and genera that are gymnosperms

b. Coniferous tree species

Common names(s)	**Scientific name**
fir	*Abies* Mill. spp.
balsam fir	*Abies balsamea* (L.) Mill.
bristlecone fir	*Abies bracteata* D. Don
Fraser fir	*Abies fraseri* (Pursh.) Poir.
cedar	*Cedrus* Trew spp.
Chamaecyparis, Asian cedar	*Chamaecyparis* Spach spp.
Port-Orford-Cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.
cypress	*Cupressus* L.
golden larch	*Pseudolarix amabilis* (Nelson) Rehder
larches	*Larix* Mill.
eastern larch/tamarack	*Larix laricina* (Du Roi) K. Koch
western larch	*Larix occidentalis* Nutt.
spruce	*Picea* A. Dietr.spp.
white spruce	*Picea glauca* (Moench) Voss
red spruce	*Picea rubens* Sarg.
pine	*Pinus* L. spp.
five-needle pine species	species in *Pinus* subgenus *Strobus* Lemm., emend.
whitebark pine	*Pinus albicaulis* Engelm.
bristlecone pine	*Pinus aristata* Engelm.
lodgepole pine	*Pinus contorta* Dougl. Ex Loud.
shortleaf pine	*Pinus echinata* Mill.
slash pine	*Pinus elliotti* Englem.
limber pine	*Pinus flexilis* James
sugar pine	*Pinus lambertiana* Dougl.
western white pine	*Pinus monticola* Dougl. ex D. Don.

longleaf pine	*Pinus palustris* Mill.
Monterey pine	*Pinus radiata* D. Don.
pitch pine	*Pinus rigida* Mill.
southwestern white pine	*Pinus strobiliformis* Engelm.
eastern white pine	*Pinus strobus* L.
loblolly pine	*Pinus taeda* L.
southern yellow pines	*Pinus taeda* L., *P. palustris* Mill., *P. echinata* Mill., *P. elliotti* Englem.
Torrey pine	*Pinus torreyana* Parry ex Carr.
Douglas-fir	*Pseudotsuga menziesii* Carr..
baldcypress	*Taxodium distichum* var. *distichum* (L.) Rich.
arborvitae	*Thuja* L. spp.
Carolina hemlock	*Tsuga caroliniana* Engelm.
eastern hemlock	*Tsuga canadensis* (L.) Carr.
western hemlock	*Tsuga heterophylla* (Raf.) Sarg.

c. Pathogen species

Common name	**Scientific name**
Amylostereum	*Amylostereum areolatum* Fr. Boidin
root and stem rots	*Armillaria* (Fr.:Fr.) Staude spp.
	Ganoderma lucidium (Reishi)spp.
	Heterobasidion (Niemeld & Korhonen) spp.
	Phellinus Quel. spp.
Chrysomyxa ledi var. *rhododendri* (de Bary) Saville	
Bacillus thuringiensis (known as Bt)	*Bacillus thuringiensis* Beliner
dogwood anthracnose disease	*Discula destructiva* Redlin
pitch canker	*Fusarium moniliforme* var. *subglutinans* Wollenw. & Reinking
white pine blister rust	*Cronartium ribicola* J.C. Fisch.
chestnut blight	*Cryphonectria parasitica* (Murr.) Barr
Entomophaga maimaiga	*Entomophaga maimaiga* Humber, Shimazu & Soper
pitch canker	*Fusarium circinatum* Nirenberg and O'Donnell
citrus black spot	*Guignardia citricarpa* Kiely
European larch canker	*Lachnellula willkommii* (R. Hartig) Dennis
beech bark disease	*Nectria coccinea* var.*faginata* Lohman, A.M. Watson, and Ayers
parasitic fungus of *Nectria* fungus	*Nematogonum ferrugineum* (Pers.) S. J. Hughes
Phytophthora cinnamomi	*Phytophthora cinnamomi* Rands
Port-Orford-Cedar root disease	*Phytophthora lateralis* (Tucker & Milbrath)
sudden oak death syndrome	*Phytophthora ramorum* Werres *et al.*
black stain fungus	*Ophiostoma* Syd. & P. Syd. spp.
	Ophiostoma ips (Rimb.) Nannf.
Dutch elm disease	*Ophiostoma ulmi* (Buis.) Narruf.
	Ophiostoma novo-ulmi (Brasier)
butternut canker disease	*Sirococcus clavigignenti-juglandacearum* Nair, Kostichka, & Kuntz
Diplodia shoot blight	*Sphaeropsis sapinea* (Fr.) Dyko & Sutton (syn. *Diplodia pinea* (Desm.) Kickx .
Verticillium (wilts)	*Verticillium* Nees. Hope spp.
crown rots	caused a variety of bacteria, fungi or nematodes
deep wood pathogens	caused by a variety of pathogens from different genera

d. Arthropod species

Common name	Scientific name
balsam woolly adelgid	*Adelges piceae* (Ratzeburg)
hemlock woolly adelgid	*Adelges tsugae* Annand
emerald ash borer	*Agrilus planipennis* Fairmaire
Agathis pumila	*Agathis pumila* (Ratzeburg)
Asian longhorned beetle	*Anoplophora glabripennis* Motschulsky
wood-boring beetles	*Anoplophora* spp.
	Ceresium spp.
	Hesperophanes Mulsant spp.
	Monochamus Megerle spp.
citrus longhorned beetle	*Anoplophora chinensis* (Forster)
Pine flat bug	*Aradus cinnamomeus* Panzer
longhorned beetles	*Cerambycideae* spp.
Chilean carpetworm	*Chilecomadia valdiviana* (Phillippi)
ladybird beetle	*Chilocorus stigma* L.
Chrysocharis laricinellae	*Chrysocharis laricinellae* (Ratzeburg)
larch casebearer	*Coleophora laricella* (Huebner)
beech scale	*Cryptococcus fagisuga* Lindinger
Asiatic oak weevil	*Cyrtepistomus castaneus* Roelofs
bark beetles	a variety of beetles including *Dendroctonus* Erichson and *Ips* DeGeer species
southern pine beetle	*Dendroctonus frontalis* Zimmerman
Siberian silk moth	*Dendrolimus superans* Butler
chestnut gall wasp	*Dryocosmus kuriphilus* Yasumatsu
elongate hemlock scale	*Fiorinia externa* Ferris
large pine weevil	*Hylobius abietis* L.
elm bark beetle	*Hylurgopinus rufipes* (Eichhoff)
red-haired pine bark beetle	*Hylurgus ligniperda* Fabricius
European spruce beetle	*Ips typographus* L.
Asian gypsy moth	*Lymantria dispar* L.
European gypsy moth	*Lymantria dispar* L.
nun moth	*Lymantria monacha* L.
Mediterranean pine engraver beetle	*Orthotomicus erosus* Wollaston
Mexican grasshopper	*Pterophylla beltrani* (Bolivar & Bolivar)
(small) Japanese cedar longhorned beetle	*Callidiellum rufipenne* Motschulsky
European oak bark beetle	*Scolytus intricatus* (Ratzeburg)
Smaller European elm bark beetle	*Scolytus multistriatus* (Marsham)
woodwasp	*Sirex noctilio* F.
Brown longhorned spruce beetle	*Tetropium fuscum* (Fabricius)
basswood thrips	*Thrips calcaratus* Uzel
pear thrips	*Thrips inconsequens* (Uzel)
common pine shoot beetle	*Tomicus piniperda* L.
ambrosia beetle	*Trypodendron lineatum* (Olivier)

e. Mammalian species

Common name	Scientific name
red-backed vole	*Clethrionomys* spp. (Tilesius)
snowshoe hare	*Lepus americanus (*Erxleben)
bobcat	*Lynx rufus* (Schreber)
white-tailed deer	*Odocoileus virginianus* (Zimmermann)

Red squirrel	*Tamiasciurus hudsonicus (*Trouessart)
grizzly bear	*Ursus horribilis* (Ord)
black bear	*Ursus americanus* (Pallas)

f. Bird species

Common name	**Scientific name**
northern goshawk	*Accipiter gentilis* (L.)
(Northern) saw-whet owl	*Aegolius acadicus* (Gmelin)
ruffed grouse	*Bonasa umbellus* (L.)
blackburnian warbler	*Dendroica fusca* (Statius Muller)
chestnut-sided warbler	*Dendroica pensylvanica* (L.)
black-throated green warbler	*Dendroica virens* (Gmelin)
pileated woodpecker	*Dryocopus pileatus* (L.)
Acadian flycatcher	*Empidonax virescens* (Vieillot)
wild turkey	*Meleagris gallopavo* (L.)
Clark's nutcracker	*Nucifraga columbiana* (Wilson, A.)
downy woodpecker	*Picoides pubescens* (L.)
rufous-sided towhee	*Pipilo fuscus* (Swainson)
golden-crowned kinglet	*Regulus satrapa* (Lichtenstein)
Louisiana waterthrush	*Seiurus noveboracensis* (Gmelin)
red-breasted nuthatch	*Sitta canadensis* (L.)
winter wren	*Troglodytes troglodytes*
robin	*Turdus* spp. (L.)
blue-headed/solitary vireo	*Vireo solitarius* (Wilson, A.)
Canada warbler	*Wilsonia pusilla* (Wilson, A.)

Appendix 2
Summaries of regulations, laws, and international agreements

U.S. Prevention Strategies

Summary of APHIS' Current Regulations Governing Imports of Wood [see 7 Code of Federal Regulations Part 319, subpart 40)

In all cases, imports are subject to inspection and remedial action if pests are found.

Wood packaging (SWPM) imported as cargo (not accompanying cargo, but for future use):

Pallets must be stripped of bark, and be accompanied by a statement that the pallets were previously eligible for importation and no wood has been added since that certification. Other forms of wood packaging must meet the requirements for raw lumber imported from the specific region (see below).

Canada and Mexican states bordering the U.S.:

Logs and lumber from these regions may be imported without any treatment or precaution, regardless of whether bark is present.

The so-called **"Universal" requirements** actually apply only to softwood (coniferous) imports from most temperate regions; and to hardwood logs from the region East of 60^0 E and North of the Tropic of Cancer (Siberia and all of China except Hong Kong and neighboring Kwangtung province). They require that logs from these regions be stripped of bark, heat treated, then handled so as to prevent re-infestation.

Softwood Lumber:

1) softwood lumber from the region East of 60^0 E and North of the Tropic of Cancer (Siberia and all of China except Hong Kong and neighboring Kwangtung province) must be heat treated and kept segregated from other lumber.

2) softwood lumber from all other origins -- including Brazil and Europe -- may be imported if it meets either of the following conditions :

   a) it has been heat treated (with or without moisture reduction) prior to importation
   b) it is imported untreated or raw, then shipped to an APHIS-approved facility, where it must be heat-treated within 30 days

Logs derived from Monterey pine (*Pinus radiata*) and Douglas-fir (*Pseudotsuga taxifolia*) grown in plantations in Chile and New Zealand may be imported if the logs:

! are from healthy trees apparently free of plant pests, pest damage, or decay
! debarked and fumigated before they arrive in the U.S.
! once in the U.S., kept segregated until processed;
! moved by a direct route between port and processing facility;
! at the processing facility, the logs and lumber must be heat treated and then processed within 60 days

Tropical hardwoods:

! logs and lumber that have been debarked may be imported subject only to inspection;

- logs and lumber with bark must be fumigated prior to arrival in U.S.; however, fumigation is not required if the shipment contains 15 logs or fewer and is imported into non-tropical parts of the country.

Temperate hardwoods:
Logs and lumber from regions other than East of 60^0 E and North of the Tropic of Cancer, must be fumigated. This applies whether or not bark is present.

Railroad ties
Crossties from all places except East of 60E E and North of the Tropic of Cancer must be stripped of bark, then imported with a promise by the importer that the crossties will be pressure treated within 30 days.

Chips
- Wood chips from temperate regions other than Asia east of 60E E Longitude and north of the Tropic of Cancer may be imported after fumigation or heat treatment. Once imported, the chips must be consigned to an APHIS-approved facility, where the chips must be burned or heat treated or otherwise processed within 30 days.
- In 2000, APHIS amended its regulations (Federal Register April 10, 2000 (Vol. 65, No.77)) to allow exporters shipping chips from Chilean plantation-grown *Pinus radiata* to treat the chips with a surface pesticide while they are being loaded onto the ship
- Chips made from plantation-grown tropical trees may be imported without any additional safeguards.

Wood Packaging

SWPM must be accompanied by a statement by the importer that all bark has been removed and the packaging is apparently free from live plant pests. Since 1998, SWPM from China is subject to special regulations that require shippers to treat the wood packaging, using fumigation, kiln drying, or treatment with preservatives.

Summary of APHIS' Regulations Governing Imports of Living Plants ("Q-37")
7 CFR 319.37 Nursery Stock, Plants, Roots, Bulbs, Seeds, and Other Plant Products

Section 319.37 requires that all plant importers comply with these regulations and any instructions by APHIS staff to destroy, re-export, or apply treatments to prevent pest introductions. The APHIS inspector decides on any remedial action after considering the degree of pest risk presented by the imported article and pest, the presence of host materials near the port, the climate and season, and the availability of treatment facilities.

Under Section 319.37 -2(a), APHIS requires that importers of listed species from specified countries obtain and comply with a permit. These species/country combinations include numerous types of woody plants; species/country combinations not specified are exempt from the regulations.

319.37-2(b) lists numerous species, plant types, and sizes which may be imported from a country other than Canada only under the terms of a permit. These plants include rhododendrons and naturally dwarf forms of a tree or shrub. However, the regulations allow imports of artificially dwarfed trees or shrubs.

319.37-3 specifies that importers must have a written permit for several types of imports, including lots containing 13 or more woody plants or seeds of any trees or shrubs, when those plants or seeds are from any country other than Canada. APHIS also requires written permits for certain species destined for states that impose quarantines.

319.37-3(c) allows imports of greenhouse-grown plants from Canada when APHIS is satisfied that Agriculture Canada adequately supervises the exporting greenhouse and the exporter ships only approved plant types.

319.37-5 specifies special foreign inspection and certification requirements for particular kinds of plants. Paragraph (b)(1) allows imports of several types of plants as long as the plants had been grown in a nursery in several European countries or Canada, and are accompanied by a phytosanitary certificate issued by the exporting country starting that the plants are free of specific diseases -- as determined largely by visual inspection.

319.37-6 specifies special treatment and other requirements for various imports, including seeds of *Castanea* and *Quercus* from all countries except Canada and Mexico, with the goal of excluding various insect pests .

319.37- 7 establishes APHIS' right to impose certain postentry quarantine procedures, and specifies to which species/country combinations such conditions apply. Postentry quarantine requirements apply not just to the imported plants themselves, but also to any progeny. Plants subject to these conditions may be imported only if APHIS has signed a postentry quarantine management program agreement with both the state and the grower to which they are destined. The species/country combinations listed here do not completely match those listed in Section 319.37-2.

319.37-8 requires plants to be imported without any growing media, with certain exceptions. Those exceptions are plants from Canada other than Newfoundland or parts of British Columbia; articles grown in agar or other transparent or translucent tissue culture medium; epiphytic plants established on tree fern slabs, coconut husks, or coconut fiber; and plants belonging to several specific genera which are subject to special rules. These exemptions include *Rhododendron* from Europe, as long as the plants are accompanied by a phytosanitary certificate declaring that the plant meets certain specified conditions. The approved growing media are baked expanded clay pellets, cork, glass wool, organic and inorganic fibers, peat, perlite, polymer stabilized starch, plastic particles, phenol formaldehyde, polyethylene, polystyrene, polyurethane, rock wool, sphagnum moss, ureaformaldehyde, vermiculite, or volcanic rock, or any combination of these media. Growing media must not have been previously used. The plants imported under this paragraph must be grown in compliance with a written agreement signed by the national phytosanitary agency, they must be developed from mother stock that was inspected and found free from evidence of disease and pests by APHIS or the exporting country's phytosanitary agency no more than 60 days prior to the time the plants are established in the greenhouse; and they must be grown solely in a greenhouse meeting prescribed conditions over specified periods of time.

317.37-14 Plants imported under a written USDA permit pursuant to 319.37-3(a) must be imported through special ports of entry at which APHIS has established plant quarantine stations with enhanced inspection and pest identification facilities. These ports are Nogales, AZ; Los
Angeles, San Diego, San Francisco, and San Pedro CA; Miami and Orlando FL; Honolulu, HI; New Orleans, LA; Hoboken, NJ; Jamaica, NY ; San Juan, PR; Brownsville, El Paso, and Houston TX; and Seattle, W A.

The Plant Protection Act (adopted in 2000)
(7 U.S.C. 7701 -7772)

In June 2000, the new Plant Protection Act was passed by the Congress as Title IV of PL 106-224 (the crop insurance program). The new PP A replaces the Plant Quarantine Act, Plant Pest Act, Federal Noxious Weed Act, and other statutes.

The Plant Protection Act gives a strong endorsement to biological control.

The definition of plant pest [Sec. 403(14)] for the first time includes vertebrate animals that "can directly or indirectly injure, cause damage to, or cause disease in any plant or plant product ..."

The PPA requires APHIS to issue, within one year, a notice for public comment on the procedures and standards it will follow in responding to importers' requests to import something, including how to involve the public in the risk assessment process, how to assign priorities, guidelines for early solicitation of relevant scientific and economic information, and guidelines for ensuring that its risk assessment process will be transparent and clarify assumptions and uncertainties in the process.

Furthermore, by June 2002, APHIS must report on how it will improve programs to prevent introduction of plant pathogens travelling on plants or plant products. APHIS is required to consult with scientists from state departments of agriculture, academia, the private sector, and the Agricultural Research Service.

The PPA greatly strengthened APHIS' enforcement powers, including allowing higher fines (up to $50,000 for individuals, $250,000 for corporations), giving the agency the power to issue a subpoena, expanding the agency's ability to institute an "extraordinary emergency" to prevent the spread of weeds as well as pests that are "new to or not known to be widely prevalent or distributed within and throughout the United States." However, USDA must take the least drastic action "that is feasible and that would be adequate to prevent the dissemination of any" such plant pest or noxious weed. Furthermore, the pest or weed must threaten "plants or plant products". [USDA attorneys have stated repeatedly that such damage might be to any plant, not just an agricultural one]. As in the past, APHIS may declare an "extraordinary emergency" only when the Secretary of Agriculture finds that state efforts are inadequate to eradicate the pest or weed.

When someone imports a plant, plant product, biocontrol agent, plant pest, or noxious weed, U.S. Customs must hold the shipment and inform USDA of its arrival [Sec. 413(a)]. The importer of any plant, plant product, biocontrol agent, plant pest, noxious weed, or any article or means of conveyance required to have a permit must also notify USDA of the incoming shipment [Sec. 413(b)]. Furthermore, no one may move any plant, plant product, biocontrol agent, plant pest, noxious weed, article, or means of conveyance from the port of entry until such movement as been authorized by USDA [Sec. 413(c)]- giving APHIS a chance to inspect it.

Under Sec. 421, APHIS' need not find probable cause to inspect a person or means of conveyance entering the country .The agency must have probable cause to inspect a person or means of conveyance moving in interstate commerce or moving out of a quarantine area (but still within the state). APHIS must obtain a warrant or the voluntary permission of the owner to inspect any premises.

Under Sec. 436, APHIS' regulations overrule regulations by the states pertaining to foreign or interstate commerce. A state may win an exemption if the state convinces the Secretary of Agriculture that the state has a special need -- as demonstrated by sound scientific data or a thorough risk assessment.

Executive Order 13112 and the Invasive Species Management Plan

In 1997, more than 500 scientists wrote to then Vice President Gore to request action on invasive species. Their letter stated: "We are losing the war against invasive exotic species, and their economic impacts are soaring. We simply cannot allow this unacceptable degradation of our Nation's public and agricultural lands to continue." The government formed an interagency team to develop a comprehensive and coordinated strategy. The team prepared a review of the issue with recommendations, foremost among them that an executive order be issued providing standards and a framework for continuing action. On February 3, 1999, President Clinton issued Executive Order 13112 on Invasive Species. We summarize Executive Order 13112 below. The text can be found at http://www.invasivespecies.gov.

Executive Order 13112 directs Federal agencies, to the extent practicable and permitted by law, to take affirmative steps to prevent introduction of invasive species; detect and respond rapidly to new invasions; control established invaders; monitor invasive species populations; restore native species and habitat conditions in invaded ecosystems; conduct research on invasive species and develop technologies to deal with them; and promote public education on invasive species.

Executive Order 13112 also directs each Federal agency not to authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, "pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

All of these responsibilities are to be carried out in consultation with the National Invasive Species Council and in line with the National Invasive Species Management Plan.

The Order also established the National Invasive Species Council (Council) chaired by the Secretaries of Agriculture, Commerce, and the Interior. The Departments of State, Treasury, Defense, Transportation and the Environmental Protection Agency are also members of the Council. The Council is to provide national leadership and oversight on invasive species and to see that Federal efforts are coordinated and effective. In addition, the Council has specific responsibilities including: promoting action at local, State, tribal and ecosystem levels; identifying recommendations for international cooperation; facilitating a coordinated network to document, evaluate, and monitor invasive species' effects; developing a web-based information network on invasive species; developing guidance on invasive species for Federal agencies to use in implementing the National Environmental Policy Act; and preparing the National Invasive Species Management Plan.

An Advisory Committee – appointed by the Secretary of the Interior with input from the other Council agencies – represents diverse stakeholders. The committee appointed in 2000 had 32 members, of which only 2 had a notable background in forest pest issues. (The members of the Advisory Committee are also listed on the web site.)

The first edition of the Management Plan was developed by the Council with considerable input from the Advisory Committee; from six working groups which cumulatively consisted of a few hundred people; and two public comment periods, in which more than 181 people and organizations commented. The Plan was finalized in January 2001. Titled Meeting the Invasive Species Challenge, it also can be found on the Invasive Species Councils' web page, www.invasivespecies.gov.

The plan focuses on those non-native species that cause or may cause significant negative impacts and do not provide an equivalent benefit to society. The plan lays out actions in nine areas: leadership and coordination, prevention, early detection and rapid response, control and management, restoration, international cooperation, research, information management, and education and public awareness. These actions will be carried out in coordination and partnership with states, tribes, local governments, and other stakeholders.

Despite the clear mandate in the Executive Order, the authors of the Plan have not yet determined whether
1) existing legal authorities to address invasive species are sufficient and how they can be better utilized; or
2) those existing legal and regulatory authorities are being adequately enforced.

Here we summarize those parts of the plan that apply most directly to preventing the introduction of exotic forest pests. Plan components that address control of established invaders will be summarized later.

The Plan is fairly blunt about the shortfall in funding for invasive species efforts (see Chapter 5). The Plan also identified another gap: while the USDA has emergency authority to deal with an incipient invasion, there is no comprehensive national system for detecting, responding to, and monitoring incipient invasions. Finally, the Plan notes that growing trade, tourism, and transport exacerbate the invasive species threat. It then outlines a strategy that incorporates international agreements and cooperation, as well as assistance to help developing countries obtain the needed scientific, technological, and financial resources to curtail both imports and exports of potentially invasive species. The Plan also suggests that the U.S. encourage industry and other sectors to adopt codes of conduct and other voluntary standards to help limit the spread of invasive species.

Promised actions that are particularly relevant to preventing introduction of forest pests
(numbers taken from the Natural Plan):

10. By February 2001, the Council will convene an interagency working group to facilitate the development of consistent U.S. policies for relevant International agreements --e.g., trade agreements. These positions will be developed through a more open process ensuring adequate stakeholder input.

13. As resources permit, APHIS will put additional human and financial resources into its port inspection services.

16. USDA will issue new regulations governing wood packaging by January 2002.

17. By January 2002, the Council will implement a process for identifying high priority invasive species that are likely to be introduced unintentionally, and for which effective mitigation tools are needed.

20. By January 2003, the Council will implement a system for evaluating invasive species pathways and will assign priorities to the most significant. The report will discuss the most useful tools for identifying pathways, including emerging or changing pathways, and for stopping introductions most efficiently.

21(b). By January 2003, USDA and other federal agencies, appropriate scientific societies, and others will initiate a program for the development of new methods to detect specific pathogens and parasites that may affect human, animal, or plant health.

21(c). By January 2003, USDA, Interior, Commerce, and EPA will institute systematic monitoring surveys of locations where introductions of invasive species are most likely to occur.

23. By July 2003, the Council in coordination with other Federal, State, local, and tribal agencies, will develop a program for coordinated rapid response to incipient invasions of both natural and agricultural areas and pursue increased funding to support this program.

24. During spring 2002, the Council, in consultation with the States, will draft legislation establishing a system for rapid responses to incipient invasions, including exploring permanent funding.

37. The Council will strengthen and expand U.S. participation in the development and application of international standards and codes of conduct.

37b. By June 2002, the Council, in cooperation with other relevant bodies, will identify the limitations and strengths of existing international agreements and develop a program for working with other governments and international organizations to improve them.

38. By December 2001, the Council will outline an approach to a North American invasive species strategy, to be built upon existing tripartite agreements and regional organizations, and initiate discussions with Canada and Mexico for further development and adoption.

Executive Order 13141, Environmental Review of Trade Agreements

In November 1999, President Clinton issued Executive Order 13141, Environmental Review of Trade Agreements. Under the executive order, the United States will use "ongoing assessment and evaluation, and, in certain instances, written environmental reviews" to "factor environmental considerations into the development of its trade negotiating objectives. .." An environmental review will automatically be done for certain types of trade agreements, among them:

(i) comprehensive multilateral trade rounds;

- ! bilateral or multi-country free trade agreements; and
- ! major new trade liberalization agreements in natural resource sectors.

The public will have input into the scope of such an environmental review, and – where practicable – can comment on the draft. While the environmental review is supposed to be done sufficiently early to influence the negotiating position, putting forward a particular negotiating proposal does not have to wait for completion of the review. Usually, the environmental reviews will focus on impacts in the United States. As appropriate and prudent, reviews may also examine global and transboundary impacts. Implementation is the joint responsibility of the United States Trade Representative (USTR) and the Chair of the Council on Environmental Quality (CEQ). USTR conducts the environmental reviews.

Environmentalists and others may not sue the government for failing to comply with the terms of this executive order.

International Trade Agreements

The WTO Agreement on the Application of Sanitary and Phytosanitary (SPS Agreement)

In 1994, more than 100 countries concluded the Uruguay Round of the General Agreement on Tariffs and Trade by forming the World Trade Organization, which enforces the rules for international trade. One of the principal concerns of those negotiating the new trade agreement was that phytosanitary safeguards not be misused as "non-tariff barriers" to protect domestic agricultural producers from foreign competition. Consequently, the negotiators simultaneously adopted the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), which establishes the parameters within which countries may apply phytosanitary safeguards. We summarize the SPS Agreement here; for a copy of the full document, consult the WTO web site at http://www.wto.org.

The Preamble states that the Agreements' adherents ("Members") reaffirm their individual right to adopt and enforce phytosanitary measures, subject to the requirement that these measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between Members where the same conditions prevail or a disguised restriction on international trade. Members also encourage development of international standards by several named international organizations; the relevant organization in the case of forest pests is the International Plant Protection Convention. At the same time, Members are not required to change their "appropriate level of protection". Finally, Members recognize that developing countries may encounter special difficulties and should be assisted.

Article 1 requires that all phytosanitary measures which may affect international trade be developed and applied in accordance with the provisions of this Agreement.

Article 2 establishes Members' basic rights and obligations. Members may take phytosanitary measures necessary for the protection of plant life or health – as long as those measures are consistent with this Agreement. The phytosanitary measure may be applied only to the extent necessary, and must be based on sufficient scientific evidence – although provisional measures are allowed in paragraph 7 of Article 5. Furthermore, the phytosanitary measures must not arbitrarily discriminate between Members where identical or similar conditions prevail, including within Members' own territory.

Article 3 urges Members, to the extent possible, to base their phytosanitary measures on international standards. Phytosanitary measures which are based on international standards are presumed to be consistent with the relevant provisions of this Agreement and of GATT 1994. Paragraph 3 allows Members to adopt phytosanitary measures that are more protective than the relevant international standard if there is a scientific justification, or as a consequence of the Member choosing a higher level of protection. The Member must comply with paragraphs 1 through 8 of Article 5 in determining its "appropriate level of protection". Furthermore, all national measures which result in a different level of phytosanitary protection must be consistent with other provision of this Agreement.

Article 4 requires Members to accept the phytosanitary measures of other Members as equivalent if the exporting Member objectively demonstrates that its measures achieve the importing Member's chosen level of protection.

Article 5 lays out the process for assessing risk and determining a country's appropriate level of protection. Members must base their phytosanitary measures on a risk assessment. While the IPPC and other international organizations are defining risk assessment techniques, Article 5 lays out factors that must be considered. These include, but are not limited to, available scientific evidence; relevant production methods and inspection methods; the prevalence of specific diseases or pests; ecological and environmental conditions; and quarantine or other treatment. In determining the measure to be applied, Members must consider several economic factors, including potential losses of production or sales, control costs, and the relative cost-effectiveness of alternative approaches to limiting risks. Members should also take into account the objective of minimizing negative trade effects. Members shall avoid arbitrary distinctions in the levels of protection considered to be appropriate in different situations, if such distinctions result in discrimination or a disguised restriction on international trade. Members shall ensure that phytosanitary measures are not more trade-restrictive than required to achieve their appropriate level of protection, taking into account technical and economic feasibility. Paragraph 7 states that when scientific evidence is insufficient, a Member may provisionally adopt phytosanitary measures on the basis of available information. In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the measure within a reasonable period of time. When a Member has reason to believe that a trading partner's phytosanitary measure harms or
could constrain its exports, and that measure is not based on an international standard, the Member has the right to an explanation.

Under Article 6, phytosanitary measures must reflect differences in the prevalence of specific diseases or pests – including pest- or disease-free areas – and the existence of eradication or control programs.

Article 7 requires Members to provide notice of changes in their phytosanitary measures.

Article 8 requires Members to apply the provisions of Annex C in implementing control, inspection and approval procedures. Under Annex C, these procedures must be completed without undue delay and be limited to what is reasonable and necessary; information requirements must be limited to what is necessary; business information must be kept confidential; and any fees must be equitable when compared to fees charged on like domestic products or products originating in any other Member and should be no higher than the actual cost of the service. There must also be a complaint procedure. Where a phytosanitary measure specifies pest management practices at the level of production, the exporting Member must assist in verifying compliance. Article 9 promises that Members will provide technical assistance to developing countries. Under Article 10, Members may allow developing countries extra time to phase in new phytosanitary measures -- as long as the importing country's appropriate level of protection allows for such phase-ins. In addition, the Committee on Sanitary and Phytosanitary Measures may grant developing countries time-limited exceptions to all or part of their obligations under the SPS Agreement. Finally, Members are encouraged to help fund developing countries' active participation in the work of the IPPC and other relevant international organizations.

Article 11 lays out the procedures for consultations and dispute settlement.

Article 12 provides for administration of the Agreement. A Committee on Sanitary and Phytosanitary Measures provides a regular forum for consultations. The Committee shall reach its decisions by consensus. The Committee shall encourage the use of international standards and maintain close contact with the IPPC and other relevant international organizations to secure the best available scientific and technical advice for the administration of this Agreement and to avoid unnecessary duplication of effort.

The International Plant Protection Convention (IPPC)

In November, 1997, the 46-year old International Plant Protection Convention (IPPC) was revised to bring it into compliance with the SPS Agreement (the text may be read at www.pps.go.jp./english/agr_01/contents.html). One hundred sixteen countries are party to the IPPC. While these revisions have not yet come into force (because too few countries have deposited their instruments of acceptance), the IPPC is proceeding to carry out its new standard-setting obligations assigned by the SPS Agreement. The revised IPPC applies to governmental actions regarding plants, plant products, storage places, conveyances, containers, soil, and other objects that might harbor or spread plant pests. Again, the IPPC recognizes the need to protect domestic resources from foreign pests and requires the measures to be technically justified and transparent and that they not be used as non-tariff barriers to trade.

Under the IPPC, phytosanitary measures may be no more stringent than measures applied to the same pests if those pests are present within the territory of the importing country. Furthermore, the phytosanitary measures must be limited to what is necessary to protect plant health. No phytosanitary safeguards may be applied to non-regulated pests. Two types of regulated pests are recognized:
a) "quarantine pest" --a pest of potential economic (interpreted to include environmental) importance to the area endangered thereby and not yet present there; or
b) "regulated non-quarantine pest" --a non-quarantine pest which threatens to cause economically unacceptable damage to horticultural plants and which is therefore regulated within the territory of the importing country.

Phytosanitary measures must be necessary and technically justified (through a risk assessment); and the least restrictive measure available that results in the minimum impediment to international trade. A country may take emergency action when it detects a pest that poses a potential threat to its territory , but it must evaluate the action as soon as possible to ensure that its continuance is justified. The IPPC has begun carrying out its new responsibilities under the SPS Agreement to develop international standards. Priorities are set by the new governing body, the Interim Commission on Phytosanitary Measures, and work is coordinated by the IPPC Secretariat (Griffin 2001). IPPC standards developed so far include:

! Principles of plant quarantine as related to international trade
! Guidelines for Pest Risk Analysis
! Glossary of Phytosanitary Terms
! Requirements for the establishment of pest free areas

The development of standards is a new task, and everyone is learning. Some have found the just-adopted standard on Guidelines for Pest Risk Analysis to be insufficiently detailed, especially on the following topics:

! pest categorization - initial screening to determine whether an organism qualifies as a quarantine pest
! assessment of probability of introduction
! assessment of potential economic impact
! risk management -evaluating phytosanitary measures that could be applied

However, the parties have agreed to work with the document as it is now (David McNamara, pers. comm. 12/01).

Standards now under development by the IPPC include those for issuance of phytosanitary certificates, surveillance for citrus canker, wood packaging (Griffin 2001); and incorporation of environmental impacts into pest risk assessment.

Negotiators are finding it difficult to reconcile countries two different approaches – some countries prohibit all imports until they have evaluated and approved it – they do risk assessments on any proposed commodity from every source. Other countries allow imports unless they have adopted regulations to limit the import; risk assessments usually deal with the specific pest rather than the origin or commodity. In addition, many countries doubt that they can comply with the complex risk assessment process developed by the IPPC (David McNamara 2001).

IPPO International Standard for SWPM

A draft IPPO standard for SWPM was first released for comment in June 2000; a substantially revised standard was subsequently published in November 2001. The final standard was adopted in March 2002 [it can be found at www.aphis.usda.gov/ppq; click on "International Standards"].

In June 2000, the draft gave the following rationale for adopting a broad "pathway" standard (as opposed to a pest- or country-specific standard): SWMP is often made of low grade, inexpensive wood that is likely to transport hitchhiking pests; SWPM can be present with any imported consignment, including many which would not normally be targets of phytosanitary inspection; and regulators cannot "characterize" the risk associated with any particular shipment containing wood packaging because they do not know the wood's origin, age, or whether any treatment has been applied.

The final standard retained this rationale but added a goal, stated as "to practically eliminate risk for most quarantine pests and significantly reduce risk [for a] number of others".

Both versions exempted from the regulation wood packing that has been manufactured wholly of plywood, particle board, oriented strand board, or veneer because their manufacture, using glue, heat and pressure, or a combination thereof, is thought to render this packaging inhospitable to pests. Both also exempted loose wood packing such as sawdust and shavings, and raw wood cut into thin pieces (equal to or less than 6 mm). The burden of proof was reversed during the negotiations. In the June 2000 draft, countries which confirmed -- through a risk analysis -- that these latter forms were not important pathways, could exempt them from treatment. By November 2001, countries had to prove -- again, through a risk analysis -- that these types of packaging presented a risk before they could regulate them.

In both versions, countries may exempt any trading partner from the requirements contained in the standard when the importing country determines that the pest risk is adequately managed by existing or proposed procedures.

While the standard provides for a "pathway" approach, Section 3, paragraph 1 allows states to prepare individual risk assessments and develop specific treatments or systems approaches when the source of packing material is known.

Between June 2000 and November 2001, the IPPC parties made significant changes in the measures incorporated into the standard and expected to be applied in most cases. In June 2000, these "universal measures" were defined as "treatment, processing, or a combination of these which permanently change the character of the wood and which removes or kills pests. Kiln drying and chemical pressure impregnation are such Universal measures." By November 2001, these had become "Approved measures" and were defined as "Any treatment, process, or a combination of these that is significantly effective against most pests ..." Furthermore, the choice of which measure to apply should be "based on consideration of:

- the range of pests that may be affected
- the efficacy of the measure
- a change in [wood] character ... which has an effect in reducing risk
- the technical and/or commercial feasibility."

The specific approved measures contained in the November 2001 draft and final standard are

- heat treatment — 56^0 for 30 minutes; includes kiln drying and chemical impregnation when they meet these requirements
- methyl bromide fumigation.

The final standard thus does not retain the requirement in the earlier version that countries apply measures that change the wood's character to deter infestation. It also deleted any specific for moisture content requirements and even the earlier language urging countries to insist on removal of bark as a minimal measure in cases where kiln drying or chemical impregnation could not be applied or verified by an exporting country.

The final standard asserts that the following types of insects would be "practically eliminated" by proper application of the approved treatment measures: Anobiidae, Bostrichidae, Buprestidae, Cerambycidae, Curculionidae, Isoptera, Lyctidae (with some exceptions for heat treatment), Oedemeridae, Scolytidae, Siricidae. Also the nematode *Bursaphelenchus xyolphilus.*

Both the draft and final standard urge countries party to the IPPC to accept SWPM that has undergone one of the treatments outlined in the standard "without further requirements except where interception and/or [risk assessment show] that specific quarantine pests associated with certain types of wood packaging ... from specific sources require more rigorous measures." (Language from the final standard).

While the June 2000 draft urged countries to consider methyl bromide fumigation as an emergency action rather than a routine measure, the later draft treated it as an "approved" measure equal to kiln drying and chemical impregnation.

Both the draft and final standards allow importing countries to accept other pest management systems which they find to be adequate; and to negotiate special provisions with individual trading partners.   The June 2000 draft specified that these other measures should "result in the non-manufactured wood packing being free from quarantine pests". The November 2001 draft lacked any such advice. Further, by 2001 it was suggested that temperate countries accepting shipments from tropical countries might grant easier terms under the expectation that such shipments posed little hazard.

Both the draft and final allow importing countries to inspect any wood packaging and to take appropriate action -- including treatment, disposal, or refusal of entry -- when pest infestations are found.

However, both tightly restrict the circumstances under which countries can require additional safeguards if the country's phytosanitary agency suspects that SWPM might not have been treated, or might be infested despite earlier treatment. In the June 2000 draft, the phytosanitary agency could "act only when either 1) sign of live pests or 2) bark is present and quarantine pests have been found to be associated with such signs either during this inspection or during previous inspection(s) of equivalent consignments. [The phytosanitary agency] may not apply a treatment if an active quarantine pest has not been found to be associated with the signs at any time in equivalent consignments. If the consignments are a new commodity or from a new source, importing country NPPO may take emergency action based on the signs of live pests or bark without detection of the pest."

By November 2001, this restriction had become even tighter: the phytosanitary agency may act if "the SWPM does not carry the required mark [indicating treatment], or is found to be infested with a quarantine pest ..." There is no provision for acting based on past detections.

Regional Standards

Summary of the North American Plant Protection Organization (NAPPO) Standard on Solid Wood Packing Material, Adopted in October 1998

With discovery of the Asian longhorned beetle outbreak in New York in 1996, the U.S. and Canada began studies that revealed that many wood-boring pests were travelling on SWPM (see chapter 4). They then initiated development of a regional standard. (The standard may be obtained from www.nappo.org.) The standard was adopted in November 1998, with the expectation that the three member countries would complete their implementing regulations by October 2000. Neither the U.S. nor Canada has met that goal.

The regional standard serves as a model for the three countries in regulating SWPM from outside the region. Movement of wood packaging among Canada, Mexico, and the U.S. will continue to be governed by each country's phytosanitary agencies individually. The standard states that "[t]he occurrence and distribution of plant pests within the NAPPO region is generally known ..."

The North American regional standard for SWPM exempts wood-based products such as plywood, particle board, oriented strand board, etc., which has been processed using wood, glue, heat and compression; as well as loose wood packing materials such as sawdust, shavings, etc. All other types of wood packing, including dunnage must comply with one of the following treatments:

1) commercial kiln drying – dried by heating in a kiln in accordance with a specific time-temperature schedule, as recommended in a recognized kiln operator's manual. The treatment must achieve a moisture content of less than 20% of dry matter. In addition, it must display an internationally recognized kiln dried marking or be accompanied by a recognized certificate of kiln drying;
2) fumigation using methyl bromide, accompanied by an officially recognized certificate of fumigation;
3) some other treatments or processes approved by the national plant protection organization of the importing country, e.g. wood that has been pressure treated with an approved chemical preservative;
4) or another approved pest management system endorsed by the national plant protection organization of the importing country. An acceptable pest management system should have documentation to substantiate several specified components.

"If none of the above conditions is met the wood dunnage and other wood packing materials must be disposed of by one of the [following] methods":

1. Incineration.
2. Burial at a minimum of 2 meters in depth in approved landfill sites.
3. Chipping and processing in a commercial chipper in an approved manner that eliminates pests, *e.g.* manufacture of oriented strand board.

The non-compliant wood packing material must be safeguarded prior to disposal to prevent escape of any pest between the time of entry and the time of disposal. Other methods may be endorsed by the national plant protection organization of an importing contracting party.

The European Plant Protection Organization is developing its own regional standard based on the IPPC draft (McNamara 2001).

Other Countries' National Regulations

Canada

Logs: Risk assessments are done in response to an importer's requests to import logs from countries outside North America [it is not clear whether Canada applies this requirement to imports of non-tropical wood from Mexico]. Tropical species are exempt. For those temperate species identified as posing a risk, Canada requires that the logs be debarked and heated to a core temp of 52^0 C for 30 minutes. Importers may request special permission for other treatments. Less burdensome standards can be applied during the winter (Dawson 2001).

SWPM: Canada is preparing a risk assessment focusing on pathway; broad range of pests selected from recent interceptions (Dawson 2001). The risk assessment was not ready for review at the end of 2001.

Europe

In June 1993, to prevent introduction of the pinewood nematode, the European Communities began requiring all coniferous chips, sawn wood, and logs imported from the U. S .and Canada to be heat-treated and accompanied by a phytosanitary certificate (C. Michael Hicks, Exotic Pests and International Trade). In 2000, Finland, Sweden, and France reported detecting pinewood nematodes in wood packaging coming from Canada, China, Japan, and the U.S.A. The European Union then adopted a regulation, which took effect in October 2001, requiring that coniferous SWPM from these countries be subjected to one of the following treatments: heat treatment or kiln drying to a core temperature of 56^0 for 30 minutes; chemical pressure treatment; or fumigation (U.K Forestry Commission web site: http://www.forestry.gov.uk/) This measure does not apply to SWPM from Korea, Mexico, or Taiwan, where the PWN is also found. The European inspectors have not recorded interceptions of PWN in SWPM from these countries, so they did not believe that the SPS would allow them to apply the emergency safeguard to them. However, European officials insist that they can broaden the safeguard to other countries quickly if the pest is found in SWPM (Roddie Burgess, UK Forestry Commission, in discussion on APS on-line symposium).

China

When the U.S. adopted regulations governing SWPM from China in 1998, that country adopted regulations similar to the Finnish measures for SWPM made from coniferous species from North America (McNamara and Kroeker 2001).

Australia

According to the Agriculture Quarantine and Inspection Service website, as of March 2001 Australia required the following safeguards for wood packaging:

- Importers must declare whether SWPM is present, if any SWPM bears bark, and whether it has been treated.
- No treatment of SWPM is required. Untreated SWPM – including wood used in the construction of shipping containers as well as crates, pallets, etc. inside the containers – may be unpacked at a break-bulk depot to permit inspection, with subsequent treatment if appropriate. No container with wooden dunnage is allowed to proceed outside the metropolitan area at the port of entry unless there is an official certificate or declaration that the timber has been treated by an approved method.
- Containers with exposed timber components that have not been permanently treated can be approved for entry without inspection if the container has been fumigated with methyl bromide or sulphuryl fluoride B – either within 21 days of being packed and shipped, or on arrival in Australia.
- Australia encourages owners of containers to treat them permanently – that is, by chemical preservatives – to minimize quarantine impediments in Australia.
- Australian quarantine procedures are more cautious for containers going to rural areas for unpacking than to metropolitan port cities. All containers destined for country unpacking addresses must receive a tail-gate inspection
- At break-bulk depots, all wooden dunnage must be stored in an approved place and re-used only as packing in export containers. At least once every two weeks, the waiting dunnage must be destroyed or fumigated. Dunnage which has been fumigated or inspected and certified as permanently immunized can be released from quarantine. Large-sized wood dunnage that is difficult to treat must remain under AQIS supervision until destroyed or exported.
- SWPM that has been permanently treated by a one of the approved preservatives or temporarily disinfested by fumigation with methyl bromide or sulphuryl fluoride can be imported. SWPM treated by a "non-permanent" method (including heat treatments) must be packed in a container or shipped within 21 days of that treatment. There is an exception for New Zealand – exporters in

that country are allowed 3 months.

- ! Empty pallets from Papua New Guinea and other Pacific Islands must be fumigated using methyl bromide to prevent introduction of the Giant African Snail (*Achatina fulica*).
- ! Fumigation with methyl bromide and sulphuryl fluoride are the only approved treatments for packed containers. All other treatments must be applied prior to containerization.
- ! Newly manufactured and previously unused panel products such as plywood, chipboard and particle board (both as bulk imports and packaging) are acceptable without inspection or further treatment, provided they have been manufactured in Australia, Canada, Europe, Israel, Japan, New Zealand, United Kingdom or USA. Valid certification must accompany each consignment. For other countries, the time between manufacture and shipment must be less than 21 days (with correct certification).

Statutes, Policies, Etc. Governing U.S. Efforts to Control Established Alien Forest Pests

Forest & Rangeland Renewable Resources Research Act (1978) [16 U.S.C. § 1642]

authorizes the Secretary of Agriculture to conduct research and experiments to obtain, analyze, develop, demonstrate, and disseminate scientific information about protecting and managing forests for a multitude of purposes;

§ 1642(a)(3) specifies protecting vegetation, forest, and rangeland resources from insects, diseases, noxious plants, animals, air pollutants, and other agents;

§ 1642(b) requires the Secretary to maintain a current comprehensive survey of the 'present and prospective conditions of and requirements for renewable resources of the forests and rangelands ... and means needed to balance the demand for and supply of these renewable resources, benefits, and uses in meeting the needs of the people of the United States. ...'1

Cooperative Forestry Assistance Act (1978) [16 U.S.C. §§ 2101,2102, 2104]

§ 2101(a) recognizes that "efforts to prevent and control ... insects and diseases often require coordinated action by both Federal and non-Federal land managers; ..."
§ 21 02(b) authorizes the Secretary of Agriculture to provide assistance to state foresters to develop and distribute genetically improved tree seeds and to improve management techniques aimed at increasing production of a variety of forest products, including wildlife habitat and water
§ 2104 authorizes the Secretary to protect from insects and diseases trees and wood products in use on National forests or, in cooperation with others, on other lands in the U.S.; such assistance may include surveys and determination and organization of control methods. Programs on non-federal lands can be instituted only with the consent of, and with a contribution of resources from, the owner. The Secretary may also prescribe other conditions for such cooperative efforts.

Executive Order 13112 and the invasive species management Plan as they relate to established pests

As noted above, in February 1999, President Clinton issued Executive Order 13112, establishing new policies and a coordinating Council to improve mitigation efforts targetting invasive species. The Executive Order called for agencies to control invasions, monitor invasivespecies populations, restore native species and habitat conditions in invaded ecosystems, conduct research on invasive species and develop technologies to deal with them, and promote public education on invasive species. Agencies are also to avoid actions that are likely to cause or promote the introduction or spread of invasive species, unless they determine that the benefits of the actions "clearly outweigh the potential harm ... and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

The first edition of the Management Plan, issued in January 2001 (www.invasivespecies.gov), gave little explicit attention to the problem of managing exotic forest pests already established in the United States. The funding shortfalls are highlighted in a general way: the Plan notes that while all Federal land and water management agencies have authority to control and manage invasive species as well as restore affected areas on their lands and waters, none has sufficient resources to control every invasive species present. The agencies' research and monitoring programs are also described as substantially underfunded.

The national invasive species management plan contains the following recommendations that address efforts to eradicate, control, or mitigate the impacts of established invaders (numbers correspond to those in the plan):

28. By January 2002, the USDA, in consultation with regional, State, tribal, and local agencies, will develop a proposal for accelerating the development, testing, assessment, transfer, and post-release monitoring of environmentally safe biological control agents; the Council will review this plan.

31. If the Bush Administration so chooses, it should request the Congress to provide additional funding for Federal agencies' control and management activities.

32. By January 2003, the Council will develop guidance for prioritizing control projects at local, regional, and ecosystem levels.

45 & 46. By July 2002, the Council, Smithsonian Institution, and National Science Foundation, utilizing input from the interagency Committee on the Environment and Natural Resources (CENR), will establish and coordinate a program to improve long- and short-term research capacity; adequate funding will be included in this initiative.

50. By November 2001, the Council will implement an MOU among appropriate Federal Departments to establish an assessment and monitoring network comprised of on-the-ground managers of Federal invasive species programs and appropriate technical specialists; and encourage involvement by appropriate State, and local agency personnel.

Appendix 3
Proposed Amendments to the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement)

Proposed additions are IN CAPITALS;
Proposed deletions are in [brackets]

PREAMBLE:

Members,

RECOGNIZING THAT THE ENTRY, ESTABLISHMENT AND SPREAD OF PESTS AND DISEASES TO NEW ENVIRONMENTS (INCLUDING HUMAN AND ANIMAL POPULATIONS) IN THE COURSE OF INTERNATIONAL TRADE CAUSES SEVERE LOSSES AND CONTROL COSTS, AND THAT THE DISRUPTIONS CAUSED TO NATURAL ENVIRONMENTS, PUBLIC HEALTH, AND AGRICULTURAL SYSTEMS ARE OFTEN IRREVERSIBLE;

RECOGNIZING FURTHER THE INCREASED RISK OF ENTRY, ESTABLISHMENT AND SPREAD OF PESTS AND DISEASES TO NEW ENVIRONMENTS THAT FOLLOWS LIBERALIZATION OF INTERNATIONAL TRADE;

Reaffirming that no Member should be prevented from adopting or enforcing measures necessary to protect human, animal or plant life or health, subject to the requirement that these measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between Members where the same conditions prevail or a disguised restriction on international trade;

Desiring to improve the human health, animal health and phytosanitary situation in all Members;

Noting that sanitary and phytosanitary measures are often applied on the basis of bilateral agreements or protocols;

Desiring the establishment of a multilateral frameworks of rules and disciplines to guide the development, adoption and enforcement of sanitary and phytosanitary measures in order to ENSURE ADEQUATE PROTECTION WHILE minimizing their AVOIDABLE negative effects on trade;

Recognizing the important contribution that international standards, guidelines and recommendations can make in this regard;

Desiring to further the use of harmonized sanitary and phytosanitary measures between Members, on the basis of international standards, guidelines and recommendations] developed by the relevant international organizations, including BUT NOT LIMITED TO Codex Alimentarius Commission, the International Office of Epizootics, [and] the relevant international and regional organizations operating within the framework of the International Plant Protection Convention, THE UN CONVENTION ON THE LAW OF THE SEA, THE CONVENTION ON BIOLOGICAL DIVERSITY, AND THE INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE, without requiring Members to change their appropriate level of protection of human, animal or plant life or health;

Recognizing that developing country Members may encounter special difficulties in complying with the sanitary or phytosanitary measures of importing Members, and as a consequence in access to markets, and also in the formulation and application of sanitary or phytosanitary measures in their own territories, and desiring to assist them in their endeavours in this regard;

Desiring therefore to elaborate rules for the application of the provisions of GATT 1994 which relate to the use of sanitary or phytosanitary measures, in particular the provisions of Article XX(b) See footnote 1;

Hereby agree as follows:

Article 1 General Provisions

1. This Agreement applies to all sanitary and phytosanitary measures which may, directly or indirectly, affect international trade. Such measures shall be developed and applied in accordance with the provisions of this Agreement.
2. For the purposes of this Agreement, the definitions provided in Annex A shall apply.
3. The annexes are an integral part of this Agreement.
4. Nothing in this Agreement shall affect the rights of Members under the Agreement on Technical Barriers to Trade with respect to measures not within the scope of this Agreement.

Article 2 Basic Rights and Obligations

1. Members have the right to take sanitary and phytosanitary measures necessary for the protection of human, animal or plant life or health, provided that such measures are not inconsistent with the provisions of this Agreement.
2. Members shall ensure that any sanitary or phytosanitary measure is applied [only to the extent necessary to] FOR THE PURPOSE OF PROTECTING human, animal or plant life or health, is based on scientific principles and is not maintained without sufficient scientific evidence[, except as provided for in paragraph 7 of Article 5]. A MEMBER MAY ADOPT OR MAINTAIN A SANITARY OR PHYTOSANITARY MEASURE THAT RESTRICTS OR PROHIBITS EXISTING OR PROPOSED IMPORTS BASED ON A WELL-CONSIDERED RISK -- SEE NEW DEFINITION -- OF HARM ASSOCIATED WITH THAT TYPE OF PRODUCT, PACKING MATERIAL, TRADE ROUTE, OR TRANSPORT METHOD, UNLESS THE EXPORTING MEMBER OBJECTIVELY DEMONSTRATES THAT THE PRODUCT, PACKING MATERIAL, TRADE ROUTE, OR TRANSPORT METHOD MEETS THE IMPORTING MEMBER'S APPROPRIATE LEVEL OF SANITARY OR PHYTOSANITARY PROTECTION.
3. Members shall ensure that their sanitary and phytosanitary measures do not arbitrarily or unjustifiably discriminate between Members where identical or similar conditions prevail, including between their own territory and that of other Members. WHILE sanitary and phytosanitary measures shall not be applied in a manner which would constitute a disguised restriction on international trade, MEMBERS MAY APPLY SANITARY AND PHYTOSANITARY MEASURES TO AN ALIEN [NON-INDIGENOUS] SPECIES ALREADY ESTABLISHED ON THEIR OWN TERRITORY IN CASES WHEN THAT SPECIES IS THE TARGET OF MITIGATION EFFORTS BY A GOVERNMENTAL AGENCY RESPONSIBLE FOR HUMAN, PLANT, OR ANIMAL HEALTH OR NATURAL RESOURCE MANAGEMENT AND CONSERVATION.
4. Sanitary or phytosanitary measures which conform to the relevant provisions of this Agreement shall be presumed to be in accordance with the obligations of the Members under the provisions of GATT 1994 which relate to the use of sanitary or phytosanitary measures, in particular the provisions of Article XX(b).

Article 3 Harmonization

1. To harmonize sanitary and phytosanitary measures on as wide a basis as possible, Members shall base their sanitary or phytosanitary measures on international standards, guidelines or recommendations, where they exist, except as otherwise provided for in this Agreement, and in particular in paragraph 3.
2. Sanitary or phytosanitary measures which conform to international standards, guidelines or recommendations shall be deemed to be necessary to protect human, animal or plant life or health, and presumed to be consistent with the relevant provisions of this Agreement and of GATT 1994.
3. Members may introduce or maintain sanitary or phytosanitary measures which result in a higher level of sanitary or phytosanitary protection than would be achieved by measures based on the relevant international standards, OR, WHERE APPROPRIATE -- SEE NEW DEFINITION RE: CODEX -- , guidelines or recommendations, if there is a scientific justification -- SEE NEW DEFINITION -- , or as a consequence of the level of sanitary or phytosanitary protection a Member determines to be appropriate [in accordance with the relevant provisions of paragraphs 1 through 8 of Article 5. See footnote 2] Notwithstanding the above, all measures which result in a level

of sanitary or phytosanitary protection different from that which would be achieved by measures based on international standards, guidelines or recommendations shall not be inconsistent with any other provision of this Agreement.
4. Members shall play a full part, within the limits of their resources, in the relevant international organizations and their subsidiary bodies, in particular the Codex Alimentarius Commission, the International Office of Epizootics, [and] the international and regional organizations operating within the framework of the International Plant Protection Convention, THE UN CONVENTION ON THE LAW OF THE SEA, THE CONVENTION ON BIOLOGICAL DIVERSITY, AND THE INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE to promote within these organizations the development and periodic review of standards, guidelines and recommendations with respect to all aspects of sanitary and phytosanitary measures.
5. The Committee on Sanitary and Phytosanitary Measures provided for in paragraphs 1 and 4 of Article 12 (referred to in this Agreement as the "Committee") shall develop a procedure to monitor the process of international harmonization and coordinate efforts in this regard with the relevant international organizations.

Article 4 Equivalence

1. Members shall accept the sanitary or phytosanitary measures of other Members as equivalent, even if these measures differ from their own or from those used by other Members trading in the same product, if the exporting Member objectively demonstrates to the importing Member that its measures achieve the importing Member's appropriate level of sanitary or phytosanitary protection. For this purpose, reasonable access shall be given, upon request, to the importing Member for inspection, testing and other relevant procedures.
2. Members shall, upon request, enter into consultations with the aim of achieving bilateral and multilateral agreements on recognition of the equivalence of specified sanitary or phytosanitary measures.

Article 5 Assessment of Risk and Determination of the Appropriate Level of Sanitary or Phytosanitary Protection

1. Members shall ensure that their sanitary or phytosanitary measures are based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organizations. WHEN INFORMATION IS INCOMPLETE, MEMBERS MAY ADOPT MEASURES BASED ON ANALOGIES, HISTORICAL EXAMPLES, EXPERT OPINION, OR EVIDENCE OF GENERALIZED RISKS OF ENTRY OR ESTABLISHMENT OF PESTS OR DISEASES ASSOCIATED WITH A PRODUCT, PACKING MATERIAL, TRADE ROUTE, OR TRANSPORT METHOD.
2. In the assessment of risks, Members shall take into account available scientific evidence; relevant processes and production methods; relevant inspection, sampling and testing methods; prevalence of specific diseases or pests; existence of pest- or disease-free areas; relevant ecological and environmental conditions; and quarantine or other treatment.
3. In assessing the risk to animal or plant life or health and determining the measure to be applied for achieving the appropriate level of sanitary or phytosanitary protection from such risk, Members shall take into account as relevant economic factors: the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease; the costs of control or eradication in the territory of the importing Member; and the relative cost-effectiveness of alternative approaches to limiting risks.
4. Members should, when determining the appropriate level of sanitary or phytosanitary protection, take into account the objective of minimizing negative trade effects.
5. With the objective of achieving consistency in the application of the concept of appropriate level of sanitary or phytosanitary protection against risks to human life or health, or to animal and plant life or health, each Members [shall] SHOULD SEEK TO avoid arbitrary or unjustifiable distinctions in the levels it considers to be appropriate in different situations, if such distinctions result in discrimination or a disguised restriction on international trade, PROVIDED THAT THIS PARAGRAPH SHALL NOT BE INTERPRETED SO AS TO PREVENT A MEMBER FROM ACHIEVING ITS APPROPRIATE LEVEL OF PROTECTION IN ANY PARTICULAR CASE. Members shall cooperate in the Committee, in accordance with paragraphs 1, 2 and 3 of Article 12, to develop guidelines to further the practical implementation of this provision. In developing the guidelines, the Committee shall take into

account all relevant factors, including the exceptional character of human health risks to which people voluntarily expose themselves.
6. Without prejudice to paragraph 2 of Article 3, when establishing or maintaining sanitary or phytosanitary measures to achieve the appropriate level of sanitary or phytosanitary protection, Members [shall] SHOULD SEEK TO ensure that such measures are not more trade-restrictive than required to achieve their appropriate level of sanitary or phytosanitary protection, taking into account technical and economic feasibility -- See footnote 3 -- AND MEMBERS' OBLIGATIONS AND RESPONSIBILITIES UNDER OTHER INTERNATIONAL AGREEMENTS -- SEE NEW FOOTNOTE 3a
7. In cases where relevant scientific evidence is insufficient, a Member may [provisionally] adopt sanitary or phytosanitary measures on the basis of available pertinent information, including that from the relevant international organizations as well as from sanitary or phytosanitary measures applied by other Members. [In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time.]
8. When a Member has reason to believe that a specific sanitary or phytosanitary measure introduced or maintained by another Member is constraining, or has the potential to constrain, its exports and the measure is not based on the relevant international standards, guidelines or recommendations, or such standards, guidelines or recommendations do not exist, an explanation of the reasons for such sanitary or phytosanitary measure may be requested and shall be provided by the Member maintaining the measure.

Article 6 Adaptation to Regional Conditions, Including Pest- or Disease-Free Areas and Areas of Low Pest or Disease Prevalence

1. Members shall ensure that their sanitary or phytosanitary measures are adapted to the sanitary or phytosanitary characteristics of the area - whether all of a country, part of a country, or all or parts of several countries - from which the product originated and to which the product is destined. In assessing the sanitary or phytosanitary characteristics of a region, Members shall take into account, inter alia, the level of prevalence of specific diseases or pests, the existence of eradication or control programmes, and appropriate criteria or guidelines which may be developed by the relevant international organizations.
2. Members shall, in particular, recognize the concepts of pest- or disease-free areas and areas of low pest or disease prevalence. Determination of such areas shall be based on factors such as geography, ecosystems, epidemiological surveillance, and the effectiveness of sanitary or phytosanitary controls.
3. Exporting Members claiming that areas within their territories are pest- or disease-free areas or areas of low pest or disease prevalence shall provide the necessary evidence thereof in order to objectively demonstrate to the importing Member that such areas are, and are likely to remain, pest- or disease-free areas or areas of low pest or disease prevalence, respectively. For this purpose, reasonable access shall be given, upon request, to the importing Member for inspection, testing and other relevant procedures.Article 7 Transparency
Members shall notify changes in their sanitary or phytosanitary measures and shall provide information on their sanitary or phytosanitary measures in accordance with the provisions of Annex B.

Article 8 Control, Inspection and Approval Procedures

Members shall observe the provisions of Annex C in the operation of control, inspection and approval procedures, including national systems for approving the use of additives or for establishing tolerances for contaminants in foods, beverages or feedstuffs, and otherwise ensure that their procedures are not inconsistent with the provisions of this Agreement.

Article 9 Technical Assistance

1. Members agree to facilitate the provision of technical assistance to other Members, especially developing country Members, either bilaterally or through the appropriate international organizations. Such assistance may be, inter alia, in the areas of processing technologies, research and infrastructure, including in the establishment of national regulatory bodies, and may take the form of advice, credits, donations and grants, including for the purpose of seeking technical expertise, training and equipment to allow such countries to adjust to, and comply with, sanitary

or phytosanitary measures necessary to achieve the appropriate level of sanitary or phytosanitary protection in their export markets.
2. Where substantial investments are required in order for an exporting developing country Member to fulfil the sanitary or phytosanitary requirements of an importing Member, the latter shall consider providing such technical assistance as will permit the developing country Member to maintain and expand its market access opportunities for the product involved.

Article 10 Special and Differential Treatment

1. In the preparation and application of sanitary or phytosanitary measures, Members shall take account of the special needs of developing country Members, and in particular of the least-developed country Members.
2. Where the appropriate level of sanitary or phytosanitary protection allows scope for the phased introduction of new sanitary or phytosanitary measures, longer time-frames for compliance should be accorded on products of interest to developing country Members so as to maintain opportunities for their exports.
3. With a view to ensuring that developing country Members are able to comply with the provisions of this Agreement, the Committee is enabled to grant to such countries, upon request, specified, time-limited exceptions in whole or in part from obligations under this Agreement, taking into account their financial, trade and development needs.
4. Members should encourage and facilitate the active participation of developing country Members in the relevant international organizations. Article 11 Consultations and Dispute Settlement
1. The provisions of Articles XXII and XXIII of GATT 1994 as elaborated and applied by the Dispute Settlement Understanding shall apply to consultations and the settlement of disputes under this Agreement, except as otherwise specifically provided herein.
2. In a dispute under this Agreement involving scientific or technical issues, a panel should seek advice from experts chosen by the panel in consultation with the parties to the dispute. To this end, the panel may, when it deems it appropriate, establish an advisory technical experts group, or consult the relevant international organizations, at the request of either party to the dispute or on its own initiative.
3. Nothing in this Agreement shall impair the rights of Members under other international agreements, including the right to resort to the good offices or dispute settlement mechanisms of other international organizations or established under any international agreement.

Article 12 Administration

1. A Committee on Sanitary and Phytosanitary Measures is hereby established to provide a regular forum for consultations. It shall carry out the functions necessary to implement the provisions of this Agreement and the furtherance of its objectives, in particular with respect to harmonization. The Committee shall reach its decisions by consensus.
2. The Committee shall encourage and facilitate ad hoc consultations or negotiations among Members on specific sanitary or phytosanitary issues. The Committee shall encourage the use of international standards, guidelines or recommendations by all Members and, in this regard, shall sponsor technical consultation and study with the objective of increasing coordination and integration between international and national systems and approaches for approving the use of food additives or for establishing tolerances for contaminants in foods, beverages or feedstuffs.
3. The Committee shall maintain close contact with the relevant international organizations in the field of sanitary and phytosanitary protection, especially with the Codex Alimentarius Commission, the International Office of Epizootics, [and] the Secretariat of the International Plant Protection Convention, THE UN CONVENTION ON THE LAW OF THE SEA, THE CONVENTION ON BIOLOGICAL DIVERSITY, AND THE INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE with the objective of securing the best available scientific and technical advice for the administration of this Agreement and in order to ensure that unnecessary duplication of effort is avoided.
4. The Committee shall develop a procedure to monitor the process of international harmonization and the use of international standards, guidelines or recommendations. For this purpose, the Committee should, in conjunction with the relevant international organizations, establish a list of international standards, guidelines or recommendations relating to sanitary or phytosanitary measures which the Committee determines to have a major

trade impact. The list should include an indication by Members of those international standards, guidelines or recommendations which they apply as conditions for import or on the basis of which imported products conforming to these standards can enjoy access to their markets. For those cases in which a Member does not apply an international standard, guideline or recommendation as a condition for import, the Member should provide an indication of the reason therefor, and, in particular, whether it considers that the standard is not stringent enough to provide the appropriate level of sanitary or phytosanitary protection. If a Member revises its position, following its indication of the use of a standard, guideline or recommendation as a condition for import, it should provide an explanation for its change and so inform the Secretariat as well as the relevant international organizations, unless such notification and explanation is given according to the procedures of Annex B.
5. In order to avoid unnecessary duplication, the Committee may decide, as appropriate, to use the information generated by the procedures, particularly for notification, which are in operation in the relevant international organizations.
6. The Committee may, on the basis of an initiative from one of the Members, through appropriate channels invite the relevant international organizations or their subsidiary bodies to examine specific matters with respect to a particular standard, guideline or recommendation, including the basis of explanations for non-use given according to paragraph 4.
7. The Committee shall review the operation and implementation of this Agreement three years after the date of entry into force of the WTO Agreement, and thereafter as the need arises. Where appropriate, the Committee may submit to the Council for Trade in Goods proposals to amend the text of this Agreement having regard, inter alia, to the experience gained in its implementation.

Article 13 Implementation

Members are fully responsible under this Agreement for the observance of all obligations set forth herein. Members shall formulate and implement positive measures and mechanisms in support of the observance of the provisions of this Agreement by other than central government bodies. Members shall take such reasonable measures as may be available to them to ensure that non-governmental entities within their territories, as well as regional bodies in which relevant entities within their territories are members, comply with the relevant provisions of this Agreement. In addition, Members shall not take measures which have the effect of, directly or indirectly, requiring or encouraging such regional or non-governmental entities, or local governmental bodies, to act in a manner inconsistent with the provisions of this Agreement. Members shall ensure that they rely on the services of non-governmental entities for implementing sanitary or phytosanitary measures only if these entities comply with the provisions of this Agreement.

Article 14 Final Provisions

The least-developed country Members may delay application of the provisions of this Agreement for a period of five years following the date of entry into force of the WTO Agreement with respect to their sanitary or phytosanitary measures affecting importation or imported products. Other developing country Members may delay application of the provisions of this Agreement, other than paragraph 8 of Article 5 and Article 7, for two years following the date of entry into force of the WTO Agreement with respect to their existing sanitary or phytosanitary measures affecting importation or imported products, where such application is prevented by a lack of technical expertise, technical infrastructure or resources.

ANNEX A DEFINITIONS See footnote 4

1. Sanitary or phytosanitary measure - Any measure applied:
(a) to protect animal or plant life or health within the territory of the Member from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms;
(b) to protect human or animal life or health within the territory of the Member from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs;
(c) to protect human life or health within the territory of the Member from risks arising from diseases carried by animals, plants or products thereof, or from the entry, establishment or spread of pests; or

(d) to prevent or limit other damage within the territory of the Member from the entry, establishment or spread of pests.

Sanitary or phytosanitary measures include all relevant laws, decrees, regulations, requirements and procedures including, inter alia, end product criteria; processes and production methods; testing, inspection, certification and approval procedures; quarantine treatments including relevant requirements associated with the transport of animals or plants, or with the materials necessary for their survival during transport; provisions on relevant statistical methods, sampling procedures and methods of risk assessment; and packaging and labelling requirements directly related to food safety.

2. Harmonization - The establishment, recognition and application of common sanitary and phytosanitary measures by different Members.

3. International standards, guidelines and recommendations

(a) for food safety, the standards [, guidelines and recommendations] established by the Codex Alimentarius Commission relating to food additives, veterinary drug and pesticide residues, contaminants, methods of analysis and sampling, and codes and guidelines of hygienic practice; PROVIDED THAT SUCH STANDARDS WERE ADOPTED BY A TWO-THIRDS MAJORITY;

(b) for animal health and zoonoses, the standards, guidelines and recommendations developed under the auspices of the International Office of Epizootics, THE UN CONVENTION ON THE LAW OF THE SEA, THE CONVENTION ON BIOLOGICAL DIVERSITY, OR THE INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE ;

(c) for plant health, the international standards, guidelines and recommendations developed under the auspices of the Secretariat of the International Plant Protection Convention in cooperation with regional organizations operating within the framework of the International Plant Protection Convention, THE UN CONVENTION ON THE LAW OF THE SEA, THE CONVENTION ON BIOLOGICAL DIVERSITY, OR THE INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE; and

(d) for matters not covered by the above organizations, appropriate standards, guidelines and recommendations promulgated by other relevant international organizations open for membership to all Members, as identified by the Committee.

4. Risk assessment - The evaluation of the likelihood of entry, establishment or spread of a pest or disease within the territory of an importing Member according to the sanitary or phytosanitary measures which might be applied, and of the associated potential biological and economic consequences; or the evaluation of the potential for adverse effects on human or animal health arising from the presence of additives, contaminants, toxins or disease-causing organisms in food, beverages or feedstuffs.

5. Appropriate level of sanitary or phytosanitary protection - The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

NOTE: Many Members otherwise refer to this concept as the "acceptable level of risk".

6. Pest- or disease-free area - An area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specific pest or disease does not occur.

NOTE: A pest- or disease-free area may surround, be surrounded by, or be adjacent to an area - whether within part of a country or in a geographic region which includes parts of or all of several countries -in which a specific pest or disease is known to occur but is subject to regional control measures such as the establishment of protection, surveillance and buffer zones which will confine or eradicate the pest or disease in question.

7. Area of low pest or disease prevalence - An area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specific pest or disease occurs at low levels and which is subject to effective surveillance, control or eradication measures.

8. SCIENTIFIC JUSTIFICATION OR SUFFICIENT SCIENTIFIC EVIDENCE - A JUSTIFICATION OR EVIDENCE SUPPORTED BY A WELL- CONSIDERED RISK OF HARM FROM PESTS AND DISEASES THAT MAY BE ASSOCIATED WITH THE PRODUCT, PACKING MATERIAL, TRADE ROUTE, OR TRANSPORT METHOD, EVEN IF SUBSTANTIAL UNCERTAINTY EXISTS REGARDING THE RISK.

9. "WELL-CONSIDERED RISK" - A RISK BASED ON ANALOGIES, HISTORICAL EXAMPLES, EXPERT OPINION, OR EVIDENCE OF GENERALIZED RISKS OF ENTRY OR ESTABLISHMENT OF PESTS OR DISEASES ASSOCIATED WITH A PRODUCT, PACKING MATERIAL, TRADE ROUTE, OR TRANSPORT

METHOD.

ANNEX B TRANSPARENCY OF SANITARY AND PHYTOSANITARY REGULATIONS

Publication of regulations

1. Members shall ensure that all sanitary and phytosanitary regulationsSee footnote 5 which have been adopted are published promptly in such a manner as to enable interested Members to become acquainted with them.
2. Except in urgent circumstances, Members shall allow a reasonable interval between the publication of a sanitary or phytosanitary regulation and its entry into force in order to allow time for producers in exporting Members, and particularly in developing country Members, to adapt their products and methods of production to the requirements of the importing Member.

Enquiry points

3. Each Member shall ensure that one enquiry point exists which is responsible for the provision of answers to all reasonable questions from interested Members as well as for the provision of relevant documents regarding:
(a) any sanitary or phytosanitary regulations adopted or proposed within its territory;
(b) any control and inspection procedures, production and quarantine treatment, pesticide tolerance and food additive approval procedures, which are operated within its territory;
(c) risk assessment procedures, factors taken into consideration, as well as the determination of the appropriate level of sanitary or phytosanitary protection;
(d) the membership and participation of the Member, or of relevant bodies within its territory, in international and regional sanitary and phytosanitary organizations and systems, as well as in bilateral and multilateral agreements and arrangements within the scope of this Agreement, and the texts of such agreements and arrangements.
4. Members shall ensure that where copies of documents are requested by interested Members, they are supplied at the same price (if any), apart from the cost of delivery, as to the nationalsSee footnote 6 of the Member concerned.

Notification procedures

5. Whenever an international standard, guideline or recommendation does not exist or the content of a proposed sanitary or phytosanitary regulation is not substantially the same as the content of an international standard, guideline or recommendation, and if the regulation may have a significant effect on trade of other Members, Members shall:
(a) publish a notice at an early stage in such a manner as to enable interested Members to become acquainted with the proposal to introduce a particular regulation;
(b) notify other Members, through the Secretariat, of the products to be covered by the regulation together with a brief indication of the objective and rationale of the proposed regulation. Such notifications shall take place at an early stage, when amendments can still be introduced and comments taken into account;
(c) provide upon request to other Members copies of the proposed regulation and, whenever possible, identify the parts which in substance deviate from international standards, guidelines or recommendations;
(d) without discrimination, allow reasonable time for other Members to make comments in writing, discuss these comments upon request, and take the comments and the results of the discussions into account.
6. However, where urgent problems of health protection arise or threaten to arise for a Member, that Member may omit such of the steps enumerated in paragraph 5 of this Annex as it finds necessary, provided that the Member:
(a) immediately notifies other Members, through the Secretariat, of the particular regulation and the products covered, with a brief indication of the objective and the rationale of the regulation, including the nature of the urgent problem(s);
(b) provides, upon request, copies of the regulation to other Members;
(c) allows other Members to make comments in writing, discusses these comments upon request, and takes the comments and the results of the discussions into account.
7. Notifications to the Secretariat shall be in English, French or Spanish.

8. Developed country Members shall, if requested by other Members, provide copies of the documents or, in case of voluminous documents, summaries of the documents covered by a specific notification in English, French or Spanish.
9. The Secretariat shall promptly circulate copies of the notification to all Members and interested international organizations and draw the attention of developing country Members to any notifications relating to products of

particular interest to them.
10. Members shall designate a single central government authority as responsible for the implementation, on the national level, of the provisions concerning notification procedures according to paragraphs 5, 6, 7 and 8 of this Annex.
General reservations
11. Nothing in this Agreement shall be construed as requiring:
(a) the provision of particulars or copies of drafts or the publication of texts other than in the language of the Member except as stated in paragraph 8 of this Annex; or
(b) Members to disclose confidential information which would impede enforcement of sanitary or phytosanitary legislation or which would prejudice the legitimate commercial interests of particular enterprises.

ANNEX C   CONTROL, INSPECTION AND APPROVAL PROCEDURES See footnote 7

1. Members shall ensure, with respect to any procedure to check and ensure the fulfilment of sanitary or phytosanitary measures, that:
(a) such procedures are undertaken and completed without undue delay and in no less favourable manner for imported products than for like domestic products;
(b) the standard processing period of each procedure is published or that the anticipated processing period is communicated to the applicant upon request; when receiving an application, the competent body promptly examines the completeness of the documentation and informs the applicant in a precise and complete manner of all deficiencies; the competent body transmits as soon as possible the results of the procedure in a precise and complete manner to the applicant so that corrective action may be taken if necessary; even when the application has deficiencies, the competent body proceeds as far as practicable with the procedure if the applicant so requests; and that upon request, the applicant is informed of the stage of the procedure, with any delay being explained;
(c) information requirements are limited to what is necessary for appropriate control, inspection and approval procedures, including for approval of the use of additives or for the establishment of tolerances for contaminants in food, beverages or feedstuffs;
(d) the confidentiality of information about imported products arising from or supplied in connection with control, inspection and approval is respected in a way no less favourable than for domestic products and in such a manner that legitimate commercial interests are protected;
(e) any requirements for control, inspection and approval of individual specimens of a product are limited to what is reasonable and necessary;
(f) any fees imposed for the procedures on imported products are equitable in relation to any fees charged on like domestic products or products originating in any other Member and should be no higher than the actual cost of the service;
(g) the same criteria should be used in the siting of facilities used in the procedures and the selection of samples of imported products as for domestic products so as to minimize the inconvenience to applicants, importers, exporters or their agents;
(h) whenever specifications of a product are changed subsequent to its control and inspection in light of the applicable regulations, the procedure for the modified product is limited to what is necessary to determine whether adequate confidence exists that the product still meets the regulations concerned; and
(i) a procedure exists to review complaints concerning the operation of such procedures and to take corrective action when a complaint is justified.
Where an importing Member operates a system for the approval of the use of food additives or for the establishment of tolerances for contaminants in food, beverages or feedstuffs which prohibits or restricts access to its domestic markets for products based on the absence of an approval, the importing Member shall consider the use of a relevant international standard as the basis for access until a final determination is made.
2. Where a sanitary or phytosanitary measure specifies control at the level of production, the Member in whose territory the production takes place shall provide the necessary assistance to facilitate such control and the work of the controlling authorities.
3. Nothing in this Agreement shall prevent Members from carrying out reasonable inspection within their own territories.

Footnote: 1 In this Agreement, reference to Article XX(b) includes also the chapeau of that Article.

Footnote: 2 For the purposes of paragraph 3 of Article 3, there is a scientific justification if, on the basis of an examination and evaluation of available scientific information in conformity with the relevant provisions of this Agreement, a Member determines that the relevant international standards, guidelines or recommendations are not sufficient to achieve its appropriate level of sanitary or phytosanitary protection.

Footnote: 3 For purposes of paragraph 6 of Article 5, a measure is not more trade-restrictive than required unless there is another measure, reasonably available taking into account technical and economic feasibility, that achieves the appropriate level of sanitary or phytosanitary protection and is significantly less restrictive to trade.

FOOTNOTE 3a: FOR EXAMPLE, THE MONTREAL PROTOCOL ON OZONE-DEPLETING SUBSTANCES, PARTICULARLY PHASING OUT THE USE OF METHYL BROMIDE

Footnote: 4 For the purpose of these definitions, "animal" includes fish and wild fauna; "plant" includes forests and wild flora; "pests" include weeds; and "contaminants" include pesticide and veterinary drug residues and extraneous matter.
Footnote: 5 Sanitary and phytosanitary measures such as laws, decrees or ordinances which are applicable generally. Footnote: 6 When "nationals" are referred to in this Agreement, the term shall be deemed, in the case of a separate customs territory Member of the WTO, to mean persons, natural or legal, who are domiciled or who have a real and effective industrial or commercial establishment in that customs territory.
Footnote: 7 Control, inspection and approval procedures include, inter alia, procedures for sampling, testing and certification.

Literature Cited

Allen, D. and T.W. Bowersox. 1989. Regeneration in oak stands following gypsy moth defoliations. In Proc. 7th Central Hardwood Conf., G. Rink and C.A. Budelsky, eds., Gen. Tech. Rep. NC-132. United States Department of Agriculture Forest Service, North Central Experiment Station. Pp. 67-73.

Alsop, F. J., III, and T. F. Laughlin. 1991. Changes in the spruce-fir avifaunaof Mt. Guyot, Tennessee, 1967-1985. J. Tenn. Acad. Sci. 66: 207-209.

Anagnostakis, S. L. 2001a. The effect of multiple importations of pests and pathogens on a native tree. Biol. Invasions 3: 245-254.

Anagnostakis, S. L. 2001b. American chestnut sprout survival with biological control of the chestnut blight fungus population. For. Ecol. Managem. 152: 225-233.

Anderson, R.L., P. Berrang, J. Knighten, K.A. Lawton, and K.O. Britten. 1993. Pretreating dogwood seedlings with simulated acidic precipitation increases dogwood anthracnose symptoms in greenhouse-laboratory trials. Can. J. For. Res. 23: 55-58.

Anderson, R.L. and L.A. LaMadeleine. 1978. The distribution of butternut decline in the eastern United States. United States Department of Agriculture, Forest Service, NE Area, State and Private Forestry Report S-3-78. 4 pp.

Annand, P.N. 1924. A new species of *Adelges* (Hemiptera, Phylloxeridae). Pan-Pac. Entomol. 1: 79-82.

Annand, P.N. 1928. A Contribution toward a monograph of the Adelginae (Phylloxeridae) of North America. Stanford Univ. Press, Palo Alto, Calif. 146 pages.

Baker, W.L. 1941. Effect of gypsy moth defoliation on certain forest trees. J. For. 39: 1017-1022.

Balch, R.E., J. Clark and J.M. Bonga. 1964. Hormonal action in production of tumors and compression wood by an aphid. Nature 202: 721-722.

Bartram, J. 1751. Observations on the inhabitants, climate, soil, rivers, productions, animals, and other matters worthy of notice made by Mr. John Bartram in his travels from Pensilvania to Onodago, Oswego and Lake Ontario, in Canada. To which is annex'd, a curious account of the cataracts at Niagara by Mr. Peter Kalm, a Swedish gentleman who travelled there. J. Whiston and B. White, London. 94 pp. Reprinted in the March of America Facsimile Series, No. 41 as Travels in Pensilvania and Canada by John Bartram, Ann Arbor University Microfilms, Inc..

Berg, S. American Forest Paper Association. At the United States Department of Agriculture Animal and Plant Health Inspection Service public hearings on Interim Rule requiring China to Treat Solid Wood Packing Material, October 16, 1998. Washington, D.C.

Berven, L.F. Director of Corporate Compliance and Special Projects, Global Transportation Services, Inc. re: Docket No. 98-057-1 to USDA APHIS, March 19, 1999.

Bingham, R.T. 1983. Blister rust resistant western white pine for the Inland Empire: the story of the first 25 years of the research and development program. USDA Forest Service General Technical Report INT-146. 45 pages.

Botkin, D. Ecological Risk Issues Associated with Forest Biotechnology. Biotech Branches Out: A Look at the OPportunities and Impacts of Forest Biotechnology. The Pew Initiative on Food and Biotechnology. December 4 - 5, 2001. Atlanta, GA.

Brasier, C.M. 2001. Rapid Evolution of Introduced Plant Pathogens via Interspecific Hybridization. Bioscience Vol. 51 No. 2 February 2001

Bright, C. 1998. Life Out of Bounds. Bioinvasion in a Borderless World. 1998. New York. W.W. Norton 288 pp.

Britton, K.O. 1993. Anthracnose infection of dogwood seedlings exposed to natural inoculum in western North Carolina. Plant Dis. 77: 34-37.

Brooks, R. T. 2001. Effects of the removal of overstory hemlock from hemlock-dominated forests on eastern redback salamanders. For. Ecol. Managem. 149: 197-204.

Burnham, D. R., P. A. Rutter, and D. W. French. 1986. Breeding blight-resistant chestnuts. Plant Breed. Rev. 4: 347-397.

Cammermeyer, J. 1993. Life's a beech - & then you die. Am. Forests July/August 1993, Pp. 20-21, 46.

Campbell, E. M., and J. A. Antos. 2000. Distribution and severity of white pine blister rust and mountain pine beetle on whitebark pine in British Columbia. Can. J. For. Res. 30: 1051-1059.

Campbell, F.T. and S.E. Schlarbaum. 1994. Fading forests: North American trees and the threat of exotic pests. Natural Resources Defense Council report. 47 pp.

Campbell, F.T. 2001. The Science of Risk Assessment for Phytosanitary Regulation and the Impact of Changing Trade Regulations. Bioscience February 2001

Carlton, J.T. and G.M. Ruiz. 2002. Principles of Vector Science and Integrated Vector Management. In H. Mooney *et al*., Editors, Best Practices for the Prevention and Management of Alien Invasive Species. Island Press.

Choi, G. H. and D. L. Nuss. 1992. Hypovirulence of chestnut blight fungus conferred by an infectious viral cDNA. Science 257: 800-803.

Ciesla, W. 1988. Pine bark beetles: a new pest management challenge for Chilean foresters. J. For. 86: 27-31.

Ciesla, W. 1993. Recent introductions of forest insects and their effects: a global overview. FAO Plant Prot. Bull. 41: 3-13.

Clinton, G. P. 1912. Chestnut bark disease. Report of the Station Botanist, 1911-1912. Ann. Rep. Connecticut Ag. Exp. Stn., New Haven, Connecticut, pp. 407-413.

Carroll, G.C. 1998. Letter to Dan Glickman, Secretary of Agriculture on behalf of the Mycological Society of America,. December 11, 1998.

Corbett, E.S. and J.A. Lynch. 1987. The gypsy moth - does it affect soil and water resources? In S. Fosbroke and R.R. Hicks Jr. (eds.). Coping with the gypsy moth in the new frontier. W. Va. Univ. Books, Morgantown, WV, pp. 39-46.

Corn, M.L., E.H. Buck, J. Rawson, and E. Fischer. 1999. Harmful Non-Native Species: Issues for Congress. Congressional Research Service. September 1999. Order Code RL30123.

Cox, G.W. 1999. Alien species in North America and Hawaii Impacts on Natural Ecosystems. Island Press, Washington, D.C.

Daughtery, M. L., and C. R. Hibben. 1994. Dogwood anthracnose - a new disease threatens 2 native *Cornus* species. Ann. Rev. Phytopath. 32: 61-73.

Dawson, J.L.M., J.D. Bell, E.A. Allen, and L.M. Humble. 1997. Exotic insect interceptions from wooden dunnage and packing material. Presented at the North American Plant Protection Organization, November 1997.

Dedmon, J. National Wood Pallet and Container Association. At United States Department of Agriculture Animal and Plant Health Inspection Service public hearings on Interim Rule requiring China to Treat Solid Wood Packing Material, October 16, 1998. Washington, D.C.

Denton, R.E. 1979. Larch casebearer in western larch forest. United States Department of Agriculture, For. Serv. Gen. Tech. Rep. INT-55. 62 pages.

Devine, R. 1998. Alien Invasion. National Geographic Society. Washington, D.C.

Devine, R. 2002. Mighty Oaks in Trouble. Defenders Summer 2002

Dwinell, L.D. and P. Lehman. Exotic Plant Parasitic Nematodes. In Press. In K. Britton, Biopollution: An Emerging Global Menace.

Elmer, W. H. 2001. Seeds as vehicles for pathogen importation. Biological Invasions 3:263-271, 2001.

Fuester, R. W., M. Kenis, K. S. Swan, P. C. Kingsley, C. Lopez-Vaamonde, and F. Herard. 2001. Host range of *Aphantorhaphopsis samarensis* (Dipetera:Tachinidae), a larval parasite of the gypsy moth (Lepidoptera:Lymantriidae). Environ. Entomol. 30: 605-611.

Garrett, P.W. 1986. Role of tree improvement in providing pest-resistant eastern white pine (*Pinus strobus* L.). In Eastern White Pine: Today and Tomorrow Symp. Proc., U.S. Dep. Ag. For. Serv. Gen Tech. Rep. WO-51, pp. 75-88.

Garner, K. J. and J. M. Slavicek. 1996. Identification and characterization of a RAPID-PCR marker for distinguishing Asian and North American gypsy moths. Insect Mol. Biol. 5: 81-91.

Gordon, T. 2002. Pitch canker: testing the ecological limits in California. Presented at Invasive Species Symposium U.C. Davis, June 18 - 19, 2002

Gottschalk, K.W. 1993. Silvicultural guidelines for forest stands threatened by the gypsy moth. United States Department of Agriculture, Forest Service General Technical Report NE-171. 50 pages.

Gries, G., P. W. Schaefer, R. Gries, J. Liska, and T. Gotoh. 2001. Reproductive character displacement in *Lymantria monacha* from northern Japan. J. Chem.. Ecol. 27: 1163-1176.

Griffin, G. J. 2000. Blight control and restoration of the American chestnut. J. For. 98: 22-27.

Haack, R. 2002. Intercepted Bark Beetles (Scolytidae) at US Ports of Entry: 1985 - 2000. Presented at the 13th U.S. Department of Agriculture Interagency Research Forum on Gypsy Moth and Other Invasive Species, January 2002.

Haack R. A. and J.F. Cavey. 1997. Insects Intercepted on Wood Articles at United States Ports-of-Entry and Two Recent Introductions: *Anoplophora glabripennis* and *Tomicus piniperda*. In press in International forest insect workshop proceedings, 18 - 21 August 1997, Pucon, Chile. Corporacion National Forestal, Santiago, Chile.

Haack, R.A., T.R. Petrice, E.R. Hoebeke, and T.M. Poland. 2002. *Hylurgus ligniperda* (Scolytidae): A New Exotic Bark Beetle in New York State. Presented at the 13th U.S. Department of Agriculture Interagency Research Forum on Gypsy Moth and Other Invasive Species, January 2002.

Haleamau, M. Chief, Pest Exclusion Branch, Plant Health and Pest Prevent Services, California Department of Food and Agriculture; letter to Chief, Regulatory Analysis and Development, APHIS, July 30, 1998.

Hawbolt, L.S. 1944. History of spread of beech scale, *Cryptococcus fagi* (Baerensprung), an insect introduced to the Maritime provinces. Acadian Nat. 1: 137-146.

Hay, R.L. 1978. Fraser fir in the Great Smoky Mountains National Park: Its demise by the balsam woolly aphid (*Adelges piceae* Artz.). Department of Forestry, Wildlife, and Fisheries, The University of Tennessee, Knoxville. 125 pages.

Hepting, G. 1971. Disease of forest and shade trees of the United States. United States Department of Agriculture, Forest Service Agricultural Handbook No. 386. 658 pages.

Herrick, O.W. and D.A. Gansner. 1987. Gypsy moth on a new frontier: forest tree defoliation and mortality. Northern J. APpl. For. 4: 128-133.

Hicks, R. R., Jr., 1997. A resource at the crossroads: a history of the central hardwoods. Proc. 11th Central Hardwood For. Conf., pp. 1-22.

Hilburn, D.J. Oregon Department of Agriculture. 1998. Letter to Gary Carpenter, Jim Reynolds, Jane Levy, USDA APHIS, September 14, 1998.

Hilburn, D.J. Memo to Invasive Species Network. July 5, 2002.

Hilburn, D.J., K.J.R. Johnson, J. Griesbach. Oregon Department of Agriculture. Letter to Jack P. Edmundson, Environmental Protection Officer, APHIS. February 9, 1998.

Hirt, R.R. 1948. Evidence of resistance to blister rust by eastern white pine growing in the Northeast. J. For. 46: 911-913.

Hoff, R. and S. Hagle. 1989. Diseases of whitebark pine with special emphasis on white pine blister rust. In Proceedings - Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource. Bozeman, MT. March 29-31, 1989. Schmidt, W.C., and K.J. McDonald, Compilers. Pp. 179-190.

Hough, Franklin B. 1878. Report upon forestry. Washington, Government Printing Office. 650 pp.

Houston, D. R., and D. B. Houston. 2000. Allozyme genetic diversity among *Fagus grandifolia* trees resistant or susceptible to beech bark disease in natural populations. Can. J. For. Res. 30: 779-789.

Houston, D.R. and H.T. Valentine. 1988. Beech bark disease: the temporal patterns of cankering in aftermath forests of Maine. Can. J. For. Res. 18: 38-42.

Hobgood, J., J. Moody, W.S. Wood, P.C. Witherell. 1997. Test of methyl bromide fumigation of wood chips. USDA, APHIS, PPQ, Oxford [NC] Plant Protection Center. Accomplishment Report for Fiscal Year 1997, Project AQI-Ie, pp. 17-18.

Hofacker, T.H. 1993. United States Department of Agriculture, Forest Service Staff Entomologist. Memorandum of meeting on May 28, 1993 (undated).

???Hofacker, T.H. USDA Forest Service. pers. comm. May 1999

Howard, J. 2001. U.S. Timber Production, Trade, Consumption, and Price Statistics 1965 - 1999. USDA Forest Service. Forest Products Laboratory. Research Paper FPL-RP-595 April 2001

Howard, L. O. 1898. Danger of importing insect pests. 1898. In Yearbook of the United States Department of Agriculture. 1897. G. M. Hill, Editor. Government Printing Office, Washington. Pp. 529-552.

Humble, L. M. 1994. Recovery of additional exotic predators of balsam woolly adelgid, *Adelges piceae* (Ratzeburg) (Homoptera:Adelgidae), in British Columbia. Can. Entomol. 126: 1101-1103.

Hunt, R. S. 2002. Relationship between early family-selection traits and natural blister rust cankering in western white pine families. Can. J. Plant Path. 24: 200-204.

Jenkins, J. C., J. D. Aber, and C. D. Canham. 1999. Hemlock woolly adelgid impacts on community structure and N cycling rates in eastern hemlock forests. Can. J. For. Res. 29: 630-645.

Jenkins, P.T. 2002. Who should pay? A proposal for legislation to aPply the Polluter Pays Principle to biological pollution through a fee-based Invasive Species Prevention, Quarantine and Control Trust Fund. International Center for Technology Assessment. Washington, DC

Johnson, K.D. 1980. Fraser fir and woolly balsam adelgid: a summary of information. Southern APpalachian Research/Resource Management Cooperative, Western Carolina University, Cullowhee, North Carolina. 62 pages.

Karnosky, D. F. 1979. Dutch elm disease: a review of the history, environmental implications, control, and research needs. Environmental Conservation 6, no. 4.

Kartesz, J.T. 1999. A Synonimized Checklist and Atlas with Biological Attributes for the Vascular Flora of the United States, Canada, and Greenland. First Edition. In: Kartesz, J.T. and C.A. Meacham, Synthesis of the North American Flora, Version 1.0, North Carolina Botanical Garden, Chapel Hill.

Kendall, K.C. and S.F. Arno. 1989. Whitebark pine - an important but endangered wildlife species. In Proceedings - Symposium on Whitebark Pine Ecosystem: Ecology and Management of a High-Mountain Resource. Bozeman, Mt. March 29-31, 1989. Schmidt, W.C. and K.J. McDonald, Compilers. Pp. 264-273.

Kenney, M. and S.J. Bagenski, USDA APHIS The role of USDA Animal and Plant Health Inspection Service (APHIS) Plant Pathologistgs in protecting American agriculture and the environment from exotic diseases. Poster for Annual Meeting, Mycological Society of America 1998.

Ketcham, D.E., C.A. Wallner, and S.S. Evans, Jr. 1968. Western white pine management programs realigned on northern Rocky Mountain National Forests. J. Forestry 6: 329-332.

Kucera, D.R. 1992. New introduction, Common pine shoot beetle. Pest Alert, United States Department of Agriculture, Forest Service, Northeastern Area, NA-PR-??-92.

Kucera, D. Pest Risk Assessment, Asian Long-horned Beetle. October 1996.

Kuhlman, E.G. 1978. The devastation of American chestnut by blight. In Proc. Am. Chestnut Symp., W. L. MacDonald, F. C. Cech, J. Luchok, and H. C. Smith, eds., West Virginia Univ. Books, Morgantown, pp. 1-3.

La Fage, J.P. and L.H. Williams. 1979. Movement of Wood-Boring Insects in International Trade: A Summary of Interception Records in the United States 1968 - 1978 prepared for IUFRO S.5.03 Wood Preservation Meeting Wood Preservation in Tropical Countries Guaruja, SP, Brazil

LaGasa, E., M.M. Furniss, and H. Kamping. 1997. Washington State Department of Agriculture Lab Services Division 1996 Entomology Project Report. March 13, 1997.

Lanfranco, D., and H. S. Dungey. 2001. Insect damage in Eucalyptus: a review of plantations in Chile. Austral Eco. 26: 477-481.

Ledig, F.T. 1992. Human Impacts on Genetic Diversity in forest Ecosystems. Oikos 63: 87-108. Copenhagen 1992.

Liebhold, A. M., W. L. MacDonald, D. Bergdahl, and V. C. Mastro. 1995. Invasion by exotic forest pests: a threat to forest ecosystems. Forest Sci., Monograph 30. 49 pp.

Lu, W. H., and M. E. Montgomery. 2001. Oviposition, development, and feeding of *Scymnus* (*Neopullus*) *sinuanodulus* (Coleoptera:Coccinellidae): a predator of *Adelges tsugae* (Homoptera:Adelgidae). Ann. Entomol. Soc. Amer. 94: 64-70.

MacDonald, W. L. and D. W. Fulbright. 1991. Biological control of chestnut blight: use and limitations of transmissible hypovirulence. Plant Dis. 75: 656-661.

Mahony, E. M., M. G. Milgroom, and W. A. Sinclair. 1999. Origin, genetic diversity and population structure of *Nectria coccinea* var. *faginata* in North America. Mycologia 91: 583-592.

Marsh, George Perkins. 1864. Man and nature. Physical geography as modified by human action. Charles Scribner, New York. 472 pp.

Mattson, W. J., P. Niemela, I. Millers, and Y. Ingauazo. 1994. Immigrant phytophagous insects on woody plants in the United States and Canada: an annotated list. USDA For. Ser. Gen. Tech. Rep. NC-169, 27 pp.

McClure, M. S. 1995. *Diapterobates humeralis* (Oribatida: Ceratozetidae) - an effective control agent of hemlock woolly adegid (Homoptera: Adelgidae) in Japan. Environ. Entomol. 24: 1207-1215.

McCullough, D. G., and D. L. Roberts. 2002a. Manuscript Draft for USDA Pest Alert on the emerald ash borer.

McCullough, D. G., and D. L. Roberts. 2002b. Emerald ash borer. Pest Alert. USDA Forest Service, Northeastern Area, State and Private Forestry, 2 pp. www.na.fs.fed.us/spfo/eab/pubs/emeraldashborer.pdf

Mendel, A., and J. Halperin. 1982. The biology and behavior of *Orthotomicus erosus* in Israel. Phytoparasitica 10: 169-181.

Merkel, H. W. 1905. A deadly fungus on the American chestnut. New York Zool. Soc., 10th Ann. Rep., pp. 97-103.

Metcalf, H. And J. F. Collins. 1909. The present status of the chestnut bark disease. U. S. Dept. Ag. Bull. 141, part 5, pp. 45-53.

Mielke, J.L. 1938. Spread of blister rust to sugar pine in Oregon and California. J. For. 36: 695-701.

Miller, M.L. 2000. The Paradox of United States Alien Species Law. IUCN (World Conservaiton Union) Country Report, March 15, 2000.

Millikan, D.F. and S.J. Stefan. 1989. Current status of the butternut, *Juglans cinera* L. Ann. Rep. North. Nut Growers Assoc. 80: 52-54.

Mitchell, R. G. and P. E. Buffam. 2001. Patterns of long-term balsam woolly adelgid infestations and effects in Oregon and Washington. West. J. APpl. For. 16: 121-126.

Mitchell, W., P. Gibbs, and C. Martin. 1988. Flowering dogwood (*Cornus florida*): Section 7.5.9., U.S. Army Corps of Engineers Wildlife Resource Management Manual, Tech. Report EL-88-9, U.S. Army Engineer Waterways Exp. Sta., Vicksburg, MS. 25 pages.

Millsap, R. 2002. New pest killing ash trees in southeast Michigan. MSUToday, July 17, 2002. (www.msutoday.mus.edu/research/index.php3?article-17July2002-1)

Morewood, P., G. Gries, J. Liska, P. Kapitola, D. Haussler, K. Moller, and H. Bogenschutz. 2000. Towards pheromone-based montioring of nun moth, *Lymantria monacha* (L.) (Lep., Lymantriidae) populations. J. APpl. Entomol. 124: 77-85.

Murakami, Y., N. Ohkubo, S. Moriya, Y. Gyoutoku, C. H. Kim, and J. K. Kim. 1995. Parasitoids of *Dryocosmus kuriphilus* (Hymenoptera:Cynipidae) in South Korea with particular reference to ecologically different types of *Torymus* (*Syntomaspis*) *sinensis* (Hymenoptera:Torymidae). APpl. Entomol. Zool. 30: 277-284.

Mooney, H.A. and R.J. Hobbs. 2000. Invasive Species in a Changing World. Island Press, Washington, D.C.

National Academy of Sciences. 1975. Forest Pest Control. Washington, D. C.

National Academy of Sciences. 2002a (Mack, R.N., S.C.H. Barrett, P.L. Defur, W.L. MacDonald, L.V. Madden, D.S. Marshall, D.G. McCullogh, P.B .McEvoy, M.P. Nyrop, S.E.H. Reichard, K.J. Rice, S.A. Tolin) Predicting Invasions of Nonindigenous Plants and Plant Pests. National Academy of Sciences. Washington, D.C. 2002

National Academy of Sciences 2002b.(Cubbage, F.W., P.J. Brown, T.R. Crow, J.C. Gordon, R.B. McCullough, R.R. Sederoff) National Capacity in Forestry Research. National Academy of Sciences. Washington, D.C. 2002

National Plant Board. 1999. Safeguarding American Plant Resources: A Stakeholder Review of the APHIS-PPQ Safeguarding System. July 1, 1999.

National Plant Board. 2002. Preventing the Introduction of Plant Pathogens into the United States: The Role and Application of the "Systems Approach" A scientific review coordinated by The National Plant Board for The United States Department of Agriculture Animal and Plant Health Inspection Service Plant Protection and Quarantine February 2002

Neuenschwander, L. F., J. W. Byler, A. E. Harvey, G. I. McDonald, D. S. Ortiz, H. L. Osborne, G. C. Snyder, and A. Zack. 1999. White pine in the American West: a vanishing species - can we save it? USDA Forest Service Gen. Tech. Rep. RMRS-GTR-35, 21 pp.

Niemela P. and W.J. Mattson. 1996. Invasion of North American Forests by European Phytophagous Insects. Bioscience Vol. 46 No. 10 (November 1996), pp. 741-753).

Nowak, D.J., J.E. Pasek, R.A. Sequeira, D.E. Crane, V.C. Mastro. 2001. Potential Effect of *Anoplophora glabripennis* (Coleoptera: Cermabycidae) on Urban Trees in the United States. Forest Entomology. February 2001.

Oliver, C., D. Adams, T. Bonnicksen, J. Bowyer, F. Cubbage, N. Sampson, S. Schlarbaum, R. Whaley, and H. Wiant. 1997. Report on forest health of the United States. University of Washington, Center Intl. Trade Forest Prod. #43.

Ostrofsky, W.D., R.G. Pratt, and L.F. Roth. 1977. Detection of *Phytophthora lateralis* in soil organic matter and factors that affect its survival. Phytopathology 67: 79-84.

Ontario's Forests, Forest Health. 2000. Questions and answers about the brown spruce longwhorned beetle - *Tetropium fuscum* (Fabr.). July 6, 2000. www.mnr.gov.on.ca/MNR/forests/foresthealth/brown%20spruce/longhorn beetle.htm

Orwig, D. A., and D. R. Foster. 1998. Forest response to the introduced hemlock woolly adelgid in southern New England, USA. J. Torrey Bot. Soc. 125: 60-73.

Ostry, M. E., M. E., Mielke, and D. D. Skilling. 1994. Butternut - strategy for managing a threatened tree. USDA For. Ser. Gen. Tech. Rep. NC-165. 7 pp.

Ostry, M. E., M. E. Mielke, and R. L. Anderson. 1996. How to identify butternut canker and manage butternut trees. USDA For. Ser., North Central Exp. Stn., Northeast. Area State and Private Forestry, and Region 8, State and Private Forestry, HT-70.

Otvos, I.S. and F.W. Quednau. 1984. *Coleophora laricella* (Hubner), Larch Casebearer (Lepidoptera: Coleophoridae). In J.S. Kelleher and M.A. Hulme (eds.). Biological Control Programmes against Insects and Weeds in Canada 1969-1980, Commonwealth Agricultural Bureaux, England, 1984.

Payne, J.A., A.S. Menke, and P.M. Schroeder. 1975. *Dryocosmus kuriphilus* Yasumatsu, (Hymenoptera: Cynipidae), an oriental chestnut gall wasp in North America. U. S. Dept. Agr. Coop. Econ. Insect Report 25(49-52): 903-905.

Pelton, M.L. University of Tennessee, Department of Forestry, Wildlife and Fisheries. Personal communication to S.E. Schlarbaum.

Peters, R.A. Director, Educational and Information Resources, National Wooden Pallet and Container Association, letter to Mr. Orr re: Docket No. 98-057-1, March 22, 1999.

Pimentel, D., L. Lach, R. Zuniga, D. Morrison. 2000. Environmental and Economic Costs Associated with Non-Indigenous Species in the United States. Bioscience Vol. 5 No. 1 (January 2000).

Powell, C.C., R.K. Lindquist, R.K. Horst. 1984. A Study of Pest and Disease Risks Associated with the Importation of Potted Ornamental Plants into the United States. With Special Reference to Proposed Regulatory Changes in the Code of Federal Regulations, Title 7, Ag., Part 319.37-8. May 30, 1984.

Prey, F.J. and J.E. Kuntz. 1982. The distribution and impact of butternut canker. In Black walnut for the future. USDA For. Serv. Gen Tech. Rep. NC-74. Pp. 23-26.

Rabenold, K. N., P. T. Fauth, B. W. Goodner, J. A. Sadowski, and P. G. Parker. 1998. Response of avian communities to disturbance by an exotic insect in spruce-fir forests of the southern APpalachians. Conservat. Biol. 12: 177-189.

Reinhart, D. P., M. A. Haroldson, D. J. Mattson, and K. A. Gunther. 2001. Effects of exotic species on Yellowstone's grizzly bears. Western N. Amer. Naturalist 61: 277-288.

Renlund, D.W. (ed.). 1971. Forest pest conditions in Wisconsin. Wis. Dept. Nat. Res. Ann. Rep. 53 pages.

Rizzo, D. Sudden Oak Death. Presented at the 13th USDA Interagency Research Forum on Gypsy Moth and Other Invasive Species, January 15 - 18, 2002. Annapolis, MD.

Robin, C., F. Dupuis, and M. L. Desprezloustau. 1994. Seasonal changes in northern red oak susceptibility to *Phytophthora cinamomi*. Plant Dis. 78: 369-374.

Robin, C., M. L. Desprez-Loustau, G. Capron, and C. Delaour. 1998. First record of *Phytophthora cinnamomi* on cork and holm oaks in France and evidence of pathogenicity. Ann. Sci. Forest. 55: 869-883.

Rossell, I. M., C. R. Rossell, K. J. Hining, and R. L. Anderson. 2001. Impacts of dogwood anthracnose (*Discula destructiva* Redlin) on the fruits of flowering dogwood (*Cornus florida* L.): implications for wildlife. Amer. Midland Naturalist 146: 379-387.

Roth, L.F., R.D. Harvey, Jr., and J.T. Kliejunas. 1987. Port-Orford-Cedar Root Disease, United States Department of Agriculture, Forest Service, R6 FPM-PR-294-87, 1987.

Ryan, R. B. 1997. Before and efter evaluation of biological control of the larch casebearer (Lepidoptera: Coleophoridae) in the Blue Mountains of Oregon and Washington, 1912-1995. Environ. Entomol. 26: 703-715.

Sato, K. 1975. A list of bark beetles and pin-hole borers imported into Japan with timbers from abroad. Res. Bull. Plnat Prot. Ser. Japan 12: 2-67.

Schlarbaum, S. E., F. Hebard, P. C. Spaine and J. C. Kamalay. 1997. Three American tragedies: chestnut blight, butternut canker, and Dutch elm disease. Proc. Exotic Pest of Eastern Forests, April 8-10, 1997, Nashville, TN, pp. 45-54.

Schlarbaum, S.E., R.L. Anderson, and F.T. Campbell. 1999. Exotic pests: insects, pathogens and plants. In Ecosystem Management for Sustainability: Principles and Practices Illustrated by a Regional Biosphere Cooperative. J. Peine, ed., St. Lucie Press, St Louis. Pp.291-306.

Schmidt, W.C. 1992. Effects of White Pine Blister Rust on Western Wilderness. In Society of American Foresters 1992 Annual Meeting, Proceedings. SAF Publication 92-01.

Schmitz, D.C. and D. Simberloff. 2001. Needed; A Natiional Center for Biological Invasions. Issues in Science and Technology online. Summer 2001.

Schooley, H.O., Harris, J.W.E., and Pendrel, B. 1984. *Adelges piceae* (Ratz.), Balsam Woolly Adelgid (Homoptera: Adelgidae). In J.S. Kelleher and M.A. Hulme (eds.). Biological Control Programmes against Insects and Weeds in Canada 1969-1980, Commonwealth Agricultural Bureaux, England, 1984.

Sherald, J. L., F. S. Santamour, R. K. Hajela, N. Hajela, and M. B. Sticklen. 1994. A dutch elm disease resistant triploid elm. Can. J. For. Res. 24: 647-653.

Shigo, A.L. 1964. Organism interactions in the beech bark disease. Phytopathology 54: 263-269.

Smalley, E. B., and R. P. Guries. 1993. Breeding elms for resistance to Dutch elm disease. Ann. Rev. Phytopath. 31: 325-352.

Smith, G., and J. E. Hurley. 2000. First North American record of the Palearctic species *Tetropium fuscum* (Fabricius) (Colepotera:Cerambycidae). Coleopterists Bull. 54: 540.

Smith, G. F., and N. S. Nicholas. 2000. Size- and age-class distributions of Fraser fir following balsam woolly adelgid infestation. Can. J. For. Res. 30: 948-957.

Smith, J. P., and J. T. Hoffman. 2000. Status of white pine blister rust in the Intermountain West. Western N. Amer. Naturalist 60: 165-179.

Sniezko, R. A., A. Bower, and J. Danielson. 2000. A comparison of early field results of white pine blister rust resistance of sugar pine and western white pine. HortTechnology 10: 519-522.

Stipes, R. J. and R. J. Campana (eds.). 1981. Compendium of elm diseases. Am. Phytopath. Soc., St. Paul, Minn. 96 pp.

Tainter, F. H., and F. A. Baker. 1996. Principals of Forest Pathology. John Wiley & Sons, Inc., New York. 805 pp.

Triplehorn, C. A. 1955. The Asiatic oak weevil in Delaware. J. Econ. Entomol. 48: 289-293.

Townsend, A. M. 2000. USDA genetic research on elms. In The Elms: Breeding, Conservation, and Disease Management, C. L. Dunn, ed. Kluwer Academic Publ., Nowell, Massachusetts. Pp. 271-278.

Tribe, G. D. 1995. The woodwasp *Sirex noctilio* Fabricius (Hymenoptera: Siricidae), a pest of *Pinus* species, now established in South Africa. African Entomol. 3: 215-217.

Tribe, G. D., and R. Kfir. 2001. The establishment of *Dndrosoter caenopachoides* (Hymneoptera:Braconidae) introduced into South Africa for the biological control of *Orthotomicus erosus* (Coleoptera:Scolytidae), with additional notes on *D.* sp nr. *labdacus*. Afr. Entomol. 9: 195-198.

Tunnock, S. and Ryan, R.B. 1983. "Larch Casebearer in the Western Larch." United States Department of Agriculture, Forest Service. Forest Insect and Disease Leaflet 96, Revised September 1983.

Tunnock, S. and R. B. Ryan. 1995. Larch casebearer in western larch. .USDA Forest Service, Forest Insect & Disease Leaflet no. 96. 2 pp.

Tunnock, S., R.E. Denton, C.E. Carlson and W.W. Janssen. 1969. Larch casebearer and other factors involved with deterioration of western larch stands in northern Idaho. United States Department of Agriculture, Forest Serv. Res. Pap. INT-68. 10 pp.

Twery, M.J. 1987. Changes in vertical distribution of xylem production in hardwoods defoliated by gypsy moth. Ph.D. thesis, Yale Univ., New Haven, CT., 96 pp.

Twery, M.J. 1990. Effects of defoliation by gypsy moth. USDA gypsy moth research review, pp. 27-34.

United States Congress General Accounting Office. 1997. Report to Congressional Committees. Agricultural Inspection: Improvements Needed to Minimize Threat of Foreign Pests and Diseases. May 1997. GAO/RCED-97-102.

United States Congress General Accounting Office. 2000. Report to Congressional Committees. Invasive Species. Federal and Selected State Funding to Address Harmful, Nonnative Species. August 2000. GAO/RCED-00-219.

United States Congress General Accounting Office. 2001. Invasive Species: Obstacles Hinder Federal Rapid Response to Growing Threat. August 2001. GAO-01-724

United States Congress Office of Technology Assessment. 1993. Harmful Non-Indigenous Species in the United States. OTA-F-565 (Washington, DC; U. S. Government Printing Office. 391 pp.

United States Department of Agriculture Animal and Plant Health Inspection Service. 1997. Importation of Logs, Lumber, and Other Unmanufactured Wood Articles. Draft Supplement to the Environmental Impact Statement, December 1997.

United States Department of Agriculture Animal and Plant Health Inspection Service. 1998a. Importation of Logs, Lumber, and Other Unmanufactured Wood Articles. Final Supplement to the Environmental Impact Statement, May 1998.

United States Department of Agriculture Animal and Plant Health Inspection Service. 1998b. Importation of Wood Chips From Chile. Proposed rule. Federal Register, July 28, 1998 (Volume 63, Number 144). Pp. 40193-40200

United States Department of Agriculture, Animal and Plant Health Inspection Service. 1998c. Solid Wood Packing Material from China. Initial Pest Risk Assessment on Certain Wood Boring Beetles Known To Be Associated With Cargo Shipments: Asian Longhorned Beetle (*Anoplophora glabripennis*), *Ceresium*, *Monochamus* and *Hesperophanes*. August 31, 1998.

United States Department of Agriculture. Animal and Plant Health Inspection Service. 1998d. Proposed Interim Rule on Solid Wood Packing Material from China. Environmental Assessment. September 1998.

United States Department of Agriculture Animal and Plant Health Inspection Service. 2000. Proposed Rule for the Importation of Unmanufactured Wood Articles From Mexico, With Consideration for

Cumulative Impact of Methyl Bromide Use. Draft Environmental Impact Statement. June 2000.

United States Department of Agriculture, Animal Plant Health Inspection Service. 2002. Citrus longhorned beetle program. King County, Washington. Environmental Assessment. April, 2002. USDA, APHIS, 12 pp.

United States Department of Agriculture Animal and Plant Health Inspection Service and Forest Service 2000. (Pasek, J.E., H.H. Burdsall, J.F. Cavey, A. Eglitis, R.A. Haack, D.A. Haugen, M.I. Haverty, C.S. Hodges, D.R. Kucera, J.D. Lattin, W.J. Mattson, D.J. Nowak, J.G. O'Brien, R.L. Orr, R.A. Sequeira, E.B. Smalley, B.M. Tkacz, W.W. Wallner) Pest Risk Assessment for Importation of Solid Wood Packing Materials into the United States. USDA APHIS and Forest Service. August 2000.

United States Department of Agriculture Forest Service. 1991. Pest Risk Assessment of the Importation of Larch from Siberia and the Soviet Far East, Miscellaneous Publication No. 1495, September, 1991.

United States Department of Agriculture Forest Service Forest Pest Management. 1992a. AB-2S. Final Report, Scientific Panel Review of January 10, 1992 Proposed Test Shipment Protocol for Importing Siberian Larch Logs. April 15, 1992.

United States Department of Agriculture Forest Service. 1992b. Pest Risk Assessment of the Importation of *Pinus radiata* and Douglas-fir Logs from New Zealand, Miscellaneous Publication No. 1508, October 1992.

United States Department of Agriculture Forest Service. 1993. Pest Risk Assessment of the Importation of *Pinus radiata*, *Nothofagus dombeyi*, and *Laurelia philiPpiana* Logs from Chile. Miscellaneous Publication No. 1517. September 1993. 248 pages.

United States Department of Agriculture Forest Service. 1998. Pest Risk Assessment of the Importation of the Importation into the United States of Unprocessed *Pinus* and *Abies* Logs from Mexico. General Technical Report FPL-GTR-104. February 1998. 116 pages.

United States Department of Agriculture Forest Service, Southern Region, Forest Health Protection. 1999. Southern forest health atlas of insects and diseases. USDA Forest Service, R8-MR 35. 20 pp.

United States Department of Agriculture Forest Service, Forest Products Laboratory. 2001. (J.T. Kliejunas, B.M. Tkacz, H.H. Burdsall, Jr., G.A. DeNitto, A. Eglitis, D.A. Haugen, W.E. Wallner) Pest Risk Assessment of the Importation in the United States of Unprocessed *Eucalyptus* Logs and Chips from South America. General Technical Report FPL-GTR-124. April 2001.

United States Department of Interior National Park Service Northeast Region 2000. Environmental Assessment for the Release and Establishment of *Pseudoscymnus tsugae* (Coleoptera: Coccinellideae) as a Biological Control Agent for Hemlock Woolly Adelgid (*Adelges tsugae*) at Delaware Water Gap National Recreation Area.

United States Department of Interior. United States Geological Survey 1998. Status and Trends of the Nation's Biological Resources. Washington, D.C.

United States Office of the Trade Representative. 2002. U.S. Trade in 2001. Annex 1 to The President's 2001 Annual Report on the Trade Agreements Program. Executive Office of the President, Washington, D.C. www.ustr.gov/reports/2002/Annex%20I,U.S.%20Trade%20in%202001.pdf

Van Driesche, J. and R. Van Driesche. 2000. Nature out of Place Biological Invasions in the Global Age. Island Press, Washington, D.C.

van Manen, F. T., J. D. Clark, S. E. Schlarbaum, K. Johnson, and G. Taylor. 2002. A model to predict the occurrence of surviving butternut trees in the southern APpalachian region. In Predicting Species Occurrences: Issues of Scale and Accurancy, J. M. Scott, P. J. Heglund, M. L. Morrison, J. B. Haufler, M. G. Raphael, W. A. Wall, and F. B. Samson, eds. Island Press. Chapter 43, pp. 491-497.

Victor, D.G. 1999. Risk management and the World Trading System: Regulating International Trade Distortions Caused by National Sanitary and Phytosanitary Policies. Presented at the National Research Council, Board on Agriculture Conference, Incorporating Science, Economics, Sociology and Politics in Sanitary and Phytosanitary Standards in International Trade, 25 - 27 January, 1999, Irvine, CA.

Wallace, M. S., and F. P. Hain. 2000. Field surverys and evaluation of native and established predators of the hemlock woolly adelgid (Homoptera:Adelgidae) in the southeastern United States. Environ. Entomol. 29: 638-644.

Wallner, W. E. Assessing Exotic Threats to Forest Resources. In press. In K.O. Britton, Editor. Biopollution: An Emerging Global Menace.

Werres, S., R. Marwitz, W. A. M. I. Veld, A. W. A. M. De Cock., P. J. M. Bonants, M. De Weerdt, K. Themann, E. Ilieva, and R. P. Baayen. Phytophthora ramorum sp. nov., a new pathogen on Rhododendron and Viburnum. Mycol. Re. 105: 1155-1165.

Westbrooks, R. 1998. Invasive Plants Changing the Landscape of America Federal Interagency for the Management of Noxious and Exotic Weeds. Washington, D.C. 1998.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, E. Losos. 1998. Quantifying Threats to Imperiled Species in the United States. Bioscience Vol. 48 No. 8 August 1998.

Williams, L.H. and J.P. La Fage. 1979. Quarantine of Insects Infesting Wood in International Commerce. in J.A. Rudinksy, ed. Forest Insect Survey and Control Fourth Edition 1979

Windham, M. T., E. T. Graham, W. T. Witte, J. L. Knighten, and R. N. Trigiano. 1998. *Cornus florida* 'APplalachian Spring': a white flowering dogwood resistant to dogwood anthracnose. HortSci. 33: 1265-1267.

Wingfield, M. 2002. Understanding the threat of pathogens to exotic plantation forestry presented at Invasive Species Symposium U.C. Davis, June 18 - 19, 2002

World Trade Organization. APpellate Body. EC MEASURES CONCERNING MEAT AND MEAT PRODUCTS (HORMONES) AB-1997-4 Report of the APpellate Body

World Trade Organization. APpellate Body. AUSTRALIA – MEASURES AFFECTING IMPORTATION OF SALMON AB-1998-5 Report of the APpellate Body

Yara, K., E. Yano, T. Sasawaki, and M. Shiga. 2000. Detection of hybrids between introduced *Torymus sinensis* and native *T. beneficus* (Hymenoptera:Torymidae) in central Japan, using malic enzyme. APplied Entomol. Zool. 35: 201-206.

Young, R. F., K. S. Shields, and G. P. Berlyn. 1995. Hemlock woolly adelgid (Homoptera, Adelgidae) - stylet bundle insertion and feeding sites. Ann. Entomol. Soc. Amer. 88: 827-835.

Zhou, X. D., Z. W. de Beer, B. D. Wingfield, and M. J. Wingfield. 2001. Ophiostomatoid fungi associated with three pine-infesting bark beetles in South Africa. Sydowia 53: 290-300.

Zilahi-Balogh, G. M. G., L. T. Kok, and S. M. Salom. 2002. Host specificity of *Laricobius nigrinus* Fender (Coleoptera: Derodontidae), a potential biological control agent of the hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera:Adelgidae). Biol. Control 24: 192-198.

Zlotina, M. A., V. C. Mastro, J. S. Elkinton, and D. E. Leonard. 1999. Dispersal tendencies of neonate larvae of *Lymantria mathura* and te Asian form of *Lymantria dispar* (Lepidodoptera:Lymantriidae). Environ. Entomol. 28: 240-245.

Zobel, D.B., L.F. Roth, and G.M. Hawk, 1985. Ecology, Pathology, and Management of Port-Orford-Cedar (*Chamaecyparis lawsoniana*). United States Department of Agriculture Forest Service. Pacific Northwest, General Technical Report, PNW-184.

American Phytopathological Society Online Symposium presentations, April 2001 http://exoticpests.apsnet.org/

Risks of Exotic Forest Pests and their Impact on Trade; An International Online Workshop to reduce movement of forest pests with a minimal impact on trade.

Dawson, M. Risk Management: Elements to Consider in Developing Plant Health Policy for Forest Products

Dwinell L.D. Potential Use of Elevated Temperature to Manage Pests in Transported Wood

Fraedrich, S.W. Seedborne Pathogens and Strategies to Eliminate and Reduce their Presence on Tree Seeds.

Hicks, C.M. Exotic Pests and International Trade

Magnusson, C., B. Okland, Y. Solheim. Wood Chips

McNamara, D. International Cooperation in Risk Analysis and Development of Regulations

McNamara D. and G. Kroeker. International Measures for Solid Wood Packing Material

Ostry, M.E. Hazards Associated with Pest Pathways and Economic Impacts — Seeds, Propagative Materials and Nursery Stock