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Pest Risk Assessment for Importation of Solid Wood Packing Materials into the United States

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Abstract

A wide variety of exotic tree pests can readily be transported into the United States on untreated wooden pallets, crating, bracing, and other solid wood packing materials (SWPM). Recent introductions of forest pests associated with importation of SWPM demonstrate that current United States import regulations are inadequate to exclude such pests. Nearly all (97 percent) of the quarantine-significant tree pests found by port inspectors are associated with SWPM. In spite of current bark-free import requirements, about 9 percent of maritime shipments contain bark, which provides habitat for numerous organisms. A pest risk assessment was conducted for the SWPM pathway to document risks associated with the pathway under current import requirements. The document includes a description of SWPM pathway characteristics and assessments of potential for pest entry and establishment. The potential consequences of pest introduction, including expected environmental and economic impacts, were also assessed. The pest risk assessment team selected 19 representative species or groups of insects and fungi of potential concern for detailed assessments to represent an array of geographical origins, host types, and pest habitats. Pest risk potentials were described in relation to current regulations and practices and without regard to potential mitigation measures or proposed regulations (i.e., baseline assessment). Experts evaluated seven risk elements for each potential pest to obtain an overall qualitative ranking (high, moderate, or low pest risk potential). Four of these elements related to likelihood of introduction: (1) pest with host or commodity at origin potential, (2) entry potential, (3) establishment potential, and (4) spread potential. Elements describing consequences of introduction included (5) economic damage potential, (6) environmental damage potential, and (7) social and political considerations. To improve rating consistency, objectivity, and transparency, risk criteria were developed to define each element. In addition to the qualitative rankings, quantitative projections of economic impact were developed for seven of the potential pest species or groups based upon hypothetical scenarios of introduction and spread. Cumulative economic impacts over 30 years following pest introduction are expected to range from the tens of millions to over a billion dollars, depending upon pest species, introduction location, spread rate, and damage level. Examples of high pest risk potential for the SWPM pathway exist in both temperate and tropical and subtropical regions of origin, both conifer and hardwood host types, and for the three primary pest habitats (in deep wood, under bark, on bark) of the SWPM host material being transported. Organisms with high pest risk potentials are unlikely to be excluded solely through inspection activities and associated interdiction actions at ports of entry. Given the ubiquity of the SWPM pathway, its associated pests, and the difficulties in tracing and identifying SWPM origins and compositions, it appears that worldwide application of more stringent importation requirements may be warranted.

Keywords: Solid wood packing materials, import regulation, exotic tree pest introduction, invasive species

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Primary Contact::
Dr. Judith E. Pasek, Team Leader
Entomologist
Center for Plant Health Science and Technology
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
U.S. Department of Agriculture
1017 Main Campus Dr., Suite 2500
Raleigh, NC 27606-5202

Team Members:
Harold H. Burdsall, Jr.
Dennis A. Haugen
John D. Lattin
Richard L. Orr
William E. Wallner
Joseph F. Cavey
Michael I. Haverty
William J. Mattson
Ronaldo A. Sequeira
Andris Eglitis
Charles S. Hodges
David J. Nowak
Eugene B. Smalley
Robert A. Haack
Daniel R. Kucera
Joseph G. O'Brien
Borys M. Tkacz

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Nature of the Problem

In recent years, increased international trade has resulted in a corresponding increase in the amount of untreated solid wood packing materials (e.g., pallets, crating, dunnage) entering the United States. Recent introductions of the Asian longhorned beetle, *Anoplophora glabripennis* (Motschulsky), and pine shoot beetle, *Tomicus piniperda* (L.), have been associated with importation of solid wood packing materials (SWPM). Between August 1995 and March 1998, 97 percent of pests intercepted by Animal and Plant Health Inspection Service (APHIS) inspectors at United States ports and recognized as potential threats to forest resources of the United States were associated with SWPM.

Purpose and Scope

This pest risk assessment was initiated to support the recognized need to replace the interim rule for China (7 CFR Part 319.40–5, effective 17 December 1998) pertaining to shipment of SWPM with a permanent import regulation that addresses the problem of pest transport in SWPM on a global basis. The purpose of this document is to assess whether additional action is warranted to reduce the risk of transporting exotic pests with SWPM imported into the United States.

This assessment describes pest risk potential in relation to current import regulations and practices and is developed without regard to potential mitigation measures. Mitigation alternatives and other supporting analyses will be developed and evaluated by APHIS separately from this document.

SWPM Pathway Characteristics

The SWPM pathway (i.e., means of transport) poses considerable risk for introducing exotic forest pests into the United States. Shippers may use virtually any species of woody plant—from fresh cut to reused seasoned lumber—and often use low-grade and scrap wood to minimize cost. Any given imported cargo shipment may contain SWPM of varied wood types and ages and from unexpected and multiple origins. Recently, inspectors found that 9 percent of maritime and 4 percent of air shipments containing SWPM had bark present (USDA APHIS AQIM data base) despite import requirements enacted in 1995 that SWPM be bark free (7 CFR 319). The presence of bark allows for survival of many potential pest organisms that feed under bark, particularly bark beetles (Scolytidae) and their associated fungi. Most pests that feed or occur in or on stems and branches of woody plants may be found in or on untreated SWPM. Because of the variability in SWPM content and the inability to identify these differences readily, any given shipment may pose the highest level of pest risk offered by the SWPM pathway.

Trade patterns can significantly influence the kinds and numbers of potential exotic forest pests that may arrive in the United States. Imports have increased in recent years from countries around the world as markets have opened up and trade restrictions have declined. Pest interceptions associated with SWPM were recorded from 64 different countries of origin in 1996–98 (USDA APHIS PIN–309 pest interception data base). About 52 percent of maritime shipments and 9 percent of air shipments imported into the United States are accompanied by SWPM.

The presence of SWPM is generally not identified on a shipping manifest, making it difficult for port inspectors to select shipments for inspection. SWPM can be associated with importations of over 250 different commodities. SWPM may infiltrate the United States through approximately 100 ports of entry and often accompany the cargo to its final destination. SWPM may be reused or reconditioned for additional use, contributing to further redistribution of potentially infested wood. Many primary cargo destinations in population centers coincide with the most heavily forested regions of the United States, which provide abundant host material for pest establishment.

Introduction Potential

Forest insects and pathogens that have life stages closely associated with the trunks of trees, especially those that remain with the host for long periods (e.g., wood borers, bark beetles, deep wood pathogens) may pose the greatest risks of infesting wood materials to be exported. Other potential pests may be present only in certain life stages and seasons (e.g., eggs of some lepidopterous species such as the Asian gypsy moth).

From 1996 through 1998, APHIS inspectors recorded 1,205 interceptions (averaging 402 per year) of live exotic forest pests arriving with SWPM, representing 156 taxa (not species). Coleoptera (beetles) accounted for 94 percent of all interceptions. The most common families were the Scolytidae (bark beetles) and the Cerambycidae (long-horned wood borers). The orders Hymenoptera and Lepidoptera accounted for 3 and 2 percent, respectively, of all interceptions. Although the proportion of interceptions of bark beetles has declined compared with that before implementation of the 1995 wood import regulations (7 CFR 319), the bark-free requirement has not been sufficient to limit entry of bark beetles and provides little or no protection against deep-wood pests such as wood borers and deep-wood pathogens. The lengthy list of insect pests intercepted with SWPM at U.S. ports of entry with origins from around the world demonstrates that environmental conditions in shipping containers and airplane cargo holds are suitable for their survival.

Many pests probably escape detection at ports of entry. Most plant pathogens in cargo shipments are not often or easily detected, isolated, and identified. Inspectors are able to look at only a small percentage of all cargo entering the United States. Increasing use of containerized cargo has also made access for inspection more difficult. Only 1–5 percent of SWPM may be accessible for inspection at the container tailgate. Visual inspections are also labor intensive and inefficient at locating live pests. Given the cumulative barriers to detecting pests arriving with SWPM, port inspections and associated interdiction actions (e.g., treatment, denied entry) appear to be inadequate to reduce the pest risk associated with SWPM.

The potential for pest establishment after entry into the United States is not solely dependent upon frequency of entry or the numbers of organisms that get past APHIS' safeguarding (protection) efforts. The pest also must be able to locate suitable hosts and environmental conditions and be capable of reproducing viable populations. Forests in the United States will provide ideal colonization opportunities for many if not most immigrant tree-infesting organisms owing to the extent of forest land in nearly every region of the country and the large number of tree genera also common to Eurasia and elsewhere. Forest land covers about one-third of the land area of the United States and is widely but unevenly distributed. About two-thirds of the forested land is capable of producing commercial timber. Although closed canopies of conifers and broad-leaved deciduous trees typical of the humid parts of the Temperate Zone predominate in forests of the continental United States, tropical forests exist in Hawaii, southern Florida, Puerto Rico, and the Pacific Islands. Potential forest resources at risk include about 500 species of trees in 73 plant families in the continental United States, over 300 species in Hawaii, more than 500 species in Puerto Rico and the Virgin Islands, and numerous tropical species and fruit tree crops in American Samoa. There are sizable industries devoted to production of ornamentals, Christmas trees, and tree fruit and nut production. Urban tree plantings often are the first sites of new pest introductions given the concentrations of trade and diverse tree species in populated areas.

North American forests are highly vulnerable to invasion by exotic pests. Case histories of past introductions of insects and pathogens that may be transported with SWPM demonstrate the kinds of pest biologies and damage that can occur when organisms become established in new environments. Several introduced species were unknown as pests in their native habitats. At least 5 percent of the non-indigenous forest insect species and half of the exotic forest pathogens established in North America have become such serious pests that they threaten the health, productivity, stability, merchantability, and even the very existence of some trees and forests.

Consequences of Introduction: Potential Environmental Impacts

Certain kinds of pest damage are clearly more serious than others because not all kinds of plant injuries are repaired or compensated for physiologically to the same degree. Among 13 insect feeding guilds (or habits), those causing the lowest plant recovery capacity and highest impact are borers in the inner bark (phloem, cambium) and sapwood of the roots, root crowns, and main stems. Organisms that invade living, vascular tissues, such as phloem and sapwood, may very likely induce powerful hypersensitive reactions in the plant that can cause the swift death and plugging of such tissues. When this happens, rapid death of twigs, branches, and ultimately the entire plant results. In addition to wood-invading beetles and fungi, nematodes, true aphids, and adelgids can also trigger severe defense reactions by plants. Moreover, any herbivore that transmits or acts as a vector for plant pathogenic fungi, bacteria, phytoplasms, and viruses can have high potential for plant injury.

Ecological disruption from an exotic pest increases exponentially as the proportion of susceptible plants in a landscape increases. Significant impacts can result from a pest with very broad host plant preferences or from a pest with narrow host preferences for trees having vast, nearly pure populations. Ecological impact can also be significant for pests that attack hosts with limited distributions when they play vital ecological roles. The most devastating potential impact resulting from introduction of an exotic forest pest is the extinction of an ecologically dominant plant species. The significant decline of the American chestnut following introduction of chestnut blight is an example. Biodiversity may be reduced not only because of loss of the tree species but also of wildlife and other organisms that depend upon that habitat. Short of species extinction, depredations of exotics may alter typical plant abundance and distribution patterns. Attacked plants may gradually be eliminated from certain localized areas. Introduction of exotics may also diminish tree and forest productivity. Pest damage in turn may effect substantial changes in nutrient cycling and retention, hydrology, soil erosion, and capacity for reforestation. Extensive tree mortality would benefit some animals and threaten others, lower water quality, alter regional hydrology, increase the probability of wildfire, and reduce the carbon storage capacity of North American forests. As exotic plant-feeding organisms establish themselves in an ecosystem, they may also outcompete native insects and microorganisms and hence push them into declining abundance.

Consequences of Introduction: Potential Economic Impacts

Activity by forest pest species can result in a variety of economic losses due to damage to trees, forests, or wooden structures. Depending upon the pest species and the hosts attacked, economic losses may be reflected in

- tree mortality and timber volume loss;
- wood defects and degradation;
- tree growth loss;
- decreased production of products such as maple syrup, fruits, nuts, or seed;
- reduction in property values;
- damage to property due to tree failures;
- losses in recreation visitor days and tourism;
- increased human health problems (e.g., allergic reactions to pests, injuries from tree failures);
- higher energy costs (e.g., resulting from loss of shade);
- increased costs for mitigating pest damage or restoring habitat;
- and many other indirect effects.

Once an exotic pest becomes established, controlling its population is never simple or cheap.

Given biological and ecological uncertainties, the potential for economic damage can be difficult to quantify or predict, especially for those pest species that threaten but have not yet become established in a new environment. Assumptions that describe potential scenarios of introduction and spread over 30 years were devised to develop quantitative projections of resource and monetary losses for seven representative exotic pest species or groups. The low and high extremes of potential spread rates and damage potentials defined the best-case and worst-case scenarios, respectively, for each pest.

Potential impacts to wooden structures are illustrated by the hypothetical introduction of a drywood termite into San Diego, CA. Control costs (discounted to present value at 7 percent per year) over 30 years would range from about $17 million to $109 million, depending upon spread rate.

If pink disease [caused by *Erythricium salmonicolor* (Berk. & Broome) Burdsall] were introduced to the State of Hawaii, it could be expected to spread throughout island groups within 7–13 years. Cumulative discounted monetary losses during that time resulting from growth loss in eucalyptus plantations were estimated at $3–39 million for different island groups and scenarios. Growth losses following the initial establishment period would likely range annually from several hundred thousand to several million cubic feet of timber volume. Coffee production in the Hawaiian islands would also be heavily impacted with cumulative discounted losses after 13 years under the best-case scenarios of $3–6 million, depending upon island group affected, and $6–14 million after 7 years for the worst-case scenarios.

Potential economic impacts to the urban tree resources of eight U.S. cities were estimated using calculations of compensatory values of preferred host trees that would likely be killed following introductions of the Asian longhorned beetle. Tree resources at risk (i.e., preferred hosts) ranged from a high of 63 percent of trees in Chicago, IL, to 12 percent in Oakland, CA. At a slow natural spread rate, cumulative discounted compensatory values of potentially affected trees would range from about $25 million in Jersey City, NJ, to $403 million in Baltimore, MD, after 30 years. For a faster spread rate based upon redistribution of infested materials by human activities, beetle populations would be expected to spread throughout entire urban areas within 6 years (in the absence of any eradication or control efforts), and the cumulative discounted compensatory values of damaged trees would range from $39 million to $1.3 billion, depending upon the city infested. Additional losses in the tens to hundreds of million cubic feet of timber volume per year could be expected, depending upon location and spread rates, if beetle populations expanded beyond the urban centers to kill trees in commercial timberlands.

Of three locations modeled for introduction of a sirex woodwasp (*Sirex noctilio* F.) into commercial timberlands, the area around Atlanta, GA, would be expected to sustain the greatest damage levels with maximum annual volume losses of 550 million cubic feet to more than 6 billion cubic feet for the best and worst cases, respectively. Cumulative discounted values of timber loss due to tree mortality over 30 years would range from $48 million to $607 million. For timber production around Minneapolis, MN, and San Francisco, CA, cumulative discounted monetary losses over 30 years would be between $7 million and $77 million, depending upon spread rates.

The European spruce bark beetle [*Ips typographus* (L.)] was assumed to attack and kill only spruce, which is limited to timberland areas in the Northern United States and high elevations of the mountainous West. At the slower rate of spread, populations are expected to remain very localized. However, under a worst-case scenario, values of annual timber volume loss could range up to 919 million cubic feet for introduction into Minneapolis, 758 million cubic feet for introduction into New York, and 98 million cubic feet for introduction into Seattle. Cumulative discounted values for timber loss after 30 years would be $101 million for Minneapolis, $93 million for New York, and $14 million for Seattle.

Annual timber losses resulting from defoliation by nun moth (*Lymantria monacha* L.) could range as high as 100–700 million cubic feet, depending upon location of introduction, under the best-case scenario. Damage levels would be more variable under the worst-case scenario, with maximum annual losses of 3–8 billion cubic feet. Depending on location, cumulative discounted monetary losses over 30 years was estimated to range from $28 million to $169 million for the best-case scenario and $721 million to $921 million for the worst-case scenario.

Heterobasidion root rots are expected to spread quite slowly; therefore, maximum annual volume losses for a single introduction point would likely reach only 16 million cubic feet even under the worst-case scenario. Cumulative discounted timber value losses after 30 years under worst-case assumptions would range from about $266,500 in

Portland, OR, to $1.8 million in Atlanta, GA. Past introductions of other forest pathogens with faster spread rates demonstrate the high potential for economic damage for some wood pathogens, however.

Pest Risk Potential

Pest risk potential for a given organism and pathway is determined by the likelihood and the consequences of introduction. The likelihood that an organism will move to, and become established in, a new environment is related to the chance of its being associated with the host or commodity being moved, its survivability during transport, its ability to locate and colonize suitable hosts in its new environment, and its ability to reproduce and spread. Consequences of introduction are defined by potential economic and environmental impacts and social and political concerns. Criteria were developed to evaluate these risk elements qualitatively.

Pest risk potential was described qualitatively with ratings of low, moderate, or high risk for 19 representative insect and pathogen species or groups that may be transported with SWPM. Selected organisms were chosen to represent combinations of geographic origin (i.e., temperate, or tropical and subtropical), host type (i.e., conifers or hardwoods), pest habitat (i.e., in deep wood, under bark, or on bark), and a variety of pest types. Selected species or groups evaluated for pest risk potential were as follows:

1. Root and stem rots (caused by *Armillaria* spp., *Phellinus* spp., and *Ganoderma* spp.),
2. Heterobasidion root rots (caused by *Heterobasidion* spp.),
3. Brown root rot [caused by *Phellinus noxious* (Corner) G.H. Cunn.],
4. Stains and wilts (caused by *Ophiostoma* spp. and *Ceratocystis* spp.),
5. Canker stain (caused by *Ceratoscystis fimbriata* Ellis & Halstead),
6. Pink disease [caused by *Erythricium salmonicolor* (Berk. & Broome) Burdsall],
7. Asian longhorned beetle [*Anoplophora glabripennis* (Motschulsky)],
8. A sirex woodwasp and associated fungus [*Sirex noctilio* F./ *Amylostereum areolatum* (Fries) Boidin],
9. Drywood termites (*Cryptotermes* spp., *Incisitermes* spp. and *Kalotermes* spp.),
10. Subterranean termites (*Coptotermes* spp. and *Reticulitermes* spp.),
11. Red-haired pine bark beetle and associated fungi [*Hylurgus ligniperda* (F.)/*Leptographium* spp.],
12. European spruce bark beetle and associated fungi [*Ips typographus* (L.)/*Ceratocystis* spp.],
13. Mediterranean pine engraver beetle (*Orthotomicus erosus* Wollaston),
14. European oak bark beetle [*Scolytus intricatus* (Ratzeburg)],
15. Asian gypsy moth (*Lymantria dispar* L.),
16. Nun moth (*Lymantria monacha* L.),
17. Purple moth (*Sarsina violascens* Herrich-Schaeffer),
18. La grilleta (*Pterophylla beltrani* Bolivar y Bolivar), and
19. Pine flat bug (*Aradus cinnamomeus* Panzer).

Pest risk potential was rated as high for most organisms evaluated, although root and stem rots (*Armillaria* spp., *Phellinus* spp., *Ganoderma* spp.) and the orthopteran, *Pterophylla beltrani*, were rated as presenting only moderate risk. All but one of the assessed organisms rated high for presence with host or commodity at origin potential and entry potential, which indicates that the SWPM pathway is a viable route of entry to the United States for these organisms. Establishment potential, spread potential, and types of potential damage varied with biological characteristics of the organisms rated.

Evaluation of the 19 selected potential pest species or groups demonstrates that significant pest risk potential exists for many types of organisms that may be transported with SWPM into the United States and its territories. Examples of high pest risk potential for the SWPM pathway exist in both temperate and tropical and subtropical regions of origin, both conifer and hardwood host types, and for the three primary habitats (in deep wood, under bark, and on bark) of the SWPM host material being transported. Organisms with high pest risk potential are unlikely to be excluded adequately solely through inspections and associated interdiction actions at ports of entry.

Organisms (such as fungal root rots, stains and wilts, and wood-boring beetles, wasps and termites) that utilize the interior portions of wood represent a wide array of taxa with varied biologies; however, they all have a survival advantage in being physically protected within the host material and being difficult to detect in SWPM. Damage caused by organisms that inhabit interior portions of wood often results in defects and degradation that can cause tree failure and tree mortality, or structural damage in the case of wood buildings. Species that utilize deep wood material are common in both conifer and hardwood hosts. The greatest differences in the potentials of these kinds of organisms to become established in a new environment likely result from disparities in the ability to move from SWPM to new host tree material, rates of population increase, and rates of spread.

Bark beetles and some plant pathogens (such as those causing canker diseases) utilize the nutrient-rich inner bark and cambium of trees and are frequently transported with SWPM. Bark beetles characteristically have a high potential for dispersal, colonization, population increase, and spread; therefore, as a group they have a high potential for establishment. Those bark beetle species that have the ability to attack, colonize, and kill live trees, consequently, will have high pest risk potentials. Destructive species of bark beetles are generally more common in conifer hosts, but some of the most destructive bark beetle–fungal associations that have become established in North American have involved hardwood hosts.

Potential tree pests that may be transported on bark attached to SWPM may include a variety of taxa and pest habits. Life stages may be sessile (i.e., permanently attached like scale insects), hidden in bark crevices, or adherent to the bark with gluelike substances (e.g., egg masses). Many are difficult to detect owing to cryptic coloration, concealment in cracks, or small size. Survivability during transport may be high because of a dormant or environmentally resistant state (e.g., eggs or spores). Although some potential pests that may be transported on bark of SWPM can cause damage by sucking plant juices out of stems and tree trunks (e.g., some bark-inhabiting Hemiptera and Homoptera), others may be more damaging to other plant parts once established in a suitable environment (e.g., Lepidoptera and Orthoptera). Consequences of introduction are probably more varied for pests that may occur on bark for this reason and range from cosmetic injury to growth reduction to tree mortality.

Conclusion

Given the ubiquitousness of the SWPM pathway and associated pests and difficulties in tracing SWPM origins and identifying SWPM compositions, application of more stringent importation requirements, regardless of country of origin, appears to be warranted. Employment of effective mitigation measures that can reduce the likelihood that live pests will be transported with SWPM has the potential to reduce greatly the risk of introducing destructive exotic forest pests; however, evaluation of potential mitigation measures will be conducted separately from this document.

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