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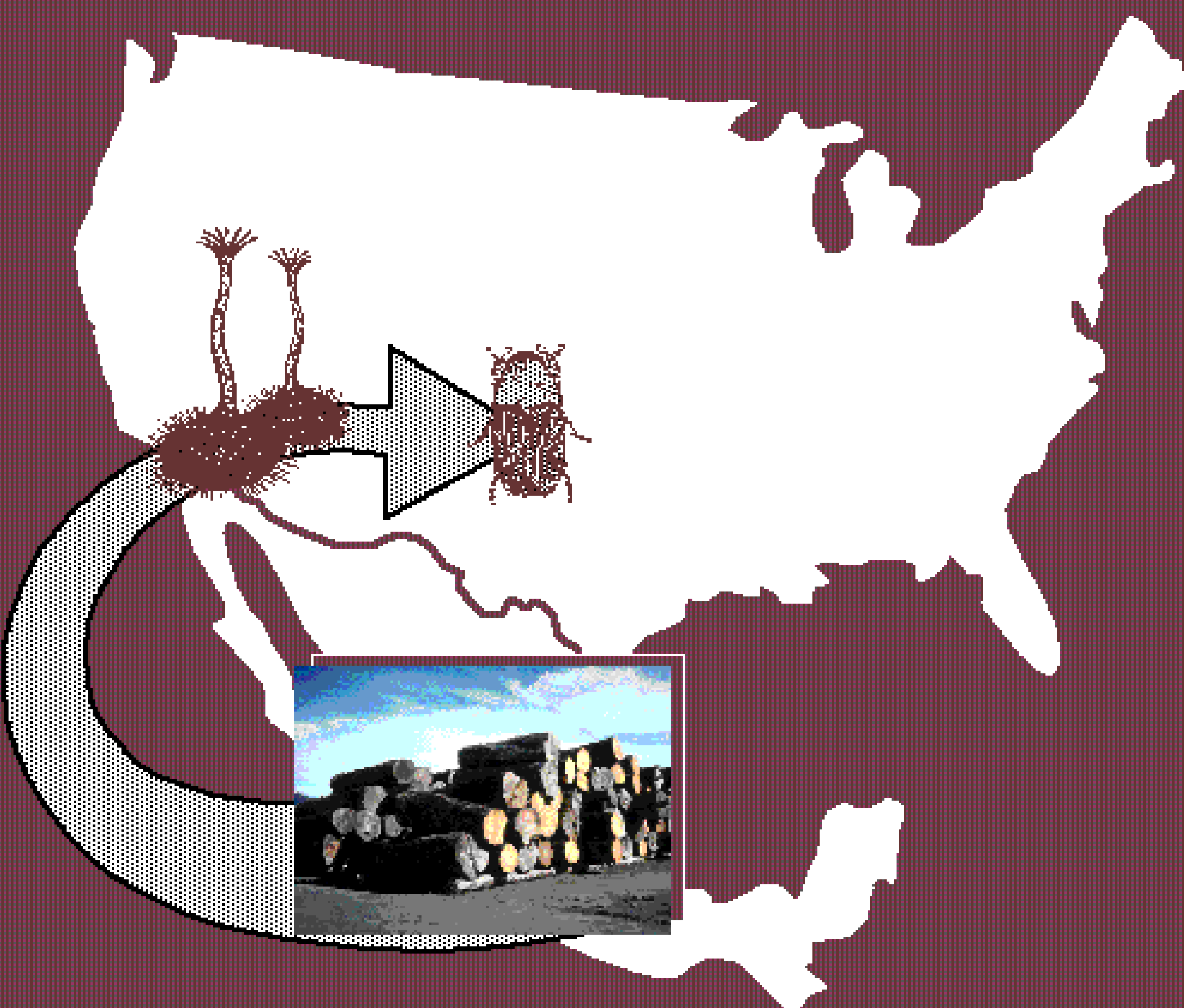
Pest Risk Assessment of the Importation into the United States of Unprocessed *Pinus* and *Abies* Logs from Mexico



Abstract

The unmitigated pest risk potential for the importation of *Pinus* and *Abies* logs from all states of Mexico into the United States was assessed by estimating the probability and consequences of establishment of representative insects and pathogens of concern. Twenty-two individual pest risk assessments were prepared for *Pinus* logs, twelve dealing with insects and ten with pathogens. Six individual assessments were prepared for *Abies* logs. The selected organisms were representative examples of insects and pathogens found on the bark, in the bark, and in the wood of *Pinus* or *Abies* logs. Among the insects and pathogens assessed for Mexican pines, eight (*Dendroctonus mexicanus*, *Coptotermes crassus*, *Pterophylla beltrani*, *Ips bonanseai*, *Gnathotrichus perniciosus, Gnathotrichus nitidifrons, Fusarium subglutinans* f. sp. *pini,* and *Ophiostoma* spp.) were rated a high risk potential. A moderate pest risk potential was assigned to nine other organisms or groups of organisms including *Pineus* spp., *Lophocampa alternata*, *Hylesia frigida*, *Hypoderma* spp., *Lophodermella* spp., *Synanthedon cardinalis*, *Heterobasidion annosum*, *Sphaeropsis sapinea*, *Bursaphelenchus xylophilus*, *Cronartium* spp., and *Peridermium* spp. The pests of concern with a moderate or high pest risk potential for *Abies* logs include *Lophocampa alternata, Scolytus mundus, S. aztecus, Pseudohylesinus variegatus, P. magnus, Ophiostoma abietinum*, and *Heterobasidion annosum*. For those organisms of concern that are associated with Mexican *Pinus* and *Abies* logs, specific phytosanitary measures may be required to ensure the quarantine safety of proposed importations.

Keywords: Pest risk assessment, Mexico, log importation

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Executive Summary

Background and Objectives

Title 7, Code of Federal Regulations, Parts 300 and 319, authorizes the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) to issue a general permit for importation of wood articles from Canada and the Mexican border states without restriction. Softwood species from the nonadjacent states of Mexico, however, are subject to the Universal Importation Options (7 CFR 319.40–6), which require logs to be debarked and heat treated to eliminate harmful pests. Because of several requests from forest industries in the United States to import logs of *Pinus* and *Abies* species from Mexico, APHIS requested on March 20, 1996, that the USDA Forest Service prepare a pest risk assessment. The objectives of the risk assessment were to identify potential pests in all the states of Mexico, estimate the probability of their entry on Mexican logs and establishment in the United States, and evaluate the economic, environmental, and social consequences of such an establishment.

The Risk Assessment Team

A USDA Forest Service Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET) conducted the assessment. The team was chartered by the Chief of the Forest Service to provide a permanent source of technical assistance to APHIS in conducting pest risk assessments. A delegation of WIPRAMET members and an APHIS representative traveled to Mexico from July 14 to 26, 1996. They met with local agricultural, quarantine, and forestry officials, entomologists, pathologists, and forest industry representatives to gather information. The team toured harvest areas, inspected processing plants and ports, and viewed pest problems in forests. The pest risk assessment document prepared by the team also takes into consideration comments by 29 individuals, 22 from the United States, 2 from Canada, and 5 from Mexico, who provided critical reviews of an earlier draft.

Pest Risk Assessment

The team compiled lists of insects, parasitic plants, and microorganisms known to be associated with Mexican species of *Pinus* and *Abies*. From these lists, insects and pathogens that have the greatest risk potential as pests on imported logs were identified. Twenty-two Individual Pest Risk Assessments (IPRA) were prepared for *Pinus*, twelve dealing with insects and ten with pathogens. Six IPRA were prepared for *Abies*. The objective was to include in the IPRA representative examples of insects and pathogens found on the bark, in the bark, and in the wood. By necessity, this pest risk assessment focuses on those insects and pathogens for which biological information is available. However, by developing IPRA for known organisms that inhabit a variety of different niches on logs, effective mitigation measures can subsequently be identified by APHIS to eliminate the recognized pests. It is anticipated that any similar unknown organisms that inhabit the same niches would also be eliminated.

Conclusions

There are numerous potential pest organisms found on both *Pinus* and *Abies* spp. in Mexico that have a high probability of being inadvertently introduced into the United States on unprocessed logs. The potential mechanisms of log infestation by nonindigenous pests are complex. Further complicating the issue is the presence of many of the potential pests of concern in Mexican states immediately adjoining the United States. These adjoining states have ecological and geographic features dissimilar to those in the United States. Current import regulations provide a general permit for the entry of unprocessed wood products from these border states. The issue of pests of concern from adjacent Mexican states should be considered concurrently with any review or revision of the current regulations.

Among the insects and pathogens found on Mexican pines, eight were rated a high risk potential: pine bark beetle (*Dendroctonus mexicanus*), subterranean termite (*Coptotermes crassus*), La Grilleta (*Pterophylla beltrani*), pine engraver beetle (*Ips bonanseai*), ambrosia beetles (*Gnathotrichus perniciosus* and *G. nitidifrons*), pine pitch canker (*Fusarium subglutinans* f. sp. *pini*), and stain and vascular wilt fungi (*Ophiostoma* spp.). All of these, except *F. subglutinans* f. sp. *pini*, are nonindigenous to the United States and would be classified as quarantine pests under the log import regulations.

A moderate pest risk potential was assigned to nine organisms (or groups of organisms) found on Mexican pines: adelgids (*Pineus* spp.), tiger moth (*Lophocampa alternata*), giant silkworm (*Hylesia frigida*), needle diseases (*Davisomycella* spp., *Dothistroma* spp., *Elytroderma deformans*, *Hypoderma mexicanum*, *Lophodermella maureri*, and

Lophodermium spp.), pitch moth (*Synanthedon cardinalis*), annosus root rot (*Heterobasidion annosum*), diplodia shoot blight (*Sphaeropsis sapinea*), pine wood nematode (*Bursaphelenchus xylophilus*), and stem and limb rusts (*Cronartium* spp. and *Peridermium* spp.). While some of these organisms do occur in the United States, they may differ in their capacity for causing damage, based on the genetic variation exhibited by the species.

Several factors suggest that pine logs destined for export from Mexico would probably be relatively free of most damaging organisms. Commercial pine forests appear to be well managed and grow under conditions that do not generally lead to a high incidence of damage by forest insects or pathogens. There appears to be a good working knowledge of forest insects along with the ability to recognize problem situations when they occur. However, concerns exist about the comparatively less well-developed knowledge of pathogens in Mexican pines.

Far less is known about organisms associated with *Abies* than with *Pinus*. The team was able to identify only seven organisms of moderate risk potential for *Abies* spp. These include the tiger moth *Lophocampa alternata*, the fir bark beetles (*Scolytus mundus, S. aztecus, Pseudohylesinus variegatus,* and *P. magnus*), *Ophiostoma abietinum*, and *Heterobasidion annosum*. Except for *H. annosum*, these would be classified as quarantine pests under the APHIS log import regulations.

For those organisms of concern that are associated with Mexican pines and firs, specific phytosanitary measures may be required to ensure the quarantine safety of proposed importations. Detailed examination and selection of appropriate phytosanitary measures to mitigate pest risk is the responsibility of APHIS and is beyond the scope of this assessment.

Chapter 1. Introduction

Background

There is increasing interest in importing large volumes of unmanufactured wood articles into the United States from abroad. The United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) is the government agency charged with preventing the introduction of exotic pests on plant material brought into the United States via international commerce. The USDA Forest Service has provided assistance to APHIS in conducting pest risk assessments of the importation of logs from Russia (USDA Forest Service 1991), New Zealand (USDA Forest Service 1992), and Chile (USDA Forest Service 1993).

On May 25, 1995, APHIS promulgated a Final Rule on Importation of Logs, Lumber, and Other Unmanufactured Wood Articles [Title 7, Code of Federal Regulations (CFR), Parts 300 and 319] with the intention of eliminating "any significant plant pest risks presented by the importation of logs, lumber, and other unmanufactured wood articles." This regulation authorizes APHIS to issue a general permit for importation of wood articles from Canada and the Mexican border states without restriction "because most insects and wood pests in these areas are also indigenous to the United States, or will become so through natural migration." Softwood species from the nonadjacent states of Mexico, however, are subject to the Universal Importation Options (Title 7 CFR 319.40-6), which require logs to be debarked and heat treated to eliminate harmful pests.

In September 1995, the Chief of the Forest Service chartered the Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET) of the FS to provide a permanent source of technical assistance to APHIS in conducting pest risk assessments of exotic pests that might be introduced into the United States as a result of importing wood and wood products. On March 20, 1996, APHIS requested that WIPRAMET conduct a pest risk assessment of the importation of unprocessed *Pinus* and *Abies* logs from Mexico into the United States.

Statement of Purpose

The specific objectives of this risk assessment are to

- identify the potential pest organisms that may be introduced with imported unprocessed *Pinus* and *Abies* logs from Mexico,
- assess the potential for introduction and establishment in the United States of selected representative Mexican forest pests, and
- estimate the potential economic and environmental impacts these pests may have on forest resources if established in the United States.

Scope of Assessment

This risk assessment estimates the probability that pests will be introduced and become established in the United States as a direct result of the importation of unprocessed logs from all states in Mexico. Pests addressed in this report are chiefly phytophagous insects, fungal pathogens, parasitic plants, and the pine wood nematode. Major emphasis is placed on pests with the potential to be transported on, in, or with unprocessed *Pinus* and *Abies* logs destined for export from Mexico to the United States. This assessment also estimates the economic and environmental impact of potentially destructive organisms or groups of organisms should they become established in the United States.

This risk assessment is developed without regard to available mitigation measures. Once the potential risks are identified, suitable mitigation measures may be formulated, if needed, to reduce the possibility that destructive pests will be introduced into the United States on Mexican logs. The prescription of mitigation measures, however, is beyond the scope of this assessment and is the responsibility of APHIS.

Pest Risk Assessment Process

This risk assessment conforms to the standards for plant pest risk assessments as described in Title 7, CFR 319.40-11:

A. Collect commodity information.

   1. Evaluate permit applications and other sources for information describing the origin, processing, treatment, and handling of *Pinus* and *Abies* logs from Mexico.

   2. Evaluate data from the United States and foreign countries on the history of past plant pest interceptions or introductions associated with *Pinus* and *Abies* wood and wood products from Mexico.

B. Catalog pests of concern.

1. Determine what plant pests or potential plant pests are associated with *Pinus* and *Abies* logs in Mexico. A plant pest that meets one of the following criteria is a quarantine pest according to Title 7, CFR 319.40-11 and is further evaluated:

   a. Nonindigenous plant pest not present in the United States

   b. Nonindigenous plant pest present in the United States and capable of further dissemination in the United States

   c. Nonindigenous plant pest that is present in the United States and has reached probable limits of its ecological range but differs genetically from the plant pest in the United States in a way that demonstrates a potential for greater damage in the United States

   d. Native species of the United States that has reached probable limits of its ecological range but differs genetically from the plant pest in the United States in a way that demonstrates a potential for greater damage in the United States

   e. Nonindigenous or native plant pest that may be able to vector another plant pest that meets one of the above criteria

   In addition to these categories of quarantine pests as specified in the log import regulations, WIPRAMET determined that a broader definition of genetic variation was needed for Category d. The definition of this category was expanded to include native species that have reached the probable limits of their range, but *may* differ in their capacity for causing damage, based on the genetic variation exhibited by the species. There are uncertainties and unknowns about the genetic variability and damage potential of many pest organisms in natural forest ecosystems. Because of these unanswered questions, the team was cautious in its assessments and included additional pests of concern not considered under the requirements of the log import regulations. For Category b pests, the team added native organisms with limited distributions within the United States but capable of further dissemination. The team believes that some of these organisms currently occupy a limited distribution only because they have not been afforded the opportunity to exploit additional environments.

C. Determine which pests of concern to assess.

1. Divide pests of concern identified in previous paragraphs into one of the following groups by associated taxa:

   a. Plant pests found on the bark

   b. Plant pests found in or under the bark

   c. Plant pests found in the wood

2. Evaluate the plant pests in each of these groups according to pest risk, based on the available biological information and demonstrated or potential plant pest importance.

3. Conduct individual pest risk assessments (IPRAs) for the pests of concern. Identify any pests of concern for which plant pest risk assessments have been previously performed in accordance with 7 CFR 319.40-11 and determine the applicability of the assessment to the proposed importation of the organism from Mexico. The number of IPRAs is based on biological similarities of the organisms as they relate to susceptibility to mitigation measures. The lack of biological information on any given insect or pathogen should not be equated with low risk (USDA Forest Service 1993). By necessity, pest risk assessments focus on those organisms for which biological information is available. By developing detailed assessments for known pests that inhabit different locations on imported logs (namely, on the surface of the bark, within the bark, and deep within the wood), effective mitigation measures can subsequently be developed to eliminate the known organisms and any similar unknown ones that inhabit the same niches.

D. Evaluate the following elements for each organism in the IPRAs and assign a risk value (high, moderate, or low) for each element [Risk element is based on available biological information and the subjective judgment of the assessment team. Each specific element in the pest risk assessment is assigned a certainty code (Table 1) as described in Orr and others (1993).].

Table 1—Description of certainty codes used with specific elements in the individual pest risk assessment process

Certainty code	Symbol
Very certain	VC
Reasonably certain	RC
Moderately certain	MC
Reasonably uncertain	RU
Very uncertain	VU

1. Probability of pest establishment: Estimate the probability that the pest will become established in the United States. Exotic organisms are considered established once they have formed a self-sustaining, free-living population at a given location (U.S. Congress 1993).

   a. Pest with host at origin potential—Probability of the plant pest being on, with, or in *Pinus* or *Abies* logs at the time of export: The affiliation of the pest with the host, both temporally and spatially, is critical to this element. Of the four elements associated with probability of pest establishment, this element carries greater weight than any other. Included in this element is a pest's capability as a hitchhiker on log shipments or on the vehicle of transport, i.e., ship's superstructure, containers, etc.

   b. Entry potential—Probability of the plant pest surviving in transit and entering the United States undetected: Important components of this element include the pest's ability to survive transport, which includes such things as the life stage and number of individuals expected to be associated with logs or transport vehicles.

   c. Colonization potential—Probability that the plant pest will successfully colonize once it has entered the United States: Some characteristics of this element include the number and life stage of the pest translocated, host specificity, and probability of encountering a suitable environment in which the pest can reproduce.

   d. Spread potential—Probability of the plant pest spreading beyond any colonized area: Factors to consider include the pest's ability for natural dispersal, ability to use human activity for dispersal, ability to readily develop races or strains, the distribution and abundance of suitable hosts, and the estimated range of probable spread (USDA Forest Service 1993).

2. Consequences of pest establishment: Estimate the potential consequences if the pest were to become established in the United States.

   a. Economic damage potential—Estimate of the potential economic impact if the pest were to become established: Factors to consider include economic importance of hosts, crop loss, effects on subsidiary industries, and costs and efficacy of eradication or control.

   b. Environmental damage potential—Estimate of the potential environmental impact if the pest were to become established in the United States: Factors to consider include potential for ecosystem destabilization, reduction in biodiversity, reduction or elimination of keystone species, reduction or elimination of endangered or threatened species, and nontarget effects of control measures.

   c. Perceived damage potential (social and political influences)—Estimate of the impact of possible pest damage on social or political influences, including the potential for aesthetic damage, consumer concerns, political repercussions, and implications for international trade.

E. Estimate the unmitigated plant pest risk for each IPRA based on the compilation of the risk values for the individual elements. The method for compilation is presented in Orr and others (1993).

   1. Step 1—Determine the probability of establishment: The overall risk rating for the probability of establishment acquires the same rank as the single element with the lowest risk rating.

   2. Step 2—Determine the consequences of establishment: Table 2 presents a method for ascertaining consequences of establishment for a specific pest organism or group of organisms with similar habits, based on the individual ratings for economic, environmental, and perceived damage potentials.

   3. Step 3—Determine the pest risk potential: The pest risk potential for each IPRA is determined based on the ratings for probability of establishment and consequences of establishment (Table 3).

Outreach

In an effort to gather information pertinent to the pest risk assessment, WIPRAMET contacted scientists and specialists in the fields of forestry, forest entomology, and forest pathology and in the timber industry throughout the United States, Canada, and Mexico. Contacts also were made with professional organizations including the American Phytopathological Society, Entomological Society of America, and Society of Nematologists. A preliminary list of potential organisms of concern was compiled and mailed to nearly 100 individuals for review. Suggested revisions to the list were incorporated into the final list prepared by WIPRAMET.

Site Visit

Site visits to the subject countries have been an integral part of previous pest risk assessments for log imports (USDA Forest Service 1991, 1992, 1993). A delegation of WIPRAMET members and an APHIS representative

Table 2—Method for estimating consequences of establishment for an individual pest risk assessment[a]

Economic damage potential	Environ-mental damage potential	Perceived damage potential	Consequences of establish-ment
H	L, M, or H	L, M, or H	H
L, M, or H	H	L, M, or H	H
M	M	L, M, or H	M
M	L	L, M, or H	M
L	M	L, M, or H	M
L	L	M or H	M
L	L	L	L

[a]L, low; M, moderate; H, high.

Table 3—Method for determining pest risk potential[a]

Probability of establishment[b]	Consequences of establishment	Pest risk potential
H	H	H
M	H	H
L	H	M or L[c]
H	M	H
M	M	M
L	M	M or L[c]
H	L	M
M	L	M
L	L	L

[a]L, low; M, moderate; H, high.
[b]The overall risk rating for the probability of establishment acquires the same rank as the single element with the lowest risk rating.
[c]If two or more of the single elements that determine probability of establishment are low, pest risk potential is considered low, rather than moderate, for this assessment.

traveled to Mexico from July 14 to 26, 1996, to meet with local agricultural, quarantine, and forestry officials, entomologists, pathologists, and forest industry representatives to gather information on the proposed importation. The team also toured harvest areas, inspected processing plants and ports, and viewed pest problems in forests. One team member took a separate trip Aug. 4 to 9 for similar purposes (Appendix A).

Characteristics of the Proposed Importation

APHIS has received written and verbal indication of intention to import or requests for permits to import at least six *Pinus* spp. and several *Abies* spp. from the Mexican states of Chihuahua, Durango, and Michoacan into the United States. Imports from other states may be possible and are included in the scope of this document. The *Pinus* spp. include but may not be limited to *P. durangensis, P. engelmannii, P. arizonica, P. strobiformis, P. ayacahuite,* and *P. cembroides*. The bulk of the proposed imports would be expected to arrive by truck, rail, and marine transport to western and southern U.S. destinations. However, if approved, it is assumed in this document that the Mexican logs would be eligible for entry into all ports of the United States. Mexico is a net importer of forest products, especially for the pulp and paper industries. However, recent studies forecast that Mexico's forest sector will increase as a result of government open trade policies (World Forest Institute 1994). Softwoods dominate the Mexican forest products industry. Production is almost all from natural forests. Annual softwood harvests decreased from 8.54 to 6.76 million m^3 during the period of 1985 to 1992. During the period of 1991 to 1993, annual exports of Mexican softwood logs dropped from 62,000 m^3 to zero. At the same time, Mexican annual exports of softwood lumber doubled from 27,000 to 55,000 m^3 with 98% of those exports destined for the United States. Appendix B lists insects that have been intercepted by APHIS on wood products from Mexico.

The major forest producing states are in the northern part of Mexico (states of Chihuahua and Durango), but significant production occurs in other states (Guerrero, Jalisco, Michoacan, and Oaxaca). The forest products industry is regulated by the Ministry of the Environment, Natural Resources and Fisheries [SEMARNAP (Secretario del Medio Ambiente, Recursos Naturales y Pesca)]. Approximately 80% of Mexico's forested lands are communally owned. Mexican law requires that private and communal landowners obtain a Federal permit from SEMARNAP to harvest timber. Permit requests are followed by a private consultant's study collecting stand inventory information and the development of a recommended management plan describing appropriate levels of tree harvest based on tree species, stocking levels, growth rates, and stand structure. SEMARNAP officials review the site plan and, if they approve, issue the harvest permit. SEMARNAP conducts forest and mill inspections and issues export phytosanitary certificates that identify origin of export logs and contain declarations of freedom from pests or required mitigation treatments, or both. SEMARNAP officials may also certify logs destined for export as harvested from healthy forests.

The amount of unprocessed *Pinus* and *Abies* spp. logs exported from Mexico to the United States will depend on, among other factors, Mexican domestic consumption, market prices, and demand from Asian, European, and South American countries. Japan recently imported 3,000 m^3 of raw logs from Mexico and has received previous shipments, as has Peru.

Resources at Risk

The forests of the United States cover in excess of 295 million hectares varying from the sparse noncommercial forests of the interior West to the highly productive forests of the Pacific Coast and the South, and from pure hardwood forests to multispecies mixtures (USDA Forest Service 1990). Log importation from Mexico could have serious adverse impacts on the economic and ecological value of these forests if destructive tree pests were introduced with the logs. Because of the possibility of pine and true fir logs from Mexico being imported to any region of the United States, WIPRAMET has chosen to consider the forest resources throughout the United States as being at risk from pest establishment. Although this risk assessment generally uses specific examples from limited regions when discussing impacts associated with introduced pests, we recognize that forests throughout the United States are potentially at risk and that in addition to economic values, other forest aspects (aesthetic, recreational, and ecological) are also important.

In addition to the extensive natural stands of conifers and hardwoods in the United States, there is a very sizable industry devoted to production of ornamentals and Christmas trees that could be affected by introduced pests. The potential impact on trees with limited range or genetic variability, as well as impacts on trees in the urban environment, also could be significant.

The dominant tree resources at risk within various regions of the country follow. More detailed descriptions of these regions can be found in USDA Forest Service (1990) and USDA APHIS (1994).

Eastern deciduous forest region: This region, which covers the Mid-Atlantic states, the Northeast, and parts of the Southeast, includes oak (*Quercus*)–pine (*Pinus*)–hickory (*Carya*), oak–hickory, sugar maple (*Acer saccharum* Marsh.)–beech (*Fagus grandifolia* Ehrh.), hemlock (*Tsuga*), white pine (*Pinus albicaulis* Engelm.), spruce (*Picea*), and the northern hardwoods.

Southeast region: The southeastern coastal plain region extends from the Texas Gulf Coast to southern New Jersey, including the lower Mississippi River Basin. Oak, pine, and mixed oak–pine forests are characteristic.

North Central and Great Plains regions: The predominant forest types of these regions include aspen (*Populus*)–birch (*Betula*), oak–hickory, northern hardwoods (maple (*Acer*), beech, basswood (*Tilia*)), lowland hardwoods (elm (*Ulmus*), cottonwood (*Populus*), oak, maple), lowland conifers (black spruce (*Picea mariana* (Mill.) B.S.P.), northern white cedar (*Thuja occidentalis* L.), larch (*Larix*)), and mixed pines.

Pacific Northwest region: Extending from mid-coastal California to southern Alaska, this region is characterized by predominantly mixed conifer forests composed of pines, true fir (*Abies*), hemlock, and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Pure pine forests occur in the southern Cascades and on the eastern slope of the Sierra Nevada. Other softwoods, including western larch (*Larix occidentalis* Nutt.), western redcedar (*Thuja plicata* Donn ex. D. Don), redwood (*Sequoia sempervirens* (D. Don) Endl.), and other minor species occur in localized areas.

Pacific Southwest region: Although mostly desert and shrub land, the area comprising mid-coastal California south and east into the desert of the Southwest contains several pine species, Douglas-fir, and incense-cedar (*Libocedrus decurrens* Torr.).

Rocky Mountain region: At lower elevations, dominant trees are broad-leaved deciduous species. Higher elevations are characterized by ponderosa pine (*Pinus ponderosa* Dougl. ex Laws var. *scopulorum*) woodlands, mixed pine–oak woodlands, and Douglas-fir and spruce–fir–hemlock forests.

Chapter 2. Topography, Climate, and Forest Resources of Mexico

Topography

There are two predominant north–south mountain ranges in Mexico: the Sierra Madre Occidental in the western states of Sonora, Chihuahua, Sinaloa, Durango, Nayarit, and northern Jalisco and the Sierra Madre Oriental in the eastern states of Coahuila, Nuevo Leon, Tamaulipas, San Luis Potosi, Queretaro, Hidalgo, Tlaxcala, and Puebla (Fig. 1 and 2). The broad, arid plateau in north-central Mexico, which separates the western and eastern mountain ranges, extends from the border with New Mexico and Texas south to 19°N latitude. Here, the Great Cross Range extends across the states of Jalisco, Michoacan, Mexico, Morelos, and Puebla joining the western and eastern mountain ranges in a series of volcanic peaks reaching 3,000 to 4,000 m above sea level. In the southwestern states of Guerrero and Oaxaca lie the Sierra Madre del Sur, a narrow range of mountains that rise from the Pacific Ocean. The low-lying Isthmus of Tehuantepec forms a barrier between the Sierra Madre del Sur and the Sierra Madre de Chiapas, which merge with the Sierra de Los Cuchumatanes in northwestern Guatemala.

Climate

Mexico has a great variety of climates that range from humid tropical on the narrow coastal plains of the south to cold temperate (and even arctic) in the mountains. Altitude is the most important factor affecting climate. Rapid changes in elevation result in dramatic changes in climate across very short distances.

Most rain in Mexico (90%) occurs during the summer and early fall, with the average rainfall varying from as much as 3,000 mm in the southern states of Tabasco and Chiapas to as little as 200 mm in the deserts of Baja and northwestern Sonora (Fig. 3). In the mountains, annual rainfall ranges from 500 to 1,000 mm in the northern Sierra Madre Occidental; 1,000 to 1,400 mm in the Great Cross Range; and 1,500 to 3,000 mm in the Sierra Madre del Sur and Sierra Madre de Chiapas.

Throughout Mexico, the hottest months are usually March, April, and May just prior to the onset of the rainy season. The coldest months are November, December, January, and February. As with rainfall, mean annual temperature is controlled by altitude rather than latitude (Fig. 4). The lowlands of central and southern Mexico, up to ~460 m above sea level, are tropical with a mean annual temperature of more than 23°C. Subtropical climates with mean annual temperatures of 19 to 24°C are found in the coastal plains of the north and the deep valleys and lower slopes in the south. The central plateau and portions of the eastern and southern Sierra Madre between 1,800 and 2,400 m above sea level are in the warm temperate zone with a mean temperature between 17 and 19°C. Most of the Sierra Madre Occidental and portions of the Great Cross Range at 2,400 to 4,000 m above sea level are in the cold temperate zone with mean temperatures of 10 to 17°C. Arctic conditions are found above 3,000 m.

Forests of Mexico

Of the 192.3 million hectares of land area in Mexico, ~49.6 million hectares are wooded, including coniferous and broad leaf forests. About 25.5 million hectares of these are located in the cold temperate zones at altitudes between 1,500 and 3,000 m and account for 90% of Mexico's forest production (World Forest Institute 1994). The vast majority (90%) of the conifer forests are comprised of *Pinus* stands. Mexico has the greatest variety of *Pinus* species in the world. Perry (1991) described 72 species, varieties, and forms in his book (Table 4). *Abies* is the second most important genus of conifers in Mexico and is represented by six species and two varieties (Liu 1971; Table 5).

The composition of the conifer forests of Mexico varies with latitude, topography, and climate (Loock 1977). Some of the largest forest regions are in the northwestern Sierra Madre Occidental. The northern portions of this mountain range, in the states of Chihuahua and Sonora, are comparatively dry (500–700 mm annual rainfall). The forests are rather open with an understory of various evergreen *Quercus* spp. and taller timber trees of *Pinus arizonica, P. engelmannii, P. leiophylla, P. ayacahuite* var. *brachyptera*, *P. durangensis*, and *P. chihuahuana*. Deep canyons and valleys in this region also support *P. strobiformis.* Sheltered warmer slopes support *P. oocarpa* and *P. lumholtzii,* whereas the drier foothills are occupied by *P. cembroides* and *P. discolor,* along with *Juniperus* spp. and *Quercus* spp.

Figure 1—State boundaries of Mexico.

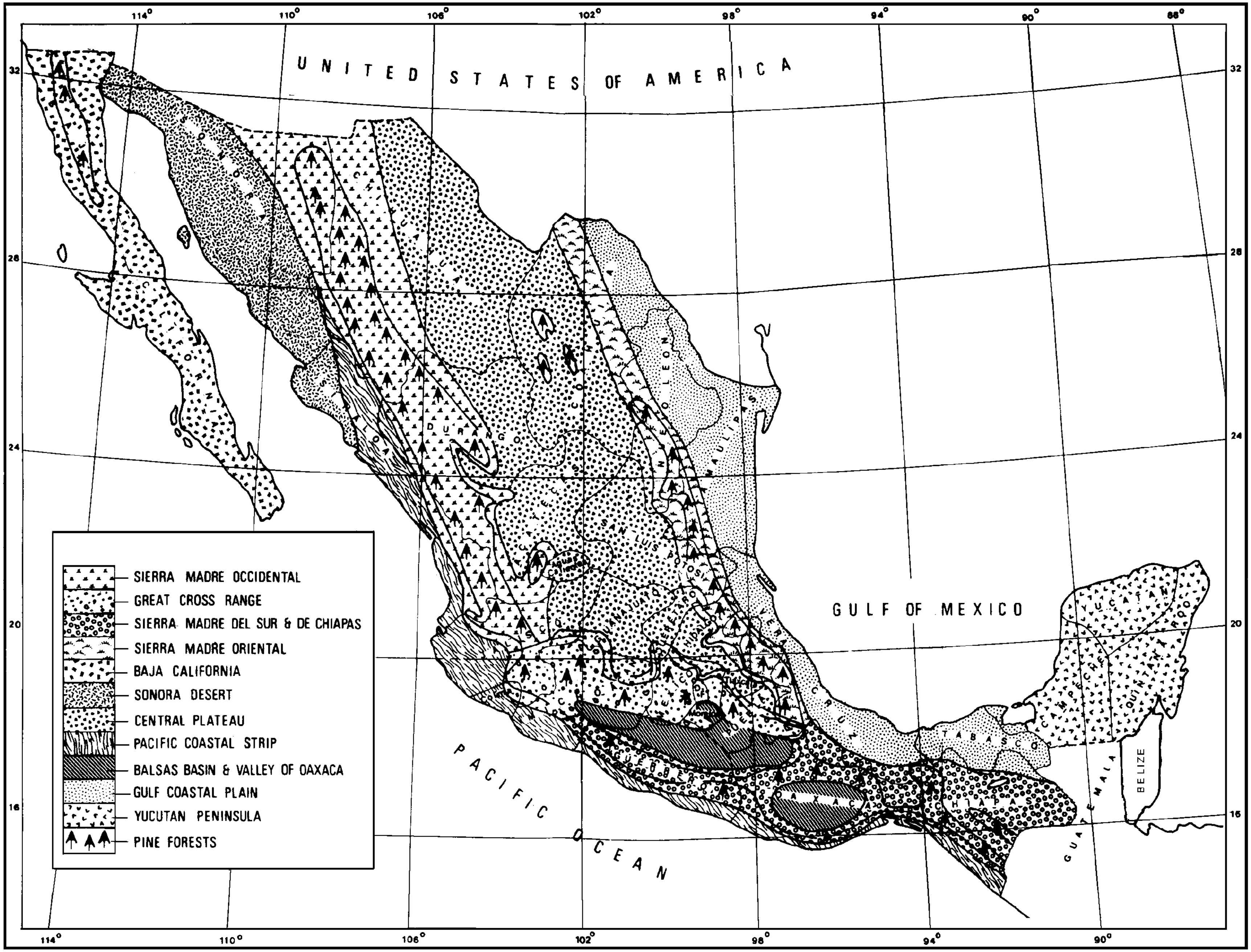

Figure 2—Physiographic divisions and pine forests of Mexico (Loock 1977).

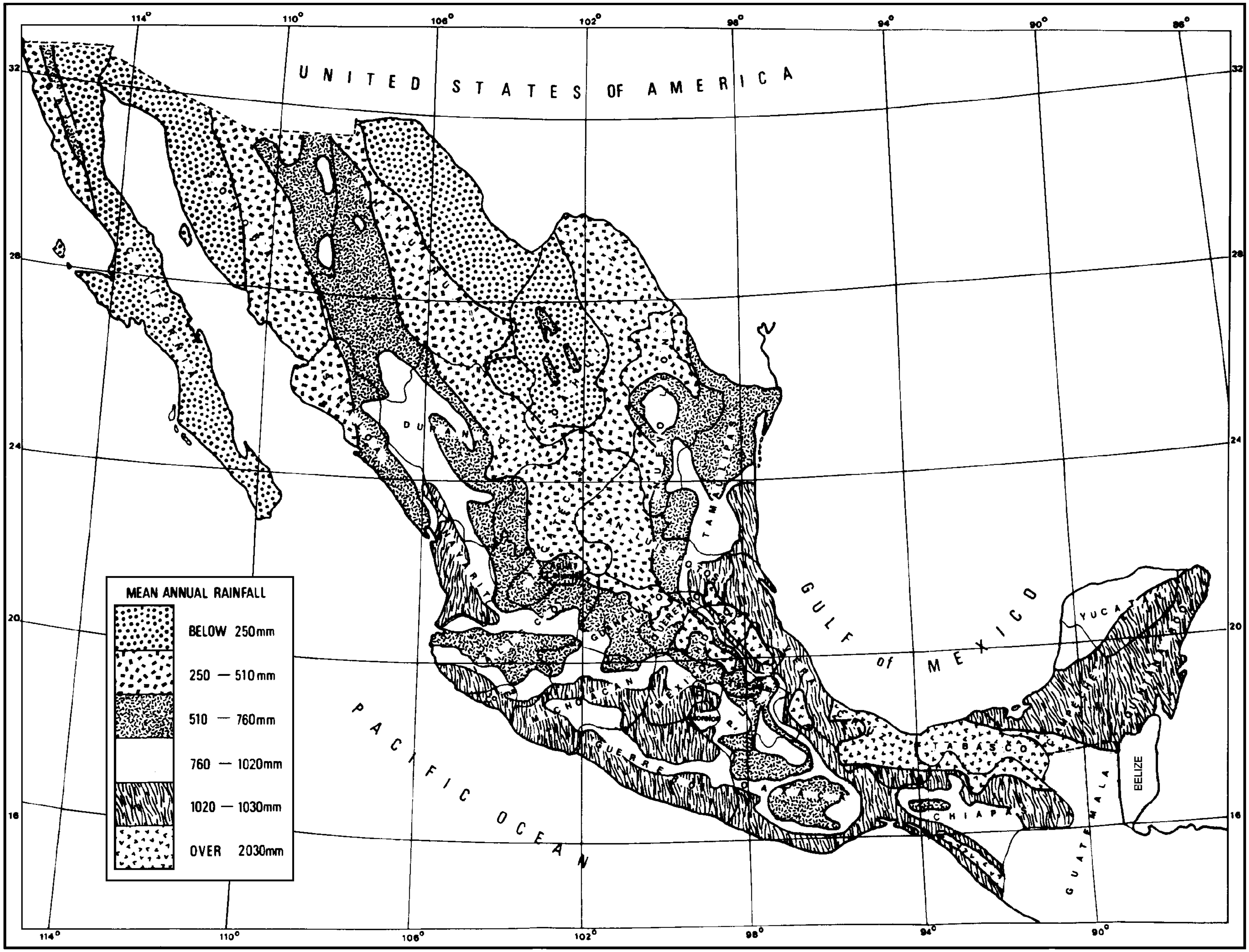

Figure 3—Mean annual rainfall of Mexico (Loock 1977).

Figure 4—Mean annual temperature of Mexico (Loock 1977).

Table 4—Mexican species of *Pinus*

Subgenus Haploxylon	Subgenus Diploxylon	Subgenus Diploxylon—con.
P. lambertiana[a]	*P. leiophylla*	*P. maximinoi*
P. flexilis[a]	*P. chihuahuana*[a]	*P. estevezii*
P. strobiformis[a]	*P. lumholtzii*	*P. pseudostrobus* var. *apulcencis*
P. ayacahuite var. *brachyptera*	*P. jeffreyi*[a]	*P. oaxacana*
P. ayacahuite var. *veitchii*	*P. arizonica*[a]	*P. pseudostrobus* var. *coatepecensis*
P. ayacahuite	*P. arizonica* var. *stormiae*	*P. nubicola*
P. chiapensis	*P. engelmannii*[a]	*P. contorta* subsp. *murrayana*[a]
P. monophylla[a]	*P. durangensis*	*P. radiata* var. *binata*
P. edulis[a]	*P. cooperi*	*P. muricata*[a]
P. remota[a]	*P. montezumae*	*P. attenuata*[a]
P. caterinae	*P. montezumae* var. *lindleyi*	*P. greggii*
P. cembroides[a]	*P. martinezii*	*P. patula*
P. cembroides subsp. *orizabensis*	*P. douglasiana*	*P. patula* var. *longepedunculata*
P. discolor[a]	*P. rudis*	*P. oocarpa*
P. johannis	*P. hartwegii*	*P. oocarpa* var. *ochoterenai*
P. lagunae	*P. michoacana*	*P. oocarpa* var. *trifoliata*
P. quadrifolia[a]	*P. michoacana* var. *cornuta*	*P. oocarpa* var. *microphylla*
P. juarezensis	*P. michoacana* var. *quevedoi*	*P. jaliscana*
P. culminicola	*P. michoacana* forma *procera*	*P. pringlei*
P. pinceana	*P. michoacana* forma *nayaritana*	*P. teocote*
P. maximartinezii	*P. pseudostrobus*	*P. lawsoni*
P. nelsoni	*P. pseudostrobus* forma *protuberans*	*P. herrerai*
P. rzedowskii	*P. pseudostrobus* forma *megacarpa*	*P. coulteri*[a]

[a]Species found in the United States.

Table 5—Mexican species of *Abies*

Abies concolor var. *concolor*[a]
A. durangensis var. *durangensis*
A. durangensis var. *coahuilensis*
A. guatemalensis
A. hickeli
A. vejari var. *vejari*
A. vejari var. *mexicana*
A. religiosa

[a]Species found in the United States.

The forests within the state of Durango receive more rainfall (760–1,000 mm per annum) than those in Chihuahua and Sonora (500–700 mm per annum). The forest overstories in Durango contain a variety of *Pinus* species, and the undergrowth includes *Quercus* spp. and *Arbutus* spp. in the higher elevations with *Juniperus* spp. and *Cupressus* spp. on the lower slopes. *Pinus durangensis* and *P. cooperi* form comparatively dense forests at altitudes of 2,300 to 2,750 m along the high mountain ranges in the west with *P. teocote* and *P. leiophylla* occurring in the more sheltered locations. *Pinus engelmannii, P. arizonica,* and *P. chihuahuana* are found in the east on extensive flat mesas where conditions are drier, and *P. ayacahuite* var. *brachyptera* and *P. strobiformis* occur in deep valleys with moist alluvial soils. The lower, sheltered slopes in the warmer parts of Durango support fairly well-stocked stands of *P. michoacana* var. *cornuta, P. oocarpa, P. lumholtzii, P. herrerai,* and *P. leiophylla*.

The southwestern Sierra Madre Occidental, in the states of Nayarit, Zacatecas, and Jalisco, have a warm temperate to subtropical climate. This area forms a connecting link between the northern and southern mountain ranges. The pine forests in this area are similar to those of southern Mexico and include many of the southern species, such as *P. douglasiana*, *P. pseudostrobus, P. montezumae*, *P. maximinoi, P. michoacana*, and *P. rudis*. The northern species, *P. lumholtzii* and *P. chihuahuana*, can be found on drier slopes.

The higher portions (above 2,400 m) of the Great Cross Range in the states of Mexico, Puebla, Vera Cruz, and Michoacan are in the cold temperate zone with annual rainfall from 800 to 1,300 mm. *Pinus montezumae* and *P. pseudostrobus* are the most important timber species at altitudes between 2,400 and 2,700 m. These species form dense forests, often in association with *P. michoacana* and *Abies religiosa*. Above 2,700 m is a cooler region occupied by *P. rudis* and scattered *P. montezumae.* Pure, dense forests of *A. religiosa* are found at altitudes of 2,900 m grading into mixtures with *P. hartwegii* at 3,000 m. A belt of pure *P. hartwegii* forests is found from 3,300 m up to the snow line.

A warmer temperate zone is found at lower altitudes of 1,800 to 2,400 m in the Great Cross Range. The lower limits of this zone contain stands of *P. lawsoni*, *P. herrerai, P. maximinoi, P. leiophylla,* and *P. michoacana,* while higher altitudes support *P. montezumae* and *P. pseudostrobus.* Some of the best and most dense forests of Mexico are found in this zone.

Below 1,800 m in the Great Cross Range is the subtropical zone. The lower slopes up to 1,200 m are covered by junipers, scrub oaks, and other hardwoods. *Pinus leiophylla, P. oocarpa,* and *P. lawsoni* appear in mixture with the oaks from 1,200 m up to 1,500 m. Above that altitude, the oaks are replaced by *P. pringlei, P. michoacana, P. douglasiana,* and *P. montezumae* with occasional *P. pseudostrobus, P. maximinoi, P. herrerai,* and *P. teocote.*

The Sierra Madre del Sur and the Sierra Madre de Chiapas, in the states of Guerrero, Oaxaca, and Chiapas, are subject to a warm temperate climate at elevations above 1,800 m. The high mesas support dense forests of *P. pseudostrobus, P. oaxacana, P. maximinoi, P. douglasiana, P. teocote,* and *P. ayacahuite.* Below 1,800 m, the climate is subtropical and the pines (*P. leiophylla*, *P. lawsoni*, *P. oocarpa*, *P. pringlei*, and *P. chiapensis*) are mixed with scrub oak and other hardwoods.

The Sierra Madre Oriental in the east are much narrower and longer than the Sierra Madre Occidental in the west. Some excellent forests are found in the southern portions of the Sierra Madre Oriental in the states of Puebla, Vera Cruz, and Hidalgo. The cold temperate zone is limited to a few volcanic peaks supporting forests of *A. religiosa, P. montezumae, P. rudis, P. teocote, P. hartwegii,* and *P. leiophylla.* Some of the best forests of Mexico are located in the warm temperate zone of this region. Pure, dense stands of *P. patula* are common on the cool eastern slopes at altitudes of 1,800 to 2,400 m. The lower, drier slopes on the western side of this region support more open forests of *P. pseudostrobus, P. oaxacana, P. michoacana* var. *cornuta, P. teocote, P. montezumae, P. oocarpa,* and *P. patula*.

The northern portions of the Sierra Madre Oriental in the states of San Luis Potosi, Tamaulipas, Nuevo Leon, and Coahuila consist of numerous mountain ranges broken by deep canyons with steep rocky slopes. The ranges and mesas above 1,500 m are in a warm temperate climatic zone. Fairly dense forests of *P. strobiformis* and *P. rudis* mixed with *A. vejari* and *Pseudotsuga menziesii* are found on the tops of the mesas. More open forests with *P. rudis* and *P. montezumae* occur on the higher slopes while *P. cembroides* or *P. nelsoni* mixed with oaks can be found on the lower slopes. Below 1,500 m is a subtropical zone covered by dense growth of scrub oaks.

The Sierra de Juarez and Sierra de San Pedro, in the northern part of Baja California, vary from warm to cool temperate with an average annual rainfall of 380 to 630 mm. The pine forests in this region are restricted to the temperate zones and are the southern-most range of some Californian *Pinus* species such as *P. contorta* var. *murrayana*, *P. coulteri*, *P. jeffreyi*, and *P. lambertiana.*

Forest Management

Nearly 80% of Mexico's forested lands are communally owned by ejidos and comunales (World Forest Institute 1994). The ejidos originated immediately following the Mexican Revolution, when large, once-private haciendas were claimed by the federal government and divided among private parties interested in managing them. The comunales, although very similar, existed long before the revolution. In both cases, decisions are made by the collective of owners and profits are shared among members. The remaining forest lands are 15% private and 5% public holdings. Most of the public lands are in national parks or preserves.

The Mexican government promotes rational utilization of the natural forests through sustainable management. Under the forest law of 1992 and the 1994 code of regulations, forest management activities on all lands involving harvesting and reforestation are regulated by SEMARNAP. The ejidos, comunales, or proprietors that wish to manage their forests must submit a Forestry Management Program to SEMARNAP for approval. The programs must include plans developed by certified consultants for harvesting under environmental regulations established by the federal government.

Forest Products

The major timber producing states are in the northern part of Mexico (Table 6):

Most of the softwood produced is used for lumber for domestic construction with other important uses including veneer and plywood, molding, flooring, manufactured doors, windows, and furniture. Other uses for wood include posts, boxes, rail ties, fuelwood, and pulp for paper (Fig. 5).

Table 6—Primary timber producing states in Mexico

Region	State	Share[a] (%)
Sierra Madre Occidental	Durango	20.8
	Chihuahua	23.7
Great Cross Range	Michoacan	6.6
	Jalisco	5.8
Sierra Madre del Sur	Oaxaca	5.7
	Guerrero	6.7
	Other	30.7

[a]Of the total production in 1993 (World Forest Institute 1994).

Comparison of Mexican and United States Forest Ecosystems

The forest ecosystems of Mexico and the United States are highly variable, both east to west and north to south. This variability is a result of climatic, soil, and biogeographical influences. The variation in plant species has led to variation in injurious insects and pathogens. Similarities do exist between Baja California and California and parts of Arizona, New Mexico, and Texas and the northern states of Mexico because of their contiguous nature. Baja California and California share a Mediterranean climate with warm, dry summers and wet winters. Likewise, the southwestern United States and northern and central Mexican states have similar moisture conditions with dry winters and moist summers. Parts of these states have floristic and physiographic continuity to each other (McLaughlin 1995). Although much of the southeastern United States does not share a border with Mexico, climates in the two areas do have some similarity. However, due to the great variety of climates in Mexico, from tropical to arctic, it is reasonable to assume that almost any forest in the United States could be favorable for the survival and spread of insects and pathogens from Mexico.

While wood products have been routinely extracted from Mexican forests, most have been for internal or local consumption. Historically, Mexico has been a net importer of wood products with relatively little export of raw wood products into the United States. This is changing rapidly (World Forest Institute 1994). This change in commerce could have a profound effect upon the distribution of indigenous organisms established through natural migration. For example, the region of northern Mexico and bordering southwestern United States possesses numerous "sky islands," which function as discrete isolated ecosystems.

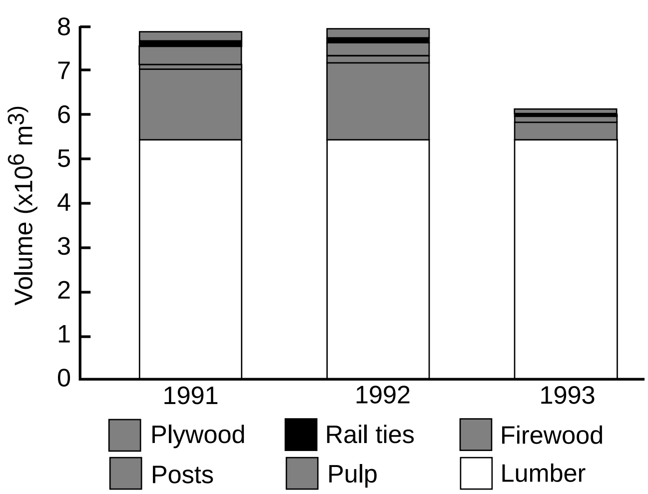

Figure 5—Volume of Mexican wood products by year (World Forest Institute 1994).

To date, there has been little extraction and shipment of wood from these ecosystems. Topography is known to dictate species distribution (Warshall 1995), and Mexico possesses a number of mountain ranges and continental deserts that have served to maintain discrete ecosystem assemblages. These topographical and climatic regions also have served as natural barriers to dispersal, survival, and colonization of plants and animals. Hence, extraction and transport of logs with attendant pests could breach these natural barriers and increase the risk of relocating organisms both within Mexico and into the United States.

The coniferous forests of the Sierra Madre Occidental continue north into southern Arizona and New Mexico. The forests of Baja California also continue north into southern California. These forests, however, are discontinuous and occur on cordilleras and volcanic peaks (Little 1962). Several species of Mexican pines have discontinuous ranges on these peaks. They may have become established during glacial epochs and subsequently have been separated by desert valleys (Little 1962). These valleys function as barriers to invasion by new species, and the islands of forests become cradles of evolution (Warshall 1995). The valleys also may limit spread of species between forests to the north and south. This includes plant species and the organisms that attack them. Many of the plants and animals of the Sierra Madre Occidental are more commonly associated with the neotropics to the south than with areas to the north in the United States (Felger and Johnson 1995). These Sierra Madre Occidental species are more susceptible to periodic climatic extremes of drought or cold temperature than those species to the north, and the presence of local populations of some of these organisms can be greatly influenced by drought or cold temperatures. The injurious organisms that are associated with these communities or ones further south may not survive for extended periods in areas of the United States that are prone to adverse conditions.

Chapter 3. Insects and Pathogens Posing Risk

Introduction

The probability of pest introduction is determined by several related factors, including the likelihood of a pest traveling with and surviving on a shipment from the place of origin, the likelihood of a pest colonizing suitable hosts at the point of entry and during transport to processing sites, and the likelihood of subsequent pest spread to adjacent territories. Many insects and pathogens could be introduced on logs from Mexico into the United States. Because it would be impractical to analyze the risk of all of them, some form of selection was necessary. Selection was based on the likelihood of the pest being on or in the logs and on their potential risk to resources in the United States. The pest risk assessment team compiled and assessed pertinent data using the methodology outlined in Pest Risk Assessment Process in Chapter 1 and as used in previous pest risk assessments (USDA 1991, 1992, 1993).

Analysis Process

Information on organisms associated with Mexican species of *Pinus* and *Abies* was collected. Lists of insects and microorganisms that have been reported to inhabit these tree genera in Mexico were compiled from the literature, from information provided by Mexican forest entomologists and pathologists, from information received from reviewers of a preliminary list prepared by the team, and from information received as result of other outreach efforts. These organisms were cataloged using the five categories described in Chapter 1. The team broadened some of the categories identified in the log import regulations (Title 7 CFR 319.40-11) (Table 7). These organisms were assessed as described previously in Chapter 1, under Pest Risk Assessment Process.

Individual Pest Risk Assessments

The species of insects and pathogens associated with species of *Pinus* and *Abies* in Mexico and identified as potential pests of concern are presented in Tables 8 through 11. The lists include 39 pathogens and 30 insects. Twenty-two Individual Pest Risk Assessments (IPRAs) were prepared for *Pinus*, 12 dealing with insects and 10 with pathogens. Six IPRAs were prepared for *Abies*. The objective was to include in the IPRA representative examples of insects and pathogens found on the bark, in the bark, and in the wood that would have the greatest potential risk to forests of the United States. The team recognizes that these may not be the only organisms associated with Mexican logs. They are, however, representative of the diversity of insects and pathogens that inhabit logs. By necessity, the IPRAs focus on those insects and pathogens for which biological information is available. Assessing the risks associated with known organisms that inhabit a variety of niches on logs will enable U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) to identify effective mitigation measures to eliminate both the known organisms and any similar heretofore unknown organisms that inhabit the same niches. Summary tables of the IPRA results can be found in Chapter 4.

Table 7—Pest categories and descriptions

Category	Description
1	Nonindigenous plant pest not present in the United States
2	Nonindigenous plant pest present in the United States and capable of further dissemination in the United States
2a	Native plant pest of limited distribution in the United States but capable of further dissemination in the United States
3	Nonindigenous plant pest present in the United States that has reached probable limits of its ecological range but differs genetically from the plant pest in the United States in a way that demonstrates a potential for greater damage potential in the United States
4	Native species of the United States that has reached probable limits of its ecological range but differs genetically from the plant pest in the United States in a way that demonstrates a potential for greater damage potential in the United States
4a	Native pest organisms that may differ in their capacity for causing damage, based on genetic variation exhibited by the species
5	Nonindigenous or native plant pest that may be able to vector another plant pest that meets one of the above criteria

Table 8—Potential insects of concern associated with *Pinus* spp. in Mexico, including known host species, location on host, and pest category

Species	Hosts	Foliage/ on bark	In bark/ cambium	Sapwood	Heartwood	Pest category[a]
Coloradia sp.	*P. durangensis, P. montezumae*	X				1
Coptotermes crassus	*P. maximinoi, P. oocarpa*		X	X	X	1
Dendroctonus mexicanus	*P. ayacahuite, P. arizonica, P. cembroides, P. chihuahuana, P. cooperi, P. douglasiana, P. durangensis, P. engelmannii, P. greggii, P. hartwegii, P. herrerai, P. lawsoni, P. leiophylla, P. maximinoi, P. michoacana, P. montezumae, P. patula, P. pinceana, P. pseudostrobus, P. rudis, P. teocote*		X			1
Dendroctonus rhizophagus	*P. arizonica, P. ayacahuite* var. *brachyptera, P. chihuahuana, P. cooperi, P. durangensis, P. engelmannii, P. jeffreyi, P. herrerai, P. leiophylla, P. lumholtzii, P. michoacana* var. *cornuta, P. ponderosa, P. sylvestris*		X			1
Eutachyptera psidii	*P. leiophylla, P. patula,*	X				1
Evita hyalinaria blandaria	Rare on *Pinus* spp.	X				1
Gnathotrichus nitidifrons	*P. cooperi, P. leiophylla, P. montezumae*			X		1
Gnathotrichus perniciosus	*P. chiapensis, P. leiophylla, P. montezumae, P. oocarpa, P. pseudostrobus*			X		1
Hylesia frigida	*P. ayacahuite, P. greggii, P. maximinoi, P. oaxacana, P. oocarpa, P. oocarpa* var. *ochoterenai*	X				1
Hylurgops planirostris	*P. hartwegii, P. leiophylla, P. montezumae, P. pseudostrobus*		X			2a
Hylurgops subcostulatus alernans	*P. ponderosa, P. leiophylla*		X			2a
Hylurgops incomptus	*Pinus* spp.		X			2a
Hylurgops longipennis	*P. leiophylla, Pinus* spp.		X			1
Ips bonanseai	*P. arizonica, P. ayacahuite, P. cembroides, P. chihuahuana, P. durangensis, P. engelmannii, P. flexilis, P. hartwegii, P. leiophylla, P. montezumae, P. oocarpa, P. patula, P. ponderosa, P. pseudostrobus, P. rudis*		X			2a
Lophocampa alternata	*P. ayacahuite, P. hartwegii, P. rudis*	X				1
Monochamus clamator rubigineus	*P. greggii, P. patula, P. rudis*		X	X	X	2a, 5
Pandeleteius viridiventris	*P. ayacahuite, P. hartwegii, P. montezumae, P. rudis*	X				1
Pineus spp.	*P. ayacahuite, P. cembroides, P. douglasiana, P. hartwegii, P. maximinoi, P. montezumae, P. oocarpa, P. radiata*	X				4a
Pissodes cibriani	*P. patula*		X			1
Pissodes guatemaltecus	*P. montezumae, P. tecunumanii*		X			1
Pissodes zitacuarence	*P. patula, P. hartwegii, P. arizonica, P. durangensis, P. montezumae, P. ayacahuite* var. *brachyptera*		X			1
Preptos hidalgoensis	*P. leiophylla, P. patula, Quercus* spp.	X				1
Pterophylla beltrani	*Acacia* spp., *Acer* spp., *Cordia* spp., *Cornus* spp., *Juglans* spp., *Platanus* spp., *Prosopis* spp., *Quercus* spp., oviposits on *Pinus* spp.	X				1
Rhyacionia cibriani	*P. hartwegii*	X				1
Synanthedon cardinalis	*P. patula, P. radiata, P. hartwegii, P. leoiphylla, P. lawsoni*		X			1
Xyleborus volvulus	*P. oocarpa*			X		2a
Zadiprion falsus	*P. arizonica, P. ayacahuite ,P. douglasiana, P. engelmanii, P. durangensis, P. leoiphylla, P. michoacana, P. montezumae, P. oocarpa, P. pseudostrobus, P. radiata, P. teocote*	X				1

[a]See Table 7 for pest category descriptions.

Table 9—Potential pathogens of concern associated with *Pinus* spp. in Mexico, including known host species, location on host, and pest category

Species	Hosts	Foli-age/ other	Bark cam-bium	Sap-wood	Heart-wood	Pest category[a]
Arceuthobium aureum subsp. *petersonii*	*P. michoacana, P. montezumae, P. oaxacana, P. oocarpa, P. patula, P. pseudostrobus*		X	X		1
Arceuthobium durangense	*P. douglasiana, P. durangensis, P. herrerai, P. michoacana, P. pseudostrobus, P. montezumae, P. oocarpa (?)*		X	X		1
Arceuthobium globosum subsp. *globosum*	*P. arizonica, P. cooperi, P. durangensis, P. engelmannii, P. rudis (?)*		X	X		1
Arceuthobium globosum subsp. *grandicaule*	*P. douglasiana, P. durangensis, P. hartwegii, P. lawsonii, P. maximinoi, P. michoacana, P. patula, P. pringlei, P. pseudostrobus, P. rudis, P. teocote, P. montezumae*		X	X		1
Arceuthobium guatemalense	*P. ayacahuite* var. *ayacahuite*		X	X		1
Arceuthobium nigrum	*P. lawsonii, P. leiophylla* var. *chihuahuana, P. leiophylla* var. *leiophylla, P. lumholtzii, P. montezumae, P. oaxacana, P. patula, P. teocote, P. pseudostrobus*		X	X		1
Arceuthobium oaxacanum	*P. lawsonii, P. michoacana, P. oaxacana, P. pseudostrobus*		X	X		1
Arceuthobium pendens	*P. discolor, P. orizabensis*		X	X		1
Arceuthobium rubrum	*P. cooperi, P. durangensis, P. engelmanni, P. herrerai, P. teocote*		X	X		1
Arceuthobium strictum	*P. leiophylla* var. *chihuahuana, P. teocote*		X	X		1
Arceuthobium vaginatum subsp. *vaginatum*	*P. arizonica* var. *arizonica, P. arizonica* var. *stormiae, P. cooperi, P. durangensis, P. engelmannii, P. hartwegii, P. herrari, P. lawsonii, P. montezumae, P. patula, P. rudis, P. teocote*		X	X		1
Arceuthobium verticilliflorum	*P. arizonica* var. *arizonica, P. cooperi, P. durangensis, P. engelmannii*		X	X		1
Arceuthobium yecorense	*P. durangensis, P. engelmannii, P. herrerai, P. leiophylla* var. *chihuahuana, P. lumholtzii*		X	X		1
Armillaria spp.	*Pinus* spp., *P. arizonica, P. hartwegii, P. montezumae, P. radiata*		X	X	X	4a
Bursaphelenchus xylophilus	*Pinus* spp.		X	X	X	4a
Ceratocystiopsis collifera	*P. teocote*			X		1
Cronartium arizonicum	*P. arizonica, P. cooperi, P. durangensis, P. engelmannii, P. michoacana*		X	X		2a, 4a

Table 9—Potential pathogens of concern associated with *Pinus* spp. in Mexico, including known host species, location on host, and pest category—con.

Species	Hosts	Foli-age/ other	Bark cam-bium	Sap-wood	Heart-wood	Pest category[a]
Cronartium conigenum	*P. arizonica, P. caribea, P. cembroides, P. chihuahuana, P. cooperi, P. douglasiana, P. durangensis, P. engelmannii, P. halepensis, P. hartwegii, P. lawsoni, P. leiophylla, P. lumholtzii, P. michoacana, P. montezumae, P. oocarpa, P. patula, P. ponderosa, P. radiata, P. rudis, P. pseudostrobus, P. teocote*		X	X		2a, 4a
Dothistroma septospora	*P. ayacahuite, P. culminicola*	X	X			4a
Fusarium subglutinans f. sp. *pini*	*P. arizonica, P. ayacahuite, P. cembroides, P. discolor, P. douglasiana, P. durangensis, P. gregii, P. halepensis, P. hartwegii, P. leiophylla, P. maximinoi, P. michoacana, P. montezumae, P. oaxacana, P. oocarpa, P. pringlei, P. pseudostrobus, P. radiata, P. rudis*		X	X		2a, 4a
Heterobasidion annosum	*P. ayacahuite, P. ayacahuite* var. *veitchi, P. douglasiana, P. greggii, P. herrerai, P. lawsonii, P. leiophylla, P. michoacana, P. montezumae, P. oocarpa, P. patula, P. pringlei, P. pseudostrobus, P. rudis*		X	X	X	4a
Hypoderma mexicanum	*P. cooperi, P. engelmannii, P. durangensis, P. leiophylla, P. teocote*	X				1
Lophodermella maureri	*P. ayacahuite*	X				1
Ophiostoma conicolum	*P. cembroides*	X				1
Peridermium harknessii	*P. contorta, P. jeffreyi*		X	X		4a
Peridermium pini	*P. lawsoni*		X	X		1
Phellinus spp.	*Pinus* spp.		X	X	X	4a
Psittacanthus americanus	*P. montezumae, P. teocote*		X	X		1
Psittacanthus calyculatus	*P. douglasiana, P. herrerai, P. leiophylla, P. michoacana, P. montezumae, P. pringlei, P. pseudostrobus, P. rudis, P. teocote, A. religiosa*		X	X		1
Psittacanthus macrantherus	*P. engelmannii, P. herrerai, P. lawsoni, P. lumholtzii, P. oocarpa, P. pseudostrobus*		X	X		1
Psittacanthus schiedeans	*P. leiophylla, P. montezumae, P. teocote*		X	X		1
Sphaeropsis sapinea	*P. arizonica, P. eldarica, P. greggii, P. halepensis, P. pseudostrobus*	X	X	X		4a
Struthanthus deppeanus	*P. patula*		X	X		1
Struthanthus micorphyllus	*P. leiophylla, P. montezumae, P. pseudostrobus*		X	X		1
Struthanthus interruptus	*P. lawsoni*		X	X		1
Struthanthus quercicola	*Pinus* spp.		X	X		1

[a]See Table 7 for pest category descriptions.

Table 10—Potential insects of concern associated with *Abies* spp. in Mexico, including known host species, location on host, and pest category

Species	Hosts	Foliage/ other	Bark cam- bium	Sap- wood	Heart- wood	Pest category[a]
Evita hyalinaria blandaria	*Abies religiosa*	X				1
Lophocampa alternata	*A. religiosa*	X				1
Pityophthorus blackmani	*A. religiosa*		X			1
Pityophthorus elatinus	*A. religiosa*		X			1
Pseudohylesinus magnus	*A. religiosa*		X			1
Pseudohylesinus variegatus	*A. religiosa, A. vejarii*		X			1
Scolytus mundus	*A. religiosa*		X			1
Scolytus aztecus, S. virgatus, S. hermosus	*A. religiosa, A. durangensis, Pseudotsuga menziesii*		X			1

[a]See Table 7 for pest category descriptions.

Table 11—Potential pathogens of concern associated with *Abies* spp. in Mexico, including known host species, location on host, and pest category

Species	Hosts	Foliage/ other	Bark cam- bium	Sap- wood	Heart- wood	Pest category[a]
Arceuthobium abietis-religiosae	*A. religiosa* var. *emarginata, A. religiosa* var. *religiosa, A. vejarii*		X	X		1
Armillaria spp.	*Abies* spp.		X	X	X	4a
Heterobasidion annosum	*Abies* spp.		X	X	X	4a
Ophiostoma abietinum	*A. vejarii*		X	X	X	1
Phellinus spp.	*Abies* spp.		X	X	X	4a
Phoradendron abietinum	*A. durangensis*		X	X		1

[a]See Table 7 for pest category descriptions.

Insects

Adelgids

Assessor—William E. Wallner

Scientific names of pest—*Pineus* and *Adelges* spp. (Homoptera: Adelgidae)

Distribution—Mexican states of Chihuahua, Coahuila, Durango, Distrito Federal, Estado de Mexico, Hidalgo, Jalisco, Michoacan, Puebla, Oaxaca, and Tlaxcala

Scientific names of hosts in Mexico—*Pinus ayachuite, P. cembroides, P. douglasiana, P. hartwegii, P. maximinoi, P. montezumae, P. oocarpa, P. radiata*, and *Abies* spp.

Summary of natural history and basic biology of the pest—While considered major pests to various *Pinus* spp., the taxonomy and distribution of distinct adelgid species in Mexico is not known. Most species alternate their life history between two different conifer hosts. Serious damage has been observed on *Pinus ayacahuite*, but other conifers including *Abies* spp. are commonly attacked. The various adelgid species are very small and easily overlooked. Additionally, proper identification requires microscopic examination and is complicated by the occurrence of mixed adelgid species on the same host(s).

Adelgids have demonstrated the unpredictability of their impact when introduced into new areas with new hosts. In the past, this has been devastating as evidenced by the balsam woolly adelgid (*Adelges piceae*), introduced into North America from western Europe (Mitchell and others 1970) and the hemlock woolly adelgid (*Adelges tsugae*), introduced into North America from Asia (Souto and others 1996). Adelgids may have several generations per year; most commonly, nymphs overwinter under bark of the main trunk or bark scales on branches. However, during the growing season, all life stages may be present at the same time. While males may be found in admixture with females, they are not essential since females can reproduce parthogenetically. Eggs, up to 100 or more, are laid under protective waxy secretions on or under the bark or on twigs or foliage. The eggs hatch in a few days producing crawlers that have limited vagility but can be moved from tree to tree by the wind or long distances by birds or other animals. Once a suitable host and location are encountered, nymphs insert their stylets into the tissues causing internal damage to the host. Damage varies with the adelgid species and host; it may be a reduction in growth, distortion of shoots and needles, or when populations are dense, premature needle cast. There are two to four generations per year depending on the adelgid species and geographic locale. The hardy, long-lived overwintering nymphs could be transported on trees or logs with bark and be expected to survive. As has been observed with the hemlock woolly adelgid, early nymphal instars are readily transported with high survival rates (M.S. McClure, 1996, personal communication). While all life stages would pose risks, females, which need not mate to reproduce, are a major colonization threat.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Low* (*MC*)
   Adelgids are widely distributed in Mexico but are particularly numerous during dry periods that coincide with timber harvesting activities. Some species would have high likelihood of occurrence, while for others, likelihood would be lower due to the specific microsites on the host that they occupy (bole compared with twigs). Some are considered pests at origin and cause serious damage to plantations, particularly *Pinus ayachuite* Christmas tree cultures. Past adelgid introductions into the United States have been traced to live plant material. Reports from Mexico suggest that adelgids occur principally on immature trees, thus their affiliation with logs is expected to be low.

2. Entry potential: *High* (*RC*)
   Since several generations occur each year with overlapping developmental stages, this increases the risk of various life stages being available for transport. The nymphal stage, which most commonly overwinters, is most likely transported and is almost undetectable under bark scales.

3. Colonization potential: *Moderate* (*RC*)
   Although adelgids only attack conifers, there are more than 70 conifer species in western North America, which enhances the possibility of successful colonization. Since they can reproduce parthogenetically, few individuals would be required to initiate colonization. Eggs or nymphs are most likely to be the initiator of a population. Both of these life stages would have difficulty dispersing from logs onto a suitable live host because they have limited mobility.

4. Spread potential: *High* (*RC*)
   Although nymphal spread is local, adelgids are commonly spread by birds and mammals across long distances (>16–24 km per year). Introduced adelgids have demonstrated a propensity to spread. For example, the balsam woolly adelgid was first detected in North America on the West Coast in 1928. By 1930, it had spread to the Willamette Valley in Oregon, and by 1954, to Mount Saint

Helens in Washington; more than 240,000 ha were infested by 1957. It had spread to Vancouver Island and Vancouver, British Columbia, by 1959. Winged females are vagile but are capable of only short distance spread, which could limit host selection and spread.

B. Consequences of pest establishment

5. Economic damage potential: *High* (*RC*)
Past introductions of adelgids have convincingly demonstrated that this group of insects colonizes well and is capable of killing trees (Mitchell and others 1970, Souto and others 1996, Furniss and Carolin 1977, Johnson and Lyon 1988). In Mexico, host trees for the genus *Pineus* include both subgenera of *Pinus*, which increases the likelihood that the insects could find hosts in the United States and could cause economic damage.

   Based on Mexican damage patterns (Cibrián Tovar and others 1995), damage from adelgids introduced from Mexico would most likely be to pine plantations. If *Pineus* spp. became established in the U.S. southern pine region, where extensive pine plantations exist, at least 3.44 million ha (Moulton and others 1996) could be at risk (assuming a high susceptibility of trees up to 5 years old). With the assumption that 1% of the plantations would be killed per year and that the lost growth and replanting cost would be $98 per ha, annual losses would be $20.7 million per year. The net present value over 30 years, assuming a rapid 10-year establishment period, would be $258 million, using a 4% discount rate.

6. Environmental damage potential: *High* (*MC*)
Other introduced adelgids (balsam woolly adelgid, hemlock woolly adelgid) have caused total destruction of hosts in certain ecosystems. This results in dramatic shifts in species composition. Pines of the West and Southeast, particularly those in managed plantations, would be at greatest risk.

7. Perceived damage potential: *High* (*MC*)
Given the likelihood that trees in forests, plantations, and urban areas will be attacked and damaged, impacts can be expected to vary. Plantations and urban areas would probably receive the greatest level of management response, including increased pesticide use. In western North America, there are more than 70 species of conifers, many occurring contiguously. The range of spread would probably proceed unimpeded through this coniferous resource of *Pinus* and *Abies.* In the southern pine regions and mountainous plantations of fir in the Southeast, valuable resources would be at risk from *Adelges* or *Pineus* introductions.

C. Pest risk potential: *Moderate*
Because of the difficulty of detecting the minute life stages, infestations would probably go unnoticed until damage was evident. This would ensure unimpeded spread of the insect by both human and natural transport mechanisms. Since there is incomplete information on what *Adelges* and *Pineus* spp. are present in Mexico and what their host associations are, assessment of risk is difficult. However, past introductions of this insect group have had devastating consequences to coniferous ecosystems in the western, eastern, and southern United States.

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Reviewers' comments—"I question whether *Pineus* sp. in Mexico merits a moderate PRA. According to Cibrián and others (1995), no species of *Adelges* is known to occur on pine or fir in Mexico and there is only one species of *Pineus*. In the Chilean pest risk assessment, we rated *Pineus böneri* as no risk, since it already occurs in the U.S. and causes little or no economic impact. It is very unlikely that *Pineus* sp. in Mexico (which causes damage very similar to that of *P. böneri*) would cause economic impacts of the same magnitude as those of *Adelges* previously introduced into the U.S. The consequences of establishment of *Pineus* sp. should be rated as moderate to low, yielding a low pest risk assessment. Furthermore, the economic analysis of potential damage given in the IPRA appears inflated, since *Pineus* seldom kills trees and would likely be of importance only in Christmas tree plantations on occasional sites." (Billings)

"Pest with host at origin. We suggest a medium rating rather than a low rating based on the first statement in 7. Perceived damage potential 'given the likelihood that trees in forests, plantations, and urban areas will be attacked and damaged, impacts can be expected to be varied. Plantations and urban systems would probably receive the greatest level of management response. . ..' Sounds like more than a low 'pest with host at origin' to us." (Johnson/Griesbach)

"The written account on Adelgids is quite good. However, based on reports from Mexico that 'suggest adelgids occur principally on immature trees' it is concluded that 'their affiliation with logs is expected to be low;' hence, the 'probability of pest with host at origin' is *low* (with moderate certainty-MC). Since almost all other probabilities were rated HIGH, it appears that the final Pest Risk Potential of *Moderate* is based on that *low* rating. If one examines the reports of adelgids in the US, we believe that one would find similar associations with immature trees; for one reason, they are easier to observe nearer the ground. Also, crawlers could be present on larger diameter logs. We believe that there are too many conjectures to justify the low rating." (Cobb/Wood)

"The lack of specific information on the Mexican fauna makes it impossible to give anything more than an overall rating for the genus. There are many species in the United States already, and the overlap between the United States and Mexican faunas is unknown. To regard the whole genus as being of quarantine significance is conservative and could lead to trade challenges until more information on which species are not found in the United States is available. The ratings are given as L + H + M + H for probability of establishment and H + H + H for consequences of establishment. We would have expected these ratings to combine to H + H = H, but the final value for pest risk potential is given as Moderate. How is this possible?" (Cree/Watler)

Response to comments—The status of both *Pineus* sp. on *Pinus* spp. and *Adelges* sp. on *Abies* spp. in Mexico is incomplete or unknown. This is corroborated by W.J. Mattson (1996, personal communication) who states that "while some 50 species of adelgids are known for North America, little is known of those in Mexico." This lack of information is reflected in the dichotomous nature of reviewer responses. Given the lack of information on species identification, distribution, and damage, there is no scientific basis to assume that Mexican *Pineus* spp. (i) would be comparable with those currently present in the United States or (ii) are unlikely to cause economic impacts similar to those caused by *Adelges* spp. previously introduced. While the emphasis of this assessment is directed at potential insect pests affiliated with unprocessed logs from Mexico, those that might be transported on logs and then become pests of immature conifers (Christmas trees and regeneration) cannot be disregarded. Furthermore, as pointed out by M.S. McClure (1996, personal communication), various life stages of U.S. adelgids have been readily transported on logs.

We believe that our assessment is reasonable and by necessity conservative based on a lack of definitive biological information on Mexican species. Clearly the disagreement between scientists on the potential threat from this insect group can be attributed in large part to this lack of crucial information.

With respect to the rating system employed, the procedure leading to a rating of moderate is consistent with that for all other potential Mexican pests evaluated. The fact that so little is known about this group does necessitate an overall generic rating—there is no other alternative. As for this procedure being conservative and leading to trade challenges, these considerations are outside the scientific purview of this report.

Tiger Moth

Assessor—William E. Wallner

Scientific name of pest—*Lophocampa alternata* (Grote) (Lepidoptera: Arctiidae)

Distribution—Mexican states of Durango, Distrito Federal, Hidalgo, Jalisco, Mexico, Michoacan, Puebla, Tlaxcala, and Veracruz.

Scientific names of hosts in Mexico—*Abies religiosa, Pinus ayacahuite, P. hartwegii, P. montezumae, P. rudis,* and *Pseudotsuga macrolepis.*

Summary of natural history and basic biology of the pest—*Lophocampa alternata* belongs to the order Lepidoptera, family Arctiidae, which contains relatively few species, several of which are serious forest pests. No species of *Lophocampa* is recorded from the United States. This genus is synonymous with *Halisidota*, but *H. alternata* is not among the six species of *Halisidota* found in the United States. Most prominent of the U.S. species is the silverspotted tiger moth (*Halisidota argentata* Packard), which ranges from California to British Columbia. It is a recurring pest of Douglas-fir, grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), Sitka spruce (*Picea sitchensis* (Bong.) Carr.), lodgepole pine (*Pinus contorta* Dougl. ex. Loud.), western redcedar, and several other conifers. This provides some evidence that *Lophocampa* (*Halisidota*) spp. could successfully establish in coniferous forests of the western United States (Furniss and Carolin 1977). Commonly found and widely distributed in Mexico, *L. alternata* is not considered a forest pest because it is naturally controlled by a number of parasites. However, it might be a pest if introduced into an environment lacking these biological control agents.

Damage is caused by larvae of *Lophocampa alternata* feeding on needles of several conifers. It is principally a pest of immature *Pinus* spp. and causes growth loss and modest amounts of tree mortality. However, on *Abies* spp., defoliation is severe and the removal of several years of needle growth causes tree mortality. There is one generation each year, which passes the winter in masses of >100 eggs that are laid on twigs or bark of the main stem from June to September. Eclosion occurs in January, and larvae live gregariously in silken tents that are most commonly found in the tops of trees. Larvae mature, reaching a length of 35 mm, and pupate from May to August under bark, stones, grass, and other debris. Adults emerge from June to September; females cover masses of eggs with abdominal hairs that are the color of bark (Cibrián Tovar and others 1995).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RU*)
   L. alternata is common under natural forest conditions, and since it feeds on three conifer genera, it would be a likely inhabitant of harvested trees. The egg masses are laid under bark scales or on twigs and are in diapause for several months. Pupae, found in bark crevices under scales or on other objects (stones, grass, etc.), are viable from May to August. Both of these life stages are associated with the bark on tree boles and could be readily transported on harvested logs.

2. Entry potential: *Moderate* (*RC*)
   Detection of egg masses would be difficult because their color is similar to that of bark and they are laid under bark scales on tree trunks or twigs. Since eggs are present on host material for approximately 5 months, they could be easily introduced on logs. Pupae also may be transported, but the occurrence of this life stage is limited in duration and survivability would probably be low. Most arctiid moths are nocturnal and attracted to lights. Although it is not known if gravid females attracted to lights oviposit on transportation devices (containers, vehicles, ships, etc.), this potential introduction pathway has been used by other lepidoptera.

3. Colonization potential: *Moderate* (*RC*)
   L. alternata feeds on at least three different conifer genera. Hence, there is every reason to anticipate that suitable hosts would be available not only in the western United States but also in the South and Southeast where *Pinus* spp. abound. As such, it poses a serious threat to plantation conifers, Christmas trees, and forest regeneration. One egg mass with >100 eggs constitutes the potential to create a viable, reproducing population.

4. Spread potential: *Moderate* (*RC*)
   Gregarious early instar larvae are not likely to disperse extensively; late instars do disperse and feed individually, but spread is likely to be limited. Adults are active flyers and can be expected to readily expand populations particularly where artificial lights may attract adults.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*RC*)
   Defoliation occurs principally on small trees up to 3 m tall. The insect seldom is considered a problem in mature forests, but it can produce serious damage to young *Abies*. Thus, the damage that might result from this pest is in young managed plantations or on regeneration where reduced growth and mortality (especially to *Abies* spp.) might occur.

6. Environmental damage potential: *Moderate* (*RC*)
   If *L. alternata* introduction and establishment coincided with intensive coniferous management, it

could precipitate insecticide applications, especially in plantations, a potential environmental hazard. Given the vulnerability of *Abies* spp. to defoliation and mortality, plantation and regeneration resources would be at risk.

7. Perceived damage potential: *Low* (*RC*)
   As immatures, all arctiids are caterpillars with urticating hairs that can cause irritating encounters with humans. The presence of gregarious larvae in tents would prove offensive to the public and present a major potential pest for Christmas tree growers through the West, Midwest, and Southeast. Damage to mature trees would be negligible.

C. Pest risk potential: *Moderate*
The estimated risk for *Lophocampa alternata* is moderate because of the difficulty of detecting camouflaged egg masses on at least three conifer genera and because the risk of importation on logs with bark is high on immature conifers. Establishment of this insect would increase management procedures on intensively managed plantations and could affect regeneration in forest stands. If introduced, this insect would probably be a pest.

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Reviewers' comments—"In the section host with pest origin, you are considering this insect as a pest of trees 1to 5 cm in diameter. It is not known to what extent oviposition occurs on potentially harvestable size trees. Then if you don't know the possibility to transport on logs and the pupae as you say if associated with the bark, what was the reason to determinate the risks as Moderate? Also it was qualified as reasonably uncertain." (Guerra Santos)

"The estimate of moderate in A1 is not consistent with the estimate of low in A1 in the risk assessment of *Pineus* spp. Both are pests mainly associated with immature trees, and therefore less likely to be associated with logs.

In A2, the cryptic colour, hidden location and long period of time over which dormant eggs occur on bark suggest that the rating should be high.

In A3, the test suggests that a rating of high would be appropriate.

In B5, the likelihood of serious damage to regeneration, plantations and Christmas trees could represent a significant economic threat to U.S. forestry. The rating of low does not reflect this. High or at least moderate would be more representative of the potential costs of this insect.

On the basis of these suggested changes, the overall ratings for this pest would be elevated to high or at least moderate." (Cree/Watler)

"With respect to the tiger moth, we see at least two problems. First, it is stated that egg masses are laid under bark scales and that it is *not* known to what extent oviposition (egg laying) occurs on potentially harvestable sized trees; also, it states that pupae are found in bark crevices. Under these circumstances, wouldn't it be more reasonable to conclude that the probability of pest with host at origin is high until we have better knowledge, rather than the moderate rating given it in the assessment. Second, the consequences of establishment are rated LOW presumably based on the assumption that damage will be limited to young, small trees. If our assumption is true, the view expressed in the assessment is extremely short sighted. It goes without saying that to have large trees in the future we must have young, healthy trees now. Over time, loss of the young trees can be devastating to huge ecosystems or landscapes: the environmental damage potential can be astronomical." (Cobb/Wood)

Response to comments—The first and second comments reflect the inability to predict the potential risk of eggs being deposited on mature trees when *L. alternata* is principally a pest of immature trees. The rating of Moderate and RU is indicative of a commonly found pest in Mexican forests whose ovipositional habits are unknown. Given this lack of information and the fact that the cryptically colored egg masses can lay dormant for long periods of time qualifies for a moderate risk rating.

The authors of the third comment convincingly argue that even though this insect is not a major problem on mature trees, it could have significant economic and environmental damage by impacting young trees. This prompted us to elevate both the Economic Damage and Environmental Damage categories from low to moderate.

La Grilleta

Assessor—William E. Wallner

Scientific name of pest—*Pterophylla beltrani* Bolivar y Bolivar (Orthoptera: Tettigonidae)

Distribution—Known to occur only in limited regions of the Mexican states of Nuevo León and Tamaulipas.

Scientific names of hosts in Mexico—*Acacia farnesiana, Acer negundo, Cordia boissieri, Cornus florida, Juglans melis, Platanus occidentalis, Prosopis glandulosa, Quercus fusiformis, Q. polymorpha, Q. tinkhami, Prosopis glanulosa, Ulmus divaricata*, and *Pinus* spp.

Summary of natural history and basic biology of the pest—*Pterophylla beltrani* belongs to the order Orthoptera, family Tettigonidae. There are some 4,000 species of Tettigonids or long-horned grasshoppers, many of which are tropical or subtropical in origin. *P. beltrani* attacks a broad range of hosts, some of which are present in North American temperate forests (Cibrián Tovar and others 1995). The first record of its appearance was the outbreak in 1981–1982 on more than 200,000 ha. In regions of Nuevo León and Tamaulipas (Góngora–Rodriguez and others 1989), it caused severe defoliation for 2 to 3 years, but since then, populations in the Sierra Madre Oriental have declined in intensity.

La Grilleta, known colloquially as "Queen of the Crickets," is a defoliating insect most commonly found in oak and mixed oak forests of 600 to 1,800 m in elevation. It has been reported as a problem principally in one region of northeastern Mexico. Nymphs and adults consume the foliage and, in dense populations, bark and cambial tissue of shoots and branches. This causes reduced growth and occasional death to portions of or entire trees. The location of the infestation also affects economic impacts; high value forests and those adjacent to agricultural cultivation, especially fruit orchards and populated areas, are most economically affected.

Longhorn grasshoppers, while present in most regions of the United States, are seldom numerous enough to cause tree damage. Some, like the Mormon cricket (*Anabrus simplex*) are periodically abundant and destructive to cultivated crops. During heavy migrations, crickets invade and damage fringe-type ponderosa pine. The true katydid (*Pterophylla camellifolia*) dwells in colonies in dense forests of the eastern and central United States but seldom causes serious damage (Craighead 1950). Contrarily, in Mexico, *P. beltrani* recently has emerged as a perennial pest of oak and other hardwoods. It is univoltine. Eggs are laid in the bark during July through October and remain unhatched, probably in diapause, until March of the following year. Hosts preferred for oviposition are oak, walnut (*Juglans*), and pine. Eggs are laid 2 to 3 cm deep within the bark along the bole in clusters of 4 to 10 eggs. Not all eggs hatch in 1 year; some remain in diapause for 1 to 2 years. After hatching from eggs, nymphs tend to be colonial and move to the new foliage to feed. Development is completed by July through September, and adults disperse not by flying but by gliding up to distances of 100 m. While natural dispersal is limited, the breadth of hosts used is not. This suggests that, if introduced, *P. beltrani* could establish in oak–pine forests of the Mid-South and West.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*MC*)
   Essentially, although pines are not preferred as a food source, eggs would be moving as hitchhikers. Since harvesting in Mexico normally is done from October to May and standing live pine would be available for ovipositing females during July through September, the opportunity for infestation by ovipositing females is high.
2. Entry potential: *High* (*RC*)
   The eggs would be deposited deep within the bark, making detection virtually impossible.
3. Colonization potential: *High* (*VC*)
   Since this species is known to attack a broad spectrum of deciduous hosts, both subtropical and temperate, it could find acceptable hosts at western and southern U.S. locations. Protracted diapause by eggs (for 1 to2 years) increases the probability of survival during and after shipment and perhaps also in bark removed from logs.
4. Spread potential: *Moderate* (*RC*)
   The aggregation tendencies at low population densities and the limited vagility of nymphs and adults (<100 m) would lead to slow natural spread. However, spread could be accelerated by humans moving bark that contains eggs.

B. Consequences of pest establishment

5. Economic damage potential: *High* (*RC*)
   In Mexico, this insect is a defoliator of hardwoods that currently are of little economic value. However, they weaken and kill trees and have proven problematic in urban and agricultural regions since pesticidal action is routinely undertaken against them. Oaks are an important, limited resource to the Southwest and Mid-South. They could be threatened by this insect altering tree vigor and inviting organisms of secondary attack to become more aggressive. Sclerophyllous forests of California, the mountainous regions of Arizona and New Mexico, and the oak–pine forests of the southeastern United States would appear to be suitable climate and

habitat for this insect. Economic damage would be through growth loss and accelerated mortality to oaks. Such losses might be acceptable in southern pine producing areas but unacceptable in other regions where oak may be the dominant tree species with high economic or ecological value. Another important economic consideration would be the ability of the insect to infest agricultural crops, such as corn and grains, and citrus, walnut, and peach orchards.

6. Environmental damage potential: *Moderate* (*RC*) This species is unlikely to cause extensive tree mortality. However, due to the sheer number of La Grilleta during an outbreak, the nuisance they cause to residents of urban areas, and the damage to urban plantings, control measures may be necessary that may have negative environmental consequences. The aesthetics of forests, urban forest regions, and fruit and nut producing regions could be seriously impacted.

7. Perceived damage potential: *Moderate* (*RC*) Defoliation will have only modest mortality impacts on oaks and other hardwoods and virtually no impact on pines. There is the risk that, if established, it could become a serious nuisance pest in agricultural and urban regions. Despite the fact that infestations appear to be restricted to limited forested regions in Mexico, the status of La Grilleta as a perennial problem and the abruptness of its recent occurrence give reason for concerns as a potential introduced pest.

C. Pest risk potential: *High*

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Góngora–Rodríguez, J.A.; Aburto, M.O.; Lopez, F.M. 1989. Diversos estudios realizados en *Pterophylla beltrani* en el estado de Nuevo León. In: IV Simposio Nacional sobre Parasitología Forestal. Tomo II; Durango, Dgo., del 28 al 30 de Octubre de 1987. México, D.F.: Instituto Nacional de Investigaciones Forestales y Agropecuarias, Publicación Especial Num. 60: 486–494.

Reviewers'comments— "La Grilleta is another potential pest I would rank as no more than moderate risk, based on its limited geographical distribution (two Mexican states), its requirements for hardwood for larval feeding which would limit its association with pine to mixed pine–hardwood stands, and its infrequent outbreaks. Thus, I would rate the 'pest with host at origin' as low. Also, the colonization potential may be low, due to its occurrence at elevations >600 m (whereas most ports and processing plants in the U.S. are at lower elevations).

Interestingly, I observed a species of Tettigoniidae ovipositing in the bark of *Pinus radiata* in the foothills of the Andes Mountains near Chillán, Chile, in November 1995. These insects, presumably native to Chile, were responsible for defoliating some 800 acres [323.9 ha] of second growth *P. radiata* in the area (but were not recognized as pests of pine at the time of our pest risk assessment). Such outbreaks are relatively rare occurrences compared to those of bark beetles or lepidopteran defoliators." (Billings)

"We agree with this assessment. This pest is not native to the U.S., could establish, and could cause economically important damage." (Cree/Watler)

"La Grilleta: This is also an ag pest. On what crops. Pest with host at origin: based on the information given, we recommend a H rating; note that outbreaks will occur." (Johnson/Griesbach)

"According to the Federal Register, January 20, 1991 (319-40-3), from the states in Mexico adjacent to the United States border there is different regulation, in this way the case of La Grilleta its current distribution is on the states of Tamaulipas and Nuevo León and those are border states. We respect about the pest risk potential (high) but will be change in this regulation? Will be considered regulation by APHIS?" (Guerra Santos).

Response to comments—In addition to a broad range of hardwoods (most notably *Quercus* spp.), this insect has been observed damaging agricultural crops such as corn, fruit-bearing citrus orchards, walnuts, and peach trees. The suggestion that colonization potential should be revised to low from high is not reasonable. Given the extremely broad host range of this pest, the probability of colonization is high. Also, there is no guarantee that introduction of potentially infested material (logs or bark) would be only at ports or processing plants at low elevations. Given these factors and the persistent egg stage leads us to conclude that an overall ranking of high is reasonable.

In response to the comments by the fourth reviewer, the intent of the Pest Risk Assessment for *Pinus* and *Abies* logs was for all of Mexico regardless of political boundaries or present temporary regulations. The basis for our assessment was biologically based; its impact on current or future U.S. import regulations is strictly the responsibility of APHIS.

Defoliador del Oyamel

Assessor—William E. Wallner

Scientific name of pest—*Evita hyalinaria blandaria* Dyar (Lepidoptera: Geometridae)

Distribution—Reported in Mexico from Distrito Federal and the states of Mexico, Hidalgo, Michoacan, and Puebla

Scientific names of hosts in Mexico—*Abies religiosa* and occurs rarely on *Pinus* spp., *Prunus* spp., and *Quercus* spp.

Summary of natural history and basic biology of the pest—*Evita hyalinaria blandaria* belongs to the order Lepidoptera and family Geometridae, which contains some species of the most serious of forest defoliators that feed on numerous tree species. Known as the "Defoliador del Oyamel" (defoliator of fir (*Abies religiosa*)), it was first observed causing severe defoliation in 1957 in the Distrito Federal and again in 1987 in the state of Mexico. Infestations occurred where no previous infestations were noted and caused economic and social disruption of the forests and threatened refuges of the monarch butterfly (*Danus plexippus*) (Cibrián Tovar and others 1995).

Evita hyalinaria blandaria is known to occur only in the southern humid region of Mexico and defoliates principally *A. religiosa*. Another subspecies, *E. hyalinaria hyalinaria*, has been reported from the arid southeastern United States, where it feeds on juniper (*Juniperus*) and oak (Rodriguez 1961). Based on these differences in host preferences, climatic preferences, distribution, and taxonomic subspecies designation by Capps (1943), *E. hyalinaria blandaria* is considered a nonindigenous species to the United States and a potential pest if introduced.

E. hyalinaria blandaria has one generation per year with diurnally active adults that lay eggs in May in clusters of 30 to 40 on host foliage or other trees and shrubs. Larvae emerge in July, feed until winter, overwinter, and resume feeding during April. Pupation occurs on the needles, branches, or bark of felled trees during May. Although capable of surviving at elevations up to 3000 m where it is univoltine, *E. hyalinaria blandaria* can survive at lower elevations where it has two generations per year (Cibrián Tovar and others 1995).

Defoliation usually proceeds upwards on trees; terminal growth is the last to be consumed. Widespread defoliation is the norm, with mature *A. religiosa* being preferred although immature firs also are defoliated. Tree vigor is seriously affected since not only the current needles but those of the previous 3 years may be removed. More than one defoliation usually kills trees.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RC*)
   Since *E. hyalinaria blandaria* is largely host specific, it probably would be affiliated with *A. religiosa* especially in southern fir regions of Mexico. The moderate rating is an average value based upon the high probability of insect association in select southern regions and an apparent rarity elsewhere in fir forests. All life stages are found on the tree (eggs, larvae, and pupae on foliage and bark). Of special concern would be pupae on the bark of felled trees.

2. Entry potential: *Moderate* (*RC*)
   Eggs (late May through June) and pupae (late April through May) could survive transport on logs with bark. Larvae overwinter under bark scales, which ensures that a life stage is present on the tree throughout the year.

3. Colonization potential: *Low* (*MC*)
   The apparent host specificity of *E. hyalinaria blandaria* and the absence of *A. religiosa* in the United States would make colonization appear unlikely. Additionally, even though *A. religiosa* is the most widely distributed of the Mexican firs, it is the only one of eight *Abies* species reportedly attacked by *E. hyalinaria blandaria*.

4. Spread potential: *Low* (*MC*)
   Adults are active flyers and, in dense populations, they are so numerous that the vision of observers is obstructed by the insect's flight activity. The adults would contribute to the spread of infestations, whereas larvae, which have limited vagility, would not. The limited availability of suitable hosts would tend to retard spread. However, should an ecological homolog to *A. religiosa* exist in the United States, such as subalpine fir (*Abies lasiocarpa*), then colonization and spread potential would be significantly increased.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*MC*)
   The apparent monophagous nature of this insect and the unpredictable availability of suitable host(s) in the United States suggest this insect would have little economic impact. However, if this insect behaves as other native fir defoliators do in the United States and Canada (Furniss and Carolin 1977), a broad cross section of U.S. fir species could be impacted.

6. Environmental damage potential: *Low* (*MC*)
   The inability to predict acceptance of fir species in the United States by *E. hyalinaria blandaria* makes predicting environmental impacts difficult. However, if suitable hosts are available, this insect can defoliate and kill trees and disrupt forest management and recreational activities across extensive areas very quickly.

7. Perceived damage potential: *Low* (*RC*)
   There is the possibility of severe, intermittent defoliation to humid, high elevation subalpine forests that could disrupt this important, extensive ecosystem, which extends from the western United States through Canada to Alaska. Other native geometrids have demonstrated that they can cause severe impacts on coniferous forests of the western United States (Furniss and Carolin 1977). This fact suggests that these humid coniferous ecosystems are particularly susceptible to geometrid attacks that often occur in complexes. Trees are killed by such defoliation, which results in shifts in tree species. The type or magnitude of these shifts cannot be predicted from what is currently known about *E. hyalinaria blandaria.*

C. Pest risk potential: Low

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Reviewers' comments— "The statement on *Evita* (a defoliator) seems to be based largely on a presumed host specificity even though it is stated under Colonization Potential that eight species are attacked by this insect. How does the assessment present any evidence that the *Abies* species in the United States would not be attacked? Again and again, this assessment appears tilted toward a conclusion that reduces the potential risks." (Cobb/Wood)

"The final pest risk potential of low is not consistent with the ratings given throughout the assessment M + M + L + L = M, M + M = M. The final rating should therefore be moderate. We would support the rating, based on the assessor's text." (Cree/Watler)

Response to comments—The questions raised by the first reviewers are not easily answered. Since the *Abies* spp. present in southern Mexico are not found in the United States, no direct comparison can be made in predicting *E. hyalinaria* pestilence. We concluded that overall rarity of this insect in Mexico, other than in the southern humid regions, indicates it may be ill suited to *Abies* forests of the United States. However, the presence of a similar species, *E. hyalinaria hyalinaria* in the southeastern United States, does lead to some concern that *E. hyalinaria blandaria* could be a successful colonizer if introduced. According to the formula for probability of pest establishment, two or more low ratings for the individual elements result in an overall low rating (Table 3).

Giant Silkworm

Assessor—William E. Wallner

Scientific name of pest—*Hylesia frigida* Schaus (Lepidoptera: Saturniidae)

Distribution—Distributed only in the Mexican states of Chiapas and Oaxaca

Scientific names of hosts in Mexico—*Pinus maximinoi, P. patula, P. oocarpa, P. greggii, P. oaxana, P. montezumae, Quercus brachystoclys,* and *Arbutus glandulosa. Pinus maximinoi* is the preferred host.

Summary of natural history and basic biology of the pest—*Hylesia frigida* belongs to the order Lepidoptera and family Saturniidae. This family contains some of the largest moths inhabiting U.S. forests, and these moths are commonly referred to as giant silkworms. The larvae are armed with tubercles, and most species feed on broad-leaved plants and spin dense silken cocoons in which they pupate. Adults are vagile, nocturnal moths readily attracted to artificial lights. Although common, most of these moths are not pests. One exception is the pandora moth (*Coloradia pandora*), which is an important defoliator of pines west of the Rocky Mountains (Furniss and Carolin 1977). No *Hylesia* spp. are recorded as forest pests in the United States or Canada.

Several species of *Hylesia* are widely distributed in Mexico and Central and South America. However, *H. frigida* is reported only from the states of Chiapas and Oaxaca at elevations of 1500 to 2300 m. First reported in 1981 following the eruption of the Chichonal Volcano, outbreaks lasted 2 years and required chemical control because of the rashes and allergic reaction by humans caused by the urticating hairs of *H. frigida* adults and larvae.

Two generations occur each year; March through August and September through February. Within 2 days after emerging, adults mate and females lay 200 eggs in masses covered with their abdominal hairs. Masses are laid on the bark of branches and tree trunks, and the brown coloration of the female abdominal hairs makes them difficult to detect. After 64 days, eggs hatch and larvae develop through six larval stages during the next 90 days. Larvae are colonial in their habits and migrate in groups to feed and produce copious silken mats that often cover trees, posts, shrubs, soil, etc. (Beutelspacher 1986, Zamora Serrano 1986).

The foliage of young and mature trees is consumed by the larvae. While pines between 16 and 25 m high are preferred, the larvae defoliate other broad-leaved hosts such as madrone (*Arbutus*) and oak when pine foliage is exhausted. Under these circumstances, numerous larvae and adults create a medical threat of severe human dermatitis referred to as Papilionitis (Cibrián Tovar and others 1995).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RC*)
   The regional abundance of this insect dictates that its affiliation would be greater with *P. maximinoi* than with other *Pinus* spp. from Chiapas and Oaxaca. Given its limited regional distribution, there is a low probability it would infest pines from other states. With respect to oak and madrone hosts, they are currently not of commercial export importance and are likely to be infested with *H. frigida* only when found in admixture with pines in outbreak areas. Recent introductions of pests such as the Asian gypsy moth underscore the difficulty of predicting introduction pathways. Like the Asian gypsy moth (*Lymantria dispar* L; Wallner and others 1995), adults of *H. frigida* are attracted to lights and could deposit their eggs on transportation vehicles, containers, wood products, etc., which would increase the risk for transport. It should be stated that nothing is known about female *H. frigida* ovipositing at lights or objects adjacent to them.

2. Entry potential: *Moderate* (*MC*)
   The Saturniid moths tend to be generally common in their native habitat. Thus, even in nonoutbreak situations, there is the potential for pine logs from Chiapas and Oaxaca to be infested with either eggs or pupae. Pupae, encased in resilient silken cocoons, would survive a 30-day transport period but, because of their size and color, should be readily detectable. In contrast, the eggs, which are laid on and under the bark, would be difficult to detect since they are covered with dull black hairs from the female's abdomen. Eggs (which incubate for 64 days) would be present from early March to early May and early September to early November, dates that coincide with the traditional harvesting periods in Mexico.

3. Colonization potential: *Moderate* (*RU*)
   This species appears to attack warm temperate species and principally one *Pinus* sp. (*maximinoi*). It will attack broad-leaved species only after defoliating its main hosts. It is unknown if it will encounter species comparable with *P. maximinoi*, which is not found in the United States. Even if introduced as egg masses, hatching larvae are not particularly vagile and are colonial, which would tend to restrict them in the host finding process. Pupae, which remain in their tough silken cocoons for up to 37 days (Zamora Serrano 1986), could be a real threat if not detected.

4. Spread potential: *Moderate* (*RU*)
   Adults are very strong fliers and readily attracted to lights (1 to 1.5 km away), which would tend to enhance their dispersal and host finding activities. Despite the introduction of vagile females and similarities between Mexican and U.S. pine species, the possible lack of acceptable hosts for this warm temperate species may limit its range.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*RC*)
   There is an observed strong correlation between the appearance of this insect and adjacent volcanic activity. This may be indicative of a causative association and may be why only limited defoliation (600 ha) has been reported. However, even with limited outbreak distribution, human dermatitis could be a real threat in urban–forest interfaces.

6. Environmental damage: *Moderate* (*RC*)
   Relatively few saturniids are serious pests, but they tend to have episodic outbreaks occurring at 20- to 30-year intervals. The urticating hairs of adults and larvae would pose a human threat that could require environmentally disruptive control measures.

7. Perceived damage potential: *Moderate* (*RU*)
   The potential risk for this insect is difficult to assess. Only recently observed and studied, its relationship to volcanic activity (and possibly other types of pollution) raises the specter that it could be an increasingly serious problem should these exogenous factors increase. However, based on its restricted distribution in Mexico and its association with *Pinus* spp. not found in the United States, *H. frigida* would pose a risk only from wood exported from a discrete Mexican forest region. It has the potential to be an adaptable pest with two generations per year and a tendency to be polyphagous. Defoliation would be limited but obtrusive, and the allergic effect of the life stages would severely impact forest management and recreational uses.

C. Pest risk potential: *Moderate*

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Reviewers' comments—"The final pest risk potential rating of low is not consistent with the ratings given throughout the assessment. M + M + L + L = M, L + M + M = M. The final rating should therefore be moderate. We would support the rating, based on the assessor's text." (Cree/Watler).

Response to comments—The ratings for colonization and spread potentials were elevated to moderate since this species occurs in a warm temperate zone, rather than in the subtropical as stated in the draft. The overall pest risk potential was elevated to moderate.

Pine Bark Beetle

Assessor—Andris Eglitis

Scientific name of pest—*Dendroctonus mexicanus* Hopkins (Coleoptera: Scolytidae)

Scientific names of hosts—*Pinus ayacahuite, P. arizonica, P. cembroides, P. cooperi, P. douglasiana, P. durangensis, P. greggii, P. hartwegii, P. herrerai, P. lawsoni, P. leiophylla, P. maximinoi, P. michoacana, P. montezumae, P. patula, P. pinceana, P. pseudostrobus, P. rudis,* and *P. teocote*.

Distribution—Mexican states of Aguascalientes, Chiapas, Colima, Durango, Guerrero, Hidalgo, Jalisco, Mexico, Michoacan, Morelos, Nuevo Leon, Oaxaca, Puebla, Queretaro, San Luis Potosi, Sinaloa, Sonora, Tamaulipas, Tlaxcala, Veracruz, and Zacatecas

Summary of natural history and basic biology of the pest—*Dendroctonus mexicanus* shares many common biological features with *Dendroctonus* spp. in the United States, particularly southern pine beetle (*D. frontalis* Zimmerman) and western pine beetle (*D. brevicomis* LeConte). *Dendroctonus* spp. are monogynous. Females of the species select host trees that are often stressed in some fashion (e.g., drought, high stocking, or fungal root disease). As they colonize the tree, the females produce an aggregating attractant (pheromone) that concentrates other in-flight females and males to the tree, resulting in a mass attack. The attacking females introduce bluestain fungi (*Ophiostoma* spp.) into the host tree, and the hyphae of this fungus grow rapidly, blocking the resin ducts and tracheids. Males soon join the females and mate with them in galleries beneath the bark. Females construct a long meandering gallery in the phloem and cambial region and lay eggs in small niches on the sides of the gallery. Within 1 to 3 weeks, the eggs hatch and larvae begin to develop in the phloem and cambium. As they reach the fourth instar, the larvae bore into the outer bark where they eventually form a pupation chamber and transform into young adults. Once mature, the new adults burrow out to the bark surface, emerge from the tree, and fly in search of new host material. *Dendroctonus mexicanus* has three to six generations per year, varying according to elevation. At elevations of 2300 to 2500 m, there are typically four generations per year with overlapping developmental stages. The beetle will attack trees from 5 cm diameter at breast height (dbh) to more than 40 cm dbh. Brood development and survival are greater in the larger diameter trees. The overlapping life stages and numerous generations lead to a continuous expansion of a spot infestation that might begin with a single attacked tree and progress to involve a sizable group of trees. Normally, a spot will increase for three or four generations and rarely more. The size of the infestation depends on factors such as the available host material (species composition, age structure of the stand, and tree condition), climatic conditions, and presence of natural enemies. Typically, infested spots will range in size from 0.1 to 3 ha, and only in exceptional cases will they cover more than 10 ha. Various levels of crown discoloration will accompany these expanding spots, such that it is often possible to determine the direction in which the spot is expanding, as with *D. frontalis* in the southeastern United States.

Dendroctonus mexicanus is considered one of the more serious forest pests of *Pinus* spp. in Mexico. The mortality caused by this insect raises a series of concerns in Mexico. These include the deforestation of significant tracts of forest land followed by their conversion to agricultural uses, volume loss, reduction of wood quality, the diversion of human resources, and the use of toxic chemicals in costly beetle population suppression efforts. Infested trees, whether used or not, are usually debarked or treated with insecticide to kill insect broods.

Although *D. mexicanus* and *D. frontalis* (southern pine beetle) are difficult to distinguish based on physical characteristics, there are some important differences in behavior, life history, and biology between the two species as they occur in Mexico. *D. mexicanus* generally has fewer generations per year, occurs at higher elevations, has a broader host range, and produces smaller patches of tree mortality than *D. frontalis*.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RC*)
   Even though *D. mexicanus* is not generally thought to be associated with cut logs, we were able to identify live beetles in several logs at several mill sites in Mexico. The reasonably high level of forest management and the ability of most foresters to recognize infested trees would probably lead to reduced likelihood of these logs being included among export material. Nonetheless, the time interval between tree infestation and crown discoloration could still lead to inadvertent transport of infested wood to the mill yard and its subsequent export among other high quality logs.
2. Entry potential: *High* (*RC*)
   D. mexicanus requires anywhere from 42 to 125 days to complete a generation. Even the shorter end of this time range would be sufficient to allow for transport of a freshly infested log to its U.S. destination prior to beetle emergence.
3. Colonization potential: *High* (*MC*)
   Whereas many of the *Dendroctonus* spp. have a very narrow host range, *D. mexicanus* infests 21 species of pines in Mexico (compared with

eight for *D. frontalis*). This host list is quite diverse and includes pines from both subgenera (Haploxylon = soft pines; Diploxylon = hard pines). At least one of those pines (*P. arizonica*) is similar to *P. ponderosa*, the most important and widespread pine in western United States. It is likely that other pines in the United States could serve as hosts for *D. mexicanus* as well. In particular, *P. engelmannii* and *P. chihuahuana* in the Sky Islands of southern Arizona could be colonized by the beetle.

4. Spread potential: *High* (*MC*)
   The numerous generations per year, broad host range (both in terms of species and sizes), and extensive forests of pine in western and southeastern United States could all be factors contributing to the spread of *D. mexicanus* if it were to become established. Since the beetle is similar to *D. brevicomis* and *D. frontalis* in the United States, *D. mexicanus* could become well established before being recognized as an exotic. Because of its greater cold tolerance, *D. mexicanus* might be competitive with *D. frontalis* in places like New Jersey and Maryland at the northern extremes of its range.

B. Consequences of pest establishment

5. Economic damage potential: *High* (*RC*)
   From the standpoint of behavior and taxonomy, *D. mexicanus* is most similar to *D. frontalis* in southeastern United States. In Mexico, Villa Castillo (1992) demonstrated strong response by *Dendroctonus mexicanus* to the synthetic pheromone of *D. frontalis*. *Dendroctonus frontalis* is considered one of the most important pine pests in the United States, and large amounts of research funding have been dedicated to the study of its biology, ecology, and management. In Mexico, *D. frontalis* only infests eight species of pines, suggesting that in that country, *D. mexicanus* may have greater adaptability and/or greater genetic variation than *D. frontalis*. With droughts and other disturbance agents playing an important role in western forests as predisposers of trees to bark beetle attack, it seems likely that *D. mexicanus* could find situations in the United States in which it could thrive, much as it does in Mexico.

   The wide number of host species in Mexico for *D. mexicanus* leads us to analyze impacts for establishment in southeastern and southwestern United States. If established in southeastern United States, *D. mexicanus* would join *D. frontalis*, which causes an estimated average loss of $30 million per year (Price and others 1990). If *D. mexicanus* added an additional 10% mortality per year by occupying a range on the cooler, higher elevation sites, an annual loss of $3 million could result ($33 million total annually). With a 20-year establishment period to reach this level, the net present value during the 30 years after establishment could reach $17.3 million at a 4% discount rate. If *D. mexicanus* became established in southwestern United States, the ponderosa pine timber resource would have potential for significant loss. New Mexico and Arizona have a ponderosa pine inventory of 87.3 million cubic meters on timberlands (Powell and others 1993). Assuming a loss of about $106 per cubic meter killed and an annual loss of 0.01% (about 364 ha annually), this would result in an annual loss of about $925,000. Assuming a 30-year period of gradual spread to reach this level of loss, the net present value during 30 years would be approximately $4.8 million with a 4% discount rate. The total net present value of these two scenarios is $22 million.

6. Environmental damage potential: *High* (*MC*)
   Drought periods, high stocking densities, wildfires, and other stress agents are currently predisposing pines in the United States to various disturbance agents. The introduction of another aggressive mortality agent of pine could further disrupt the delicate balance in pine forests. Other potential concerns include the possibility of hybridization between *D. mexicanus* and *D. frontalis* and the introduction of a potentially new species of bluestain fungus associated with *D. mexicanus.*

7. Perceived damage potential: *Moderate* (*MC*)
   The introduction of another exotic species capable of causing economic loss would be unacceptable to most people.

C. Pest risk potential: High

Selected bibliography

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Lanier, G.N.; Hendricks, J.P.; Flores Lara, J. 1988. Biosystemation of the *Dendroctonus frontalis* (Col. Scolytidae) complex. Ann. Ent. Soc. America 81: 403–418.

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Powell, D.S.; Faulkner, J.L.; Darr, D.R.; [and others]. 1993. Forest resources of the United States, 1992. Gen. Tech. Rep. RM–234. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 132 p.

Price, T.S.; Doggett, C.; Pye, J.M.; Holmes, T.P., ed. 1990. A history of southern pine beetle outbreaks in the southern United States by the Southern Forest Insect Working Group. Macon, GA: Georgia Forestry Commission. 66 p.

Schowalter, T.D.; Filip, G.M., ed. 1993. Beetle–pathogen interactions in coniferous forests. London, England: Academic Press. 252 p.

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Wood, S.L. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs No. 6. Provo, UT: Brigham Young University. 1,359 p.

Reviewers' comments—"The similarity of *D. mexicanus* to both the western and southern pine beetles would contribute to its spread potential, i.e., it could take some time to recognize it as an exotic. A similar insect, the western pine beetle, will occasionally attack cut logs and produce brood in them. This probably cannot be ruled out as a possibility for *D. mexicanus*." (D. Owen)

"In this first IPRA I would make the title more general (i.e., 'Pine Bark Beetles') and include *Dendroctonus frontalis* in the assessment. This would be an example of an economically important insect already in the United States that would be augmented by genetically different populations coming from Mexico. . . .I think that as currently written this IPRA oversimplifies and underestimates the risk of an introduction of *Dendroctonus* spp. into the US. . . .Lanier and others, (1988) indicates that Mexico has a complex of *Dendroctonus* related to *D. frontalis,* all of which can cause considerable damage to pines." (S.J. Seybold)

"With reference to the pine bark beetle, *D. mexicanus,* everything that is said. . .indicates[s] that the probability of the 'pest with host at origin' should be rated HIGH instead of MODERATE. If we were considering a single log or even ten truck loads, it might be different; but this assessment should be based on the potential for a huge number of logs." (Cobb/D. Wood)

". . .I think the possibility of *D. mexicanus* and *D. frontalis* hybridization should be considered as well as the likelihood of introducing to the United States a new strain of bluestain fungi (*Ceratocystis* spp.), along with the beetles." (J. Villa Castillo)

Response to comments—This IPRA focuses on *D. mexicanus* since this is the most important beetle species associated with *Pinus* spp. in Mexico and since it does not occur in the United States. As the primary species associated with pines, it serves as a surrogate for other species that may also be found on pine hosts and that occupy similar ecological niches. Since we have rated *D. mexicanus* as having a high risk potential, it is not necessary to evaluate other insects occupying the same niche.

S.L. Wood (1996, personal communication) believes that there is considerable uncertainty regarding the taxonomy of *Dendroctonus* spp. in Mexico. He believes that some *D. mexicanus* has been called *D. frontalis* and *D. adjunctus* has been called *D. mexicanus.* As such, it is difficult to know where to draw the lines for assessing Mexican bark beetles associated with pines.

Based on the biological information available to us, we believe that *Dendroctonus* would have a high likelihood of being associated with Mexican pine logs and that their subsequent establishment in the United States would have undesirable consequences.

Pine Engraver Beetle

Assessor—Andris Eglitis

Scientific name of pest—*Ips bonanseai* (Hopkins) (Coleoptera: Scolytidae)

Scientific names of hosts—*Pinus arizonica, P. ayacahuite, P. cembroides, P. chihuahuana, P. durangensis, P. engelmannii, P. flexilis, P. hartwegii, P. leiophylla, P. montezumae, P. oocarpa, P. patula, P. ponderosa, P. pseudostrobus,* and *P. rudis.*

Distribution—United States: southern Arizona and New Mexico. Mexico: Chiapas, Chihuahua, Distrito Federal, Durango, Mexico, Jalisco, Hidalgo, Michoacan, Morelos, Nuevo Leon, Oaxaca, Puebla, Tamaulipas, Tlaxcala, and Zacatecas.

Summary of natural history and basic biology of the pest—*Ips bonanseai* is a Mexican species that extends northward into southern Arizona and New Mexico. It most closely resembles *I. pini* (Say) in terms of appearance and biology. Typical of other insects in this genus, *I. bonanseai* is polygamous, with males being responsible for host selection. The male initiates the attack on suitable host material (small standing trees, tops of large trees, or fallen trees) and immediately constructs a nuptial chamber within the inner bark. Aggregation pheromones produced by the males and released in the frass attract more males and females to the site, leading to a mass attack. Normally, the male is joined by three females, with each constructing her own egg gallery originating from the nuptial chamber. The male keeps the nuptial chamber and egg galleries free of frass. Each female constructs niches along the sides of the egg galleries and deposits an egg in each niche. These eggs hatch in 7 to 10 days, and larvae begin feeding in the phloem and cambium, constructing their own frass-packed mines leading out from the main egg gallery. Larvae pass through three instars and complete their development within 2 to 3 weeks. Once mature, the larvae construct pupal chambers in the bark and complete their transformation to adults about 2 weeks later. The entire life cycle requires about 30 days, and *I. bonanseai* can complete six to eight generations in a year in central Mexico.

As a general rule, *I. bonanseai* is a secondary insect in Mexico, normally found in association with more aggressive species such as *Dendroctonus mexicanus* and *D. adjunctus*. On occasion, however, *I. bonanseai* has been responsible for killing trees, especially when those trees are stressed by drought, competition, or fire.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *High* (*RC*)
   We found this beetle on several occasions in sort yards and milling sites where fresh logs were stored for processing. From discussions with Mexican entomologists, we learned that *Ips* spp. will often land on fresh logs during the same day that they are cut. *Ips bonanseai* is widely distributed throughout Mexico, which increases the chances that it would be associated with fresh pine logs.

2. Entry potential: *High* (*MC*)
   If logs are transported in a timely fashion, there would be a reasonable likelihood of beetles surviving transport even though a typical generation only requires 30 days for completion. Live *Ips* spp. from Mexico have been intercepted at the U.S. border in pine products in the past (Appendix B).

3. Colonization potential: *High* (*MC*)
   Ips bonanseai is considered to be most closely allied with *I. pini*, an insect with a transcontinental distribution in North America (Lanier 1972, Seybold and others 1995). Although *I. pini* has eight native pine hosts in the United States and Canada, its host list within Mexico is more narrow (six pine species) than the host list for *I. bonanseai* in Mexico (15 pine species). As such, it seems reasonable to assume that *I. bonanseai* has at least as much adaptability as *I. pini* and that it could find suitable host material in many of the same pine forests in which *I. pini* occurs.

4. Spread potential: *High* (*MC*)
   If *I. bonanseai* is capable of infesting the same pines that serve as hosts for *I. pini*, then it could spread effectively throughout most of the country where pines occur if given that opportunity.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*MC*)
   Ips bonanseai is considered to be less aggressive than *I. pini.* In the western United States, *I. pini* is most significant during dry years, and even then, only on dry sites. *Ips bonanseai* could be expected to occupy a similar niche, based on its biology in Mexico and in the southwestern United States. *Ips bonanseai* would probably not displace *I. pini* and as such, would not add appreciably to the economic effects of *I. pini*. However, S.J. Seybold (1996, personal communication) has found *I. bonanseai* to be active at low temperatures and occurring at high densities in *Pinus hartwegii* in Nuevo Leon, Mexico. As such, *I. bonanseai* may have broader ecological flexibility and could possibly occupy habitats that are marginal for *I. pini*.

In California, *Ips mexicanus* (Hopkins) and *Ips paraconfusus* Lanier are known to vector pitch canker disease. If *I. bonanseai* or any other *Ips* spp. were brought into the United States from Mexico, it could hasten the movement of pitch canker from coastal California (or from sources in Mexico) to the Sierra Nevada of California or to interior western mountain ranges.

6. Environmental damage potential: *Low* (*RU*)
   If introduced into a new environment, *I. bonanseai* would probably compete for the ecological niche currently occupied by *I. pini.*

7. Perceived damage potential: *Low* (*MC*)
   The effects of an expanded range for *I. bonanseai* would probably go unnoticed unless the insect were able to demonstrate considerably more aggressive behavior than it has displayed within its current range in Mexico.

C. Pest risk potential: *High*

Selected bibliography

Cibrián Tovar, D.; Méndez Montiel, J.T.; Campos Bolaños, R. [and others]. 1995. Insectos forestales de México—Forest insects of Mexico. Publicación # 6. Chapingo, Mexico: Universidad Autónoma Chapingo. 453 p.

Fox, J.W.; Wood, D.L.; Koehler, C.S.; O'Keefe, S.T. 1991. Engraver beetles (Scolytidae: *Ips* species) as vectors of pitch canker fungus, *Fusarium subglutinans*. Can. Entomologist. 123: 1355–1367.

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Seybold, S.J.; Ohtsuka, T.; Wood, D.L.; Kubo, I. 1995. Enantiomeric composition of ipsdienol: A chemotaxonomic character for North American populations of *Ips* spp. in the *pini* subgeneric group (Coleoptera: Scolytidae). Journal of Chemical Ecology. 21: 995–1016.

Wood, S.L. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs No. 6. Provo, UT: Brigham Young University. 1359 p.

Reviewers'comments— " . . .in the analysis of *Ips bonanseai* and other *Ips,* the vector relationship with the pitch canker, *Fusarium subglutinans* has not really been emphasized. It is mentioned briefly in the *Fusarium* section, but I recommend that it be addressed in the *Ips* section. The *Ips* from Mexico could either bring Mexican populations of *F. subglutinans* with them or they could be better vectors of the disease population already in California." (S.J. Seybold)

Response to comments—In response to the reviewer's comment and after further analysis, the economic damage potential for *Ips bonanseai* was raised from low to moderate, based on the potential of the engraver to be a vector of pitch canker. This change in one risk element raised the overall Pest Risk Potential from moderate to high for *Ips bonanseai*.

Fir Bark Beetles

Assessor—Andris Eglitis

Scientific names of pests—*Scolytus mundus* Wood, *Scolytus* spp., *Pseudohylesinus variegatus* (Blandford), *P. magnus* Wood (Coleoptera: Scolytidae).

Scientific names of hosts—*Abies religiosa, A. vejarii,* and *Pseudotsuga menziesii.*

Distribution—*Scolytus mundus*: Distrito Federal and states of Mexico, Hidalgo, Michoacan, Morelos, Puebla, and Tlaxcala. *Pseudohylesinus variegatus*: same as *Scolytus*, plus the states of Jalisco, Nuevo Leon, and Oaxaca.

Summary of natural history and basic biology of the pests—All of these bark beetle species infest fir trees that are under some form of stress. Trees of all sizes are attacked. Factors such as root disease, air pollution, and drought can be very important in predisposing firs to attack by these beetles. Some of these beetles will commonly occur together in the same host tree, along with another scolytid, *Pityophthorus brighti*. Typically, the beetles will attack large branches and tree tops. In the case of *S. mundus*, one generation may infest the top of the tree, with subsequent generations attacking lower on the bole. *Scolytus mundus* rarely kills the infested tree, since attacks usually do not occur at the base of the tree. Nonetheless, the dead tops and branches provide entry courts for fungi, and cone production is severely reduced. In the state of Hidalgo, *S. mundus* produces two generations per year, with the first occurring between October and May and the second between June and October. The engraver beetle also is capable of infesting logs from recently cut trees. According to Mexican literature, *P. variegatus* is credited with occasionally being a mortality agent on healthy trees, especially if beetle populations have been able to build up in stressed or down host material.

On-going surveys being conducted in the state of Michoacan indicate that both *S. mundus* and *P. variegatus* may be more widespread than previously reported. In that state, both species of beetles show a strong association with annosus root disease (Villa–Castillo, 1996, personal communication).

Two other species of *Scolytus* occur in the northern states of Mexico. Although little is known about their biology, both *S. virgatus* Bright and *S. hermosus* Wood are capable of infesting *Pseudotsuga* as well as *Abies* spp. (S.L. Wood, 1996, personal communication). Another species, *S. aztecus,* is reported in central Mexico in association with *Abies religiosa* (A. Equihua-Martinez, 1996, personal communication).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *High* (*RC*)
Since *S. mundus* has two generations per year and *P. variegatus* has several overlapping generations per year, it is very probable that adult beetles would be present whenever fir trees are cut in the woods. The ability of *P. variegatus* (less so with *S. mundus*) to colonize freshly cut logs makes the host association highly likely.

2. Entry potential: *High* (*MC*)
If logs are moved quickly, there is a good chance that developmental stages could be present beneath the bark when the logs arrive in the United States. Interception records indicate that live individuals of *Scolytus* spp. have been intercepted in lumber from Mexico (Appendix B).

3. Colonization potential: *Moderate* (*RU*)
Scolytus mundus has only one fir host in Mexico, while *P. variegatus* has two. It is not known how adaptable these species might be to other fir hosts if given the opportunity to colonize them. S.L. Wood (1997, personal communication) points out that scolytids of fir are usually fairly narrow in their host range. A similar North American species, *S. ventralis* LeConte, infests several species of *Abies*. Two Mexican species, *S. virgatus* and *S. hermosus*, infest *Pseudotsuga* as well as *Abies*.

4. Spread potential: *Moderate* (*RU*)
The ability of these insects to spread is dependent on their ability to compete with native scolytids in the United States that currently occupy the same niches (*S. ventralis*, most notably). Neither species is as aggressive as *S. ventralis*, but a third Mexican species, *Pseudohylesinus magnus* Wood may be a more aggressive mortality agent than the other two (S.L. Wood, 1996, personal communication), although its known distribution is smaller.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*RU*)
In Mexico, both species generally appear to require stressed hosts to colonize them successfully. Neither one appears to be as aggressive as the native *Scolytus* in the United States, which can reach outbreak levels that persist beyond periods of drought.

6. Environmental damage potential: *Moderate* (*MC*)
The ecological niche that these insects occupy in Mexico is filled in the United States by a species that is probably more aggressive (*S. ventralis*) and at least as capable as the Mexican species in

exploiting its host when it comes under stress. Of some additional concern would be *S. virgatus* and *S. hermosus*, which can infest *Pseudotsuga* as well as *Abies*. If introduced, these could possibly infest *Pseudotsuga* in western United States.

7. Perceived damage potential: *Low* (*MC*)
   Unless these insects were able to displace *S. ventralis* in the fir ecosystem, it is unlikely that they would be perceived as a problem. Fir-inhabiting scolytids usually have very limited host tolerance. As such, it is very unlikely that an introduced phloem-feeding species could adapt to a new host (S.L. Wood, 1997, personal communication).

C. Pest risk potential: *Moderate*

Selected bibliography

Cibrián Tovar, D.; Méndez Montiel, J.T.; Campos Bolaños, R. [and others]. 1995. Insectos forestales de México—Forest insects of Mexico. Publicación # 6. Chapingo, Mexico: Universidad Autónoma Chapingo. 453 p.

Wood, S.L. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera:Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs No. 6. Provo, UT: Brigham Young University. 1359 p.

Reviewers' comments— ". . .In this IPRA I question why the role of *Pseudohylesinus magnus* Wood has been downplayed. Not only does S. L. Wood (1982) state that this species attacks the lower bole of large trees, he also states that it can kill overmature trees. Why not include this species up front in the analysis as one of the highlighted species?" (S.J. Seybold)

"*Pseudohylesinus magnus* is a much more aggressive species that can kill stressed trees, although its known distribution is much smaller than *P. variegatus*." (S.L. Wood)

"In general, fir inhabiting scolytids are much more specific in their host range (less flexible) than other species, so it is rather unlikely that they could adapt to a new host (even an *Abies*) in a strange area." (S.L. Wood)

"These insects [*Scolytus mundus* and *Pseudohylesinus variegatus*] have different behavior for this reason we think could be assessed separately, because *P. variegatus* rarely attacks healthy trees and occurs almost always on stressed trees." (J. Villa–Castillo)

"*S. mundus* normally attacks tops of trees and only in one forested area behave as described in the manuscript, perhaps the term 'one of the most important' does not apply for this species." (A. Equihua–Martinez)

"This assessment could be broken into separate assessments for *Scolytus* and *Pseudohylesinus*. It is confusing that although the assessment is supposed to be of *S. mundus,* references to other *Scolytus* species (*virgatus* and *hermosus*) appear in several places. Are these species also being assessed?" (Cree/Watler)

"Our preliminary results [in Michoacan] indicate that the two fir bark-beetle species *Scolytus mundus* and *Pseudohylesinus variegatus* are more wide-spread than previously reported. The . . .majority of the killed trees were detected with annosus root rot. . .." (J. Villa–Castillo)

Response to comments—Several bark beetles are evaluated together in this IPRA, primarily because they occupy generally the same niche beneath the bark of their *Abies* hosts. In response to comments from two reviewers, the original IPRA for *S. mundus* and *P. variegatus* was expanded to include several species of *Scolytus* and two species of *Pseudohylesinus*.

As reflected in the reviewer comments, we have somewhat limited knowledge of the biology, distributions, and effects of these bark beetles on their *Abies* and *Pseudotsuga* hosts in Mexico. This leaves us in a rather speculative position for assessing these insects and their potential for affecting forest resources in the United States. Based on the information we have available to us, we believe that the fir bark beetles, as a group, represent a moderate risk to *Abies* and *Pseudotsuga* in the United States.

Bark Insects of Saplings

Assessor—Andris Eglitis

Scientific names of pests—*Dendroctonus rhizophagus* Thomas & Bright (Coleoptera: Scolytidae); *Pissodes zitacuarence* Sleeper, *Pissodes guatemaltecus* Voss, *Pissodes cibriani* O'Brian (Coleoptera: Curculionidae)

Scientific names of hosts—
Dendroctonus rhizophagus: Pinus arizonica, P. ayacahuite var. *brachyptera, P. chihuahuana, P. cooperi, P. durangensis, P. engelmannii, P. jeffreyi, P. herrerai, P. leiophylla, P. lumholtzii, P. michoacana* var. *cornuta, P. ponderosa, P. sylvestris.*
Pissodes zitacuarence: *Pinus patula, P. hartwegii, P. arizonica, P. durangensis, P. montezumae, P. ayacahuite* var. *brachyptera*.
Pissodes guatemaltecus: *Pinus montezumae, P. tecunumanii.*
Pissodes cibriani: *Pinus patula.*

Distribution—
Dendroctonus rhizophagus: Chihuahua, Durango, Guerrero, Sinaloa, Sonora, Zacatecas.
Pissodes zitacuarence: Chihuahua, Durango, Mexico, Hidalgo, Jalisco, Michoacan, Puebla.
Pissodes guatemaltecus: Chiapas, Oaxaca.
Pissodes cibriani: Hidalgo.

Summary of natural history and basic biology of the pests—*Dendroctonus rhizophagus* has a one-year life cycle, beginning with emergence of the adults between mid-June and September. Female beetles attack host tree seedlings on the bole near the root collar. They burrow through the bark and construct an egg gallery that encircles the tree. Eggs are laid loosely in the tunnel and hatch within 7 to 10 days. Larvae make a common gallery in the phloem and feed beneath the bark of the bole at or below the root collar. They eventually move into the larger roots (to 10 mm in diameter) where they overwinter. In the spring, the larvae return to the root collar where they pupate in small chambers constructed in the surface of the wood (xylem). Trees most commonly attacked by *Dendroctonus rhizophagus* are 0.3 to 1.3 m tall. In natural stands or stands of multiple ages, *D. rhizophagus* has limited importance, at times acting as a natural thinning agent. However, mortality levels in plantations can be particularly high, and *D. rhizophagus* takes on greater importance in these settings than in naturally regenerated stands.

The life cycle of *Pissodes zitacuarence* is poorly known, but adult weevils have been found between the months of April and October. Females require an extensive period of maturation feeding in the phloem of host trees and then deposit eggs beneath the bark. The preferred oviposition site is on the main bole of a small tree, in the four or five most recent internodes. Each larva constructs a straight individual gallery, normally directed downward in the tree. Mature larvae construct an oval chamber in the xylem, densely packed with shredded wood, where they pupate. Damage results from punctures made by adult weevils during their maturation feeding and from larval mining. In the first case, where maturation feeding has been extensive, there may be needle drop, shortening of the shoot, or entry of stem pathogens, including pitch canker (*Fusarium subglutinans* f. sp. *pini)*. In the latter case, shoot mortality occurs, and on occasion, death of an entire infested tree may occur. *Pissodes zitacuarence* is common in the forests of Mexico, especially in young dense stands, where the weevil acts as a thinning agent. It attains its greatest importance where young trees are growing under stressed conditions. It is believed that the insect will become more important if future plantations are established on poor sites.

The biology of *P. guatemaltecus* is similar to that of *P. zitacuarence,* but distribution is more restricted. The insect can cause the death of suppressed trees. *Pissodes cibriani* is also similar in its biology and its effects on suppressed trees, but unlike the other two, this weevil completes two generations in a year.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Low* (*RC*)
   These insects are all associated with small, suppressed trees and generally do not occur on pines of commercial size.

2. Entry potential: *High* (*MC*)
   Subcortical insects with long life cycles are very likely to survive transport between Mexico and the United States.

3. Colonization potential: *Moderate* (*RU*)
   As a group, these insects have a broad host range and would probably find suitable pine hosts in the United States.

4. Spread potential: *Moderate* (*RU*)
   If these insects were to become established, they would probably spread since pines are so widely distributed throughout the United States. The rate of spread would be rather slow for *Pissodes* and probably more rapid for *D. rhizophagus*, which is capable of flight.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*MC*)
   All of these insects appear to be restricted to trees of smaller, precommercial sizes. Some economic losses could occur in Christmas tree plantations growing on poor sites. One potential concern could be the association of *Pissodes* weevils with pitch canker (*Fusarium subglutinans* f. sp. *pini)*

and the possible vectoring of this disease through maturation feeding.

6. Environmental damage potential: *Low* (*MC*)
   These insects would be added to a long list of thinning agents that operate in dense young stands.

7. Perceived damage potential: *Low* (*RC*)
   Insects affecting scattered young trees growing under stressed conditions are generally not perceived as having major importance. However, if these insects were to become associated with Christmas trees, their perceived and economic damage would be far greater.

C. Pest risk potential: Low

Selected bibliography

Cibrián Tovar, D.; Méndez Montiel, J.T.; Campos Bolaños, R. [and others]. 1995. Insectos forestales de México—Forest insects of Mexico. Publicación # 6. Chapingo, Mexico: Universidad Autónoma Chapingo. 453 p.

Reviewers' comments—"On page 63 there is the statement 'Insects affecting young trees growing under stressed conditions are generally not perceived as having major importance.' Again, we believe that we must try to protect young trees, even if they are occasionally under stress, if we expect to have older trees in the future; otherwise we place whole ecosystems at risk." (Cobb/D. Wood)

"These insects vector pitch canker which according to its IPRA is a high pest risk with high economic impact - so shouldn't these be high also?" (Podleckis)

Response to comments—Insects that are only able to infest young trees under stress would function as thinning agents and probably would not significantly affect whole ecosystems.

In response to the second reviewer comment, we believe that the rating for economic potential should remain low due to limited dispersal capability and small tree host preferences for these insects.

Pitch Moth

Assessor—Jim Hanson

Scientific name of pest—*Synanthedon cardinalis* Dampf (Lepidoptera: Sesiidae).

Scientific names of hosts in Mexico: *Pinus patula, P. radiata, P. hartwegii, P. leiophylla,* and *P. lawsoni.*

Distribution—Mexican states of Baja California Norte, Baja California Sur, Chihuahua, Estado de Mexico, Distrito Federal, Jalisco, Michoacan, Morelos, Tlaxcala, and Sonora.

Summary of natural history and biology of the pest— *Synanthedon cardinalis* is a clearwing moth that has two or more generations a year in Mexico. The attacked trees have pink-colored resin masses on the trunk. Similar looking resin masses are made by turpentine beetles or pitch mass borers. Cibrián Tovar and others (1995) reported that in Mexico, it is often associated with mature trees that are infected with mistletoe. They also reported that feeding by the larvae, when severe, can cause tree death. It is assumed that this scenario would occur in sapling-sized trees where the larval feeding either causes girdling or makes the stem susceptible to wind damage. A native pitch moth in California is a carrier of the pitch canker fungus and, therefore, *S. cardinalis* could also potentially vector the fungus.

Synanthedon cardinalis would have at least two hosts in the United States, *Pinus radiata* and *P. leiophylla*. *Pinus leiophylla* occurs in southeastern Arizona, whereas *P. radiata* is rare and only occurs naturally in four populations along the coast of central California. It is, however, planted very widely in California as an ornamental and as a Christmas tree. It is considered by the California Native Plant Society to be rare and is also on the Food and Agriculture Organization's list of endangered trees and scrub species and provenances. Because of this, its importance may not just be in California but worldwide.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RC*)
The pest often occurs with mature pines that have mistletoe, which for forest health reasons, may be ones that would be desirable to harvest.

2. Entry potential: *Moderate* (*MC*)
The pest would probably survive quite well in transit but should easily be detected at the place of entry under present quarantine procedures. The pinkish resin globules on a damaged stem or trunk are easy to detect. The eggs may survive transit, however.

3. Colonization potential: *Moderate* (*MC*)
The only two known hosts of this pest in the United States, *Pinus radiata* and *P. leiophylla*, have very restricted ranges, but with California and Arizona being adjacent to Mexico and potential destination points for imported logs, the potential of establishment would be good. The pest would probably be able to reproduce in California and southeastern Arizona. This pest may also have other suitable hosts in the United States.

4. Spread potential: *Moderate* (*MC*)
The moth is a good flyer, so it could fly several kilometers from its source. Several generations per year would favor a high rate of spread. Pitch mass borers, however, tend to attack the same tree repeatedly, so in actuality, the spread may not be that far. The limited number of hosts and their restricted ranges could work against the spread potential. The range of hosts in the United States, however, could include more species than the moth attacks in Mexico.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*RU*)
The economic consequences resulting from the establishment of this pest alone would be low. The caterpillars bore into the inner bark and cause copious resin flow. They can cause pitch pockets in the wood when the wounds heal over. The total amount of damage from other clearwing moths is not great. If it vectors or provides suitable entry courts for the pitch canker fungus, however, its damage could be potentially great. *Pinus radiata* is also raised for Christmas trees in California, so introduction of this pest may prompt quarantines and financial losses to growers.

6. Environmental damage potential: *Moderate* (*RU*)
This pest would not cause large outbreaks or kill trees. It could compete with native pitch mass moths for a niche in the environment. The damage could be substantially more if it facilitated infection by the pitch canker fungus.

7. Perceived damage potential: *Moderate* (*RU*)
Synanthedon cardinalis would not cause aesthetic damage in the forest. It could cause concerns with susceptible ornamentals and Christmas tree growers. It could perceivably cause a lot of damage if it were capable of vectoring the pitch canker fungus, however.

C. Pest risk potential: *Moderate*

Selected bibliography

Cibrián Tovar, D.; Méndez Montiel, J.T.; Campos Bolaños, R. [and others]. 1995. Insectos forestales de México—Forest insects of Mexico. Publicación # 6. Chapingo, Mexico: Universidad Autónoma Chapingo. 453 p.

Roundheaded Wood Borer

Assessor—Jim Hanson

Scientific name of pests—*Monochamus clamator rubigineus* (Bates) (Coleoptera: Cerambycidae).

Scientific names of hosts—*Pinus* spp. (including *P. chihuahuana, P. gregii, P. patula, P. ponderosa,* and *P. rudis*).

Distribution—Southeastern Arizona, Hidalgo, Oaxaca, Vera Cruz, and south to Honduras.

Summary of natural history and basic biology of the pests—The biology of the *Monochamus* species is similar (USDA 1985, Furniss and Carolin 1977). The adults emerge in the spring and go through a period of maturation feeding where they feed on the twigs of pines (conifers). The adult female oviposits in freshly cut, felled, or recently dead timber. They often colonize trees that have been killed by infestations of *Dendroctonus* spp. and *Ips* spp. Young larvae feed on the inner bark, cambium, and outer sapwood, forming shallow excavations called surface galleries. As they age, they bore deep into the wood and then turn around and bore back toward the surface. A pupal cell is formed at the outer end of the tunnel. When mature, the adult emerges by gnawing a round hole through the thin layer of wood and bark separating the pupal cell from the surface. The life cycle is normally one year in southern areas. All of the *Monochamus* species listed in Cibrián Tovar and others (1995) and Dwinell and Nickle (1989) are found in the United States (Linsley and Chemsak 1984), although *M. clamator rubigineus* is restricted to southeastern Arizona. The adults are vectors of the pinewood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle. Secondary transmission during oviposition of the *Monochamus* to dead or dying pines and other conifers is considered the most common means of transgenerational transfer of *Bursaphelenchus*. As a result, the pinewood nematode may be present in raw softwood products as a secondary associate (Dwinell and Nickle 1989). Dwinell reported on the recovery of *B. xylophilus* from pine in Mexico (Dwinell 1993). Other species of *Monochamus* found in Mexico, *M. scutellatus scutellatus* (Say) and *M. notatus* (Drury), are also distributed throughout the United States.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*MC*)
   Monochamus eggs and larvae are attracted to felled or recently dead trees. The adult emergence in the spring and early summer would coincide with the logging season in Mexico.

2. Entry potential: *Moderate* (*MC*)
   Because *Monochamus* oviposits in freshly cut or recently dead timber, either the eggs or larvae could be transported with the logs.

3. Colonization potential: *Moderate* (*MC*)
   Monochamus species are strong flyers and could readily locate suitable pine hosts if available. However, despite the fact that there are records of numerous *Monochamus* spp. interceptions worldwide, there is little evidence of successful colonization.

4. Spread potential: *Low* (*MC*)
   Once established, the spread of *Monochamus* spp. would be inhibited by competition with locally abundant native *Monochamus* spp. Additionally, even though adults of *Monochamus clamator rubigineus* are strong fliers, their distribution is limited within the United States and they are presumed to currently occupy their potential ecological range.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*RC*)
   All three of the *Monochamus* species mentioned are found in the United States. Other *Monochamus* species may exist in Mexico, but members of this genus haven't been a major problem in our forests. This is primarily because it attacks dead or dying trees.

6. Environmental damage potential: Low (RC)
   Monochamus would not be a tree killer or cause large outbreaks. Furthermore, it is assumed that the *Monochamus* species mentioned have reached their ecological range in the United States.

7. Perceived damage potential: *Low* (*RC*)
   Introductions of the three *Monochamus* species mentioned are unlikely to cause increased social or political impacts beyond those already caused by these insects.

C. Pest risk potential: *Low*

Selected bibliography

Cibrián Tovar, D.; Méndez Montiel, J.T.; Campos Bolaños, R. [and others]. 1995. Insectos forestales de México—Forest insects of Mexico. Publicación # 6. Chapingo, Mexico: Universidad Autónoma Chapingo. 453 p.

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Furniss, R.L.; Carolin, V.M. 1977. Western forest insects. Misc. Pub. 1339. Washington, DC: U.S. Department of Agriculture, Forest Service, U.S. Department of Agriculture, Forest Service. 654 p.

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USDA. 1985. Insects of eastern forests. Misc. Pub. 1426. Washington, DC: U.S. Department of Agriculture, Forest Service. 608 p.

Ambrosia Beetles (*Gnathotrichus* spp.)

Assessor—Jim Hanson

Scientific names of pests—*Gnathotrichus nitidifrons* Hopkins and *Gnathotrichus perniciosus* Wood (Coleoptera: Scolytidae)

Scientific names of hosts—*Gnathotrichus nitidifrons: Pinus cooperi, P. leiophylla, P. montezumae*

Gnathotrichus perniciosus: Pinus chiapensis, P. leiophylla, P. montezumae, P. oocarpa, P. pseudostrobus.

Distribution—*Gnathotrichus nitidifrons*: Durango and Hidalgo to Guatemala.

Gnathotrichus perniciosus: Sinaloa and Chihuahua to Honduras.

Summary of natural history and basic biology of the pests—Numerous species of beetles in the families Scolytidae and Platypodidae are commonly called ambrosia beetles because the adults and larvae feed on a mold type of fungus called ambrosia. The male of *Gnathotrichus* spp. constructs an entrance tunnel and inoculates the tunnel wall with fungal spores. The male is then joined by the female and mating takes place, and the female then oviposits the eggs on the sides of the gallery. Larvae feed on the ambrosial fungus and possibly some xylem. Pupation occurs in the larval galleries, and the adults emerge through the parental tunnels to attack other trees or green lumber or to reinfest the same material. *Gnathotrichus* beetles, besides having the specific hosts mentioned for Mexico, attack dead and dying pines, Douglas-fir, western hemlock, true firs, and other conifers.

Ambrosia beetles are important because of the degrade they cause from their tunnels and dark staining from the fungus associated with the beetle. Annual losses in British Columbia from their five species of important ambrosia beetles are estimated to be $64 million per year (McLean 1985). Logs can be infested in a very short time period, often within 10 days of harvesting. The pest risk assessment team members that traveled to Mexico frequently observed *Gnathotrichus* adults and boring dust on logs at the mill sites and decking areas. Some of these specimens were later identified as *G. sulcatus*. This and other species of *Gnathotrichus*, such as *G. denticulatus* and *G. imitans*, also attack conifers but are distributed in the United States and Mexico.

Wood (1982) reports two species of *Gnathotrichus* that are found in Mexico on pines and don't have distributions in the United States; they are *G. nitidifrons* and *G. perniciosus*.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *High* (*VC*)
   From the observations by members of the pest risk assessment team that traveled to Mexico, *G. sulcatus* was commonly observed both in the field at decking sites as well as at the ports. The ambrosia beetles will attack trees in as little as 10 days after cutting, so logging and shipping would have to be very efficient to avoid attacks by *Gnathotrichus* spp.

2. Entry potential: *High* (*MC*)
   The galleries of *Gnathotrichus* spp. extend through the bark and into the wood, so in light infestations they could be difficult to find. With larger attacking populations, the boring dust should be fairly easy to detect. These beetles would survive quite well during shipment.

3. Colonization potential: *High* (*MC*)
   These insects are good flyers and should be able to find suitable pine hosts within the habitat surrounding their introduction site. This would be especially true with *G. perniciosus* that attacks many species of pine.

4. Spread potential: *High* (*MC*)
   Scolytid beetles are capable of flying distances of several kilometers and could be carried further by winds. This insect may have three or more generations per year, so if it found suitable habitat, it might have multiple opportunities to disperse each year.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*MC*)
   The scolytids in this genus introduce a fungus that causes wood stain. In heavy infestations, these insects and associated fungi can cause the degrade of the wood quality resulting in a lower value for the commodity. McLean (1985) mentions that ambrosia beetle damage in British Columbia has been estimated at $64 million per year. The addition of one more species of ambrosia beetle, however, may not result in a significant increase in total damage.

6. Environmental damage potential: *Low* (*MC*)
   Ambrosia beetles of the genus *Gnathotrichus* are known to attack trees under stress. They restrict their attack to dead or dying trees or recently cut logs. These species would not add significantly to the environmental damage that is already occurring from ambrosia beetles. *Gnathotrichus perniciosus*, however, can attack the site of a minor wound on a healthy tree and, from there, spread the attack to the entire tree.

7. Perceived damage potential: *Low* (*RC*)
   Gnathotrichus species are not primary tree killers and do not cause large outbreaks. Because they

infest already dying trees or logs, they will not be of concern to the general public.

C. Pest risk potential: *High*

Selected bibliography

Cibrián Tovar, D.; Méndez Montiel, J.T.; Campos Bolaños, R. [and others]. 1995. Insectos forestales de México—Forest insects of Mexico. Publicación # 6. Chapingo, Mexico: Universidad Autónoma Chapingo. 453 p.

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Ambrosia Beetle (*Xyleborus*)

Assessor—Jim Hanson

Scientific name of pest—*Xyleborus volvulus* (F.), (Coleoptera: Scolytidae)

Scientific names of hosts in Mexico—*Astronium graveolens, Cedrela odorata, Bursera simaruba, Enterolobium* spp.*, Erythrina americana, E. glauca, Ficus* spp.*, Inga alba, Leucaena pulverulenta, Jacaranda copaia, Pinus oocarpa, Terminalia amazonia, Theobroma cacao.*

Distribution—Baja California to Argentina; Florida; Hawaii to Australia and Malaya; tropical Africa and Madagascar.

Summary of natural history and biology of the pests— The females of this species are parthenogenetic, which means the females can reproduce without mating. Because of this, there is a disproportionate number of females for each male. The insect can complete a life cycle in a month, so there can be several generations per year. The female adults attack the tree and construct communal galleries. While constructing the galleries, fungus spores are released that later serve as the food for the colony. The females lay eggs in the galleries, and the larvae feed, develop, and pupate in the galleries. Within the colony, there are usually overlapping generations. There may be as many as 500 individuals within a gallery system. The males in the colony do mate with the new females, and the females eventually leave to infest new trees. The males do not have functional wings; therefore long distance dispersion is done by the females.

Xyleborus volvulus appears to be mainly a pest of nonconiferous tropical and subtropical trees. In the United States, it is found in southern California, Florida, and Hawaii. Of the hosts mentioned above, *B. simaruba* (southern Florida), *Erythrina* spp. (Hawaii), *Ficus* spp. (central and southern Florida and Hawaii), *L. pulverulenta* (southern Texas), and *T. amazonia* (Florida and Hawaii) are found in the United States. *Xyleborus volvulus* attacks only one *Pinus* species, *P. oocarpa*, which isn't found in the United States (Little 1979), but it has several hundred hosts in the United States (Wood and Bright 1992).

Xyleborus species are ambrosia beetles that bore in the wood. Wood (1982) reports 76 *Xyleborus* species from North America, 10 of which are found in western United States. About 25 species occur in eastern United States and have hosts ranging from pecan and hardwoods to pitch pine (*Pinus rigida* Mill.). The insects mainly attack decadent trees and, as a result of the attack, transmit a stain fungus that degrades the quality of products from the infested tree. This species has several generations per year in Mexico.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Low* (*RC*/*MC*)
The only *Pinus* species that this pest has been reported on from Mexico is *P. oocarpa*.

2. Entry potential: *High* (*RC*)
The insects bore deep into the sapwood; so with a visual inspection, infested logs would be hard to find.

3. Colonization potential: *Low* (*MC*)
Generally, this species appears to attack subtropical tree species, and it probably would not be a problem in any of the other states besides already infested Florida, southern California, and Hawaii.

4. Spread potential: *Low* (*MC*)
Ambrosia beetles are capable of flying several kilometers or more and could be carried further by winds. This insect can have two or more generations per year, so there could be two or more increments of spread annually. However, being a subtropical species, its range could be rather limited.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*RC*)
This pest probably wouldn't be important beyond the already infested southern California, Hawaii, or Florida. Other *Xyleborus* species found in the United States haven't caused a major economic impact, nor has this species been important in either Hawaii or Florida.

6. Environmental damage potential: *Low* (*RC*)
This species would not cause large outbreaks or kill trees. It would compete with native pests that attack dead or dying trees.

7. Perceived damage potential: *Low* (*RC*)
This pest would not cause aesthetic damage in the forest. Damage to wood from the boring and wood staining fungus could cause consumer concern. Some people even prefer wood with evidence of old ambrosia beetle galleries for paneling and other uses.

C. Pest risk potential: *Low*

Selected bibliography

Bright, D. 1968. Review of the tribe Xyleborini in America north of Mexico (Coleoptera; Scolytidae). Canadian Entomologist. 100: 1288–1323.

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Wood, S.L.; Bright, D.E. 1992. A catalog of Scolytidae and Platypodidae (Coleoptera), Pt. 2 Taxonomic index. Vol. A., B. Great Basin Naturalist Memoirs No. 13. Provo, UT: Brigham Young University. 1553 p.

Reviewer's Comments— "Although I have seen authentic examples of *Xyleborus volvulus* from conifer logs, I regard them as acccidental. It is suspected that the specimens identified as *X. volvulus* might actually be *X. intrusus* that is restricted to conifers (it also occurs in the USA)." (Steven L. Wood).

Response to comments—We assessed the risk of *Xyleborus volvulus* because it was identified in Cibrián Tovar and others (1995) as one of the most important ambrosia beetles in Mexico and because a pine was listed as a host. After the comments of S.L. Wood were considered, the probability of association with host at origin was reduced from Moderate to Low.

Termites

Assessor—Jim Hanson

Scientific name of pest—Subterranean termite: *Coptotermes crassus* Snyder (Isoptera: Rhinotermitidae). Drywood termite: *Incisitermes marginipennis* (Latreille), Isoptera: Kalotermitidae.

Scientific names of hosts in Mexico—Subterranean termite: *Araucaria* spp., *Bursera simaruba, Casuarina equisetifolia, Cedrela odorata, Ceiba pentandra, Eucalyptus camaldulensis, Gmelina arborea, Mangifera indica, Pinus maximinoi, P. oocarpa, Quercus* spp., *Swietenia macrophylla*

Drywood termite: *Cupressus lindleyi, Fraxinus uhdei, Pinus* spp., *Populus* spp., *Salix* spp., *Taxodium mucronatum.*

Distribution—Subterranean termite: Campeche, Chiapas, Colima, Jalisco, Nayarit, Quintana Roo, and Tabasco. Drywood termite: Chiapas, Colima, Distrito Federal, Estado de Mexico, Jalisco, Michoacan, Nayarit, Oaxaca, Puebla, Tlaxcala, and Veracruz.

Summary of natural history and biology of the pests— There are about 43 species of termites in the contiguous United States, but only about 13 species are noted for their potential for economic damage. Termites are divided into three general categories: drywood, dampwood, and subterranean. Control of termites and repair of damage caused by them result in a total economic impact to the United States of $1.5 billion (billion = $\times 10^9$) per year. Drywood termites cause about 5 percent of this total damage (USDA Forest Service 1992). *Coptotermes crassus* is a subterranean termite, which means it must maintain a connection with the ground unless a supply of water is otherwise available. To attack wood away from the ground, a mud shelter tube is needed as a pathway and to maintain required moisture. Termites are social insects and live in colonies. Generally, there are three types of individuals in colonies: workers, soldiers, and reproductives. Termites have no pupal stage and therefore remain active except when molting their skin. Colonies contain large numbers of wingless workers whose role is the care of the young, feeding and foraging, and cleaning, whereas soldiers defend the colony from predators. The workers are the type that damages the wood. The flight of reproductives generally occurs during the spring and summer after a rain but can occur anytime during the year. *Coptotermes crassus* is found in tropical southeastern and western Mexico in untreated wood structures that touch the soil (Cibrián Tovar and others 1995). It can also establish colonies in live trees or other wood items that come in contact with the soil, such as poles and posts. Cibrián Tovar and others (1995) suggest that pruning broken or dead tree limbs during the dry season improves healing of wounds and thereby lessens the likelihood of termites entering the tree. The other termites mentioned by Cibrián Tovar and others (1995), *Nasutitermes nigriceps* and *N. corniger*, were not included in this summary because *Pinus* or *Abies* were not listed as hosts. *Heterotermes aureus convexinotatus, H. aureus aureus, Reticulitermes flavipes*, and *R. hesperus* were omitted because they already occur in the United States. However, these three termites are known to be destructive wood feeders and should be able to attack pine, fir, and other softwood as well as hardwood trees and lumber. They must also be considered serious threats to wood and wood products.

Incisitermes marginipennis is a drywood termite, which means that it doesn't live in the soil and doesn't require the presence of large amounts of moisture. This species attacks felled trees, stumps, and other susceptible wood, including wood already in use. The reproductives fly during the rainy season, which can vary from May through September, and form a new colony if a suitable site is found (Cibrián Tovar and others 1995). The reproductives take care of the eggs and immatures until there is a sufficient number of workers assuming the role of feeding the reproductives and immatures. When the colony gets big enough, pheromone activity by the reproductives stimulates soldier production. As the individuals in a colony of this species eat wood and cause damage, the structural integrity and load-bearing capacity of wood in use can be decreased. The other species of termites, *I. minor* and *Cryptotermes brevis*, mentioned by Cibrián Tovar and others (1995) occur in the United States (Brad Kard, 1996, personal communication, USDA Forest Service, Starkville, MS).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*MC*)
   Coptotermes spp. can be found in trees with hollow trunk syndrome associated with carpenter ants (*Camponotus* spp.). Cibrián Tovar and others (1995) list two *Pinus* spp. as hosts, *P. maximinoi* and *P. oocarpa*. *Incisitermes marginipennis* is a broad spectrum feeder that apparently attacks many species of pine. This, however, shouldn't be a problem unless the felled trees remain in the woods or at a decking site for longer than several months. The likelihood of association of either termite with the host increases with long-term storage of logs in the woods.

2. Entry potential: *Moderate* (*MC*)
   This moderate rating derives from a rating of low-moderate for subterranean termites and high for drywood termites. The termites would survive quite well during transit and may not be detected at inspection points if the log ends are not visible during inspection. However, the hollow trunk and

the mud tunnels in the bole associated with *C. crassus* should normally be easy to see. Drywood termites are extremely difficult to spot during an early infestation since a start-up colony has very few members and is established in a small area of wood.

3. Colonization potential: *Moderate* (*MC*)
The initiation of a colony is a slow process, but dead trees, logs, poles, or other suitable wood materials may provide an infestation source at ports or mills. The adults usually fly for only about 100 m but are capable of flying up to 1 km depending on wind conditions and weather. Colonization potential is variable between the two termites, depending on port conditions; moist areas are more conducive to survival of *C. crassus*, dry conditions are more conducive to the drywood species.

4. Spread potential: *Moderate* (*MC*)
Termites spread slowly (15 to 300 m per year), and only about 1 percent of those that fly eventually establish a new colony. However, an important factor concerning the termites found in both Mexico and the United States is that infested logs and wood products that move by human commerce spread termites at a much faster rate than their natural spread.

B. Consequences of pest establishment

5. Economic damage potential: *High* (*RC*)
Termites will attack untreated wood. Their damage to wooden houses can be severe if not detected at an early stage. Once they are in a structure, spread of subterranean termites can be rapid and the economic impact can be quite high. Drywood termites spread very slowly but can cause severe damage over time. These termites probably wouldn't do well in extremely cold climates but could be a problem in moist, warm climates along the western, southern, and southeastern coasts of the continental United States. Drywood termites are major pests in southern California, both in the coastal and inland regions.

Subterranean termites cause the majority of economic losses in the United States. Potential economic losses caused by *C. crassus* could be comparable with those currently caused by *C. formosanus*. If *C. crassus* were to be as aggressive as *C. formosanus*, it could cause $50 million in damage and control costs within 30 years (Michael Haverty, 1996, personal communication, USDA Forest Service). Assuming a 10-year establishment period and a gradual growth to reach this level of damage, the 30-year net present value of the impact could be $135 million at a 4 percent discount rate.

Incisitermes marginipennis is a drywood termite that, if established in the United States, would compete with the other species of drywood termites already in the contiguous United States. The USDA Forest Service (1992) estimates that an additional drywood termite could cause up to $500,000 in damages per year after a 10-year establishment period. The 30-year net present value of the damage at a 4 percent discount rate from such an infestation could be approximately $3.3 million.

6. Environmental damage potential: *Low* (*VC*)
These termites would not cause large outbreaks or kill trees. They would compete with native termites that degrade and decompose wood in use.

7. Perceived damage potential: *Moderate*
These termites do not cause aesthetic damage in the forest. However, damage to wood in use would cause consumer concerns, adding to concerns about other termite species. Control methods for termites are available but can be expensive and could be a risk to environmental quality through increased pesticide use. An imported termite that is related to *C. crassus* is the Formosan subterranean termite (*Coptotermes formosanus*). This is a destructive oriental species that costs more than $100 million in termite control treatments and damage repairs on the island of Oahu (Hawaii) alone. (Brad Kard, 1996, personal communication, USDA Forest Service, Starkville, MS).

Coptotermes crassus would probably be as damaging as other species of *Coptotermes* such as *C. formosanus*.

C. Pest risk potential: *High*

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Reviewers' comments—“What is the rationale for not including dampwood termites in the analysis?" (Seybold)

“The termite *Coptotermes crassus* merits a moderate pest risk potential, in my opinion, the same as termites associated with *Pinus radiata* from Chile. With 43 species of termites already present in the U.S., the economic impact of one or two species is unlikely to substantially increase the current level of economic damage." (Billings)

Response to comments—In this pest risk assessment, it is not our intention to conduct detailed risk assessments for all termites or all families in a particular order but to assess a representative sample of that particular order. Cibrián Tovar and others (1995) list a number of termite species that are important in Mexico. This list was examined, and two species were selected to represent the order in doing the assessment. Therefore, dampwood termites were not covered in the analysis.

It was felt that *Coptotermes crassus* deserved a high rating because of its economic damage potential. Other species in this genus have been very destructive and thus the high ratings for *C. crassus*. Entomologists that specifically work on termites also believe that it posed a high risk for economic damage (Kard, Haverty, 1996, personal communications).

Coptotermes formosanus, of the same genus as *C. crassus*, has shown itself as an aggressive economic pest causing very high levels of damage and control costs. It continues to expand its range within the United States despite the presence of many species of competing native termites. We believe that this example justifies the high rating for *C. crassus*. The termites considered in the Chilean assessment were not of the genus *Coptotermes* and were not subterranean termites.

Pathogens

Needle Diseases

Assessor—John Kliejunas

Scientific names of pests and Mexican pine hosts—
Davisomycella medusa (Darker) Darker (Discomycetes: Rhytismatales) (*P. jeffreyi*)
Dothistroma pini Hulbary (syn. = *D. septospora*) (Coelomycetes) (*P. radiata*)
Dothistroma septospora (Doroguine) Morelet (Coelomycetes) (*P. ayacahuite, P. culminicola*)
Elytroderma deformans (Weir) Darker (Discomycetes: Rhytismatales) (*P. jeffreyi*)
Hypoderma spp. (Discomycetes: Rhytismatales) (*Pinus* spp.)
Hypoderma mexicanum Wolf (Discomycetes: Rhytismatales) (*P. leiophylla*)
Lophodermella spp. (Discomycetes: Rhytismatales) (*P. ayacahuite* var. *veitchi*)
Lophodermella maureri Minter & Cibrián (Discomycetes: Rhytismatales) (*P. ayacahuite*)
Lophodermium australe Dearn. (Discomycetes: Rhytismatales) (*P. pseudostrobus*)
Lophodermium nitens Darker (Discomycetes: Rhytismatales) (*P. ayacahuite*)
Lophodermium pinastri (Schrad.:Fr.) Chev. (Discomycetes: Rhytismatales) (*P. hartwegii*)

Distribution—Several genera of needle-disease-causing fungi that affect *Pinus* spp. occur in Mexico (I. Vasquez, 1996, personal communication). *Dothistroma pini* and *Elytroderma deformans* are the most significant. Records of needle-disease-causing fungi on *Abies* spp. in Mexico have not been located.

Summary of natural history and basic biology of the pests—*Dothistroma pini* causes a needle blight of more than 30 conifer species worldwide (Ivory 1994, Sinclair and others 1987) and occurs on *P. radiata* planted in Mexico. The disease is considered the most devastating disease encountered in *P. radiata* plantations in the Southern Hemisphere (Gibson 1972). Diseased needles drop prematurely, the older ones first. Successive years of severe infection result in decreased tree growth and ultimately death (Peterson 1982a). Three varieties of the fungus have been described (Gibson 1972). These varietal differences may account for differences in observed susceptibility of various pine species following artificial inoculation (Gilmour 1967, Cobb and Libby 1968, Ivory 1968). Epidemics of dothistroma needle blight develop more quickly in areas of mild climate with high rainfall or frequent fog or mist (Sinclair and others 1987). *Dothistroma pini* is not considered a serious problem in Mexico. A related species, now considered synonymous with *D. pini*, *Dothistroma septospora* (*Mycosphaerella pini*), is the cause of red band needle blight on some 30 species, varieties, or hybrids of pines, including two pine species in Mexico. This disease is considered to be the most destructive needle disease of pines throughout the world. Under favorable environmental conditions, needle infection results in complete defoliation and may eventually kill the trees (Gibson 1979).

Elytroderma deformans occurs on *P. jeffreyi* in Baja California. Jeffrey pine in Mexico is under special protection, and a special permit is required to cut and remove any part of the tree. The pathogen is considered the most important needle pathogen of ponderosa and Jeffrey pines in western North America (Smith and Scharpf 1993). Its perennial nature and its ability to infect host twigs enable it to maintain its populations even under adverse environmental conditions (Childs 1968). In addition to ponderosa and Jeffrey, other pines reported as hosts include Coulter, knobcone, lodgepole, and pinyon. The pathogen causes the premature death of 1-year-old needles and a brooming and deformation of infected twigs and branches. Although the disease only infrequently kills mature trees, moderate to severe infection results in reduced growth and vigor, predisposing the host to other diseases and to bark beetle attack. The disease has reached epidemic proportions in certain specific environments, such as around lakes and along stream bottoms.

Species of *Davisomycella*, *Hypoderma*, *Lophodermium,* and *Lophodermella* cause needle cast of many pine species throughout the world. *Lophodermella maureri* was reported as a new species on *P. ayacahuite* in Mexico (Minter 1988) and is damaging on other pine species in plantations (Minter 1986). The species has not been reported in native forests of Mexico (J. Guerra, 1996, personal communication). *Hypoderma mexicanum* is widely distributed in Mexico, being reported on *P. leiophylla* (Wolf 1951) and collected on *P. cooperi*, *P. engelmannii*, *P. durangensis*, and *P. teocote* (Hawksworth 1987). This needle cast fungus is considered a minor pathogen of current year needles. Three species of *Lophodermium* are considered saprophytes or weak pathogens on Mexican pines (I. Vasquez, 1996, personal communication).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RC*)
With the exception of *Elytroderma deformans*, the needle-disease-causing fungi are restricted to needles and do not occur in shoot or stem tissue. Conidia of *Dothistroma pini* can survive in infected pine foliage for considerable periods of time (up to 1 year, depending on temperature) (Gibson and others 1964, Ivory 1967). The probability of their occurring on exported logs is considered moderate because infected needles may easily lodge in the bark and be transported in log shipments.
2. Entry potential: *Moderate* (*RC*)
Needle-disease-causing fungi could survive transit

to the United States in infected foliage remaining on any shoots transported with logs or in needles lodged in bark crevices. *Elytroderma deformans* could survive in infected shoots or twigs.

3. Colonization potential: *Moderate* (*RC*)
Spores of these fungi are both waterborne and windborne and could be carried for great distances. Hosts, in both native stands and ornamental plantings, grow near ports of entry. Favorable environmental conditions, including moisture and temperature (Gibson 1972), would need to be present for infection to occur.

4. Spread potential: *Moderate* (*RC*)
Spread would depend on favorable environmental conditions and the presence of susceptible hosts. Because the known species of needle fungi reported on pines in Mexico apparently already occur in the United States, their spread potential also would be the same.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*RC*)
These fungi seldom cause economic losses in native forests in the United States. Assuming that any species of needle disease fungi introduced would not be new, more virulent strains or races, economic damage potential would be low to negligible. If a more virulent strain or species were introduced into a new environment, the economic damage potential would be increased to moderate, particularly in the case of ornamentals or Christmas tree plantations. Because of limited scientific knowledge of needle disease fungi in Mexico, moderate is used.

6. Environmental damage potential: *Moderate* (*RC*)
Because these fungi seldom cause significant damage in the United States, any impact on associated ecosystems from further introductions of species already present would be minimal or nonexistent. This low rating would increase to moderate if more virulent strains of these fungi, or some unknown but potentially damaging pathogen of needles, were to be introduced. The scientific information available on needle diseases of Mexican species of *Pinus* and *Abies* is very limited; therefore, moderate is used.

7. Perceived damage potential: *Moderate* (*RC*)
Further introduction of a species already occurring in the United States is likely to result in very little increase in damage. Therefore, the social and political impact would be unnoticed or minimal. Nevertheless, the increased discoloration and casting of needles resulting from establishment of a more virulent strain of any of these pathogens would cause moderate levels of public concern, particularly in ornamental plantings.

C. Pest risk potential: *Moderate*

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Reviewers' comments— "Needle Cast Diseases are widely distributed in the USA and we have common species of the fungus; therefore I think the PRA for this disease must be low." (Vazquez Collazo)

"As a general comment, we would not consider most of these needle-born pathogens as possible quarantine pests for several reasons. With the exception of *Lophodermella maueri* and *Hypoderma mexicanum*, they are already widespread in Canada and the United States. Additionally they are not normally responsible for significant economic damage. Individual assessments of *L. maueri* and *H. mexicanum*, to determine their pest risk potential and quarantine status, are warranted. We agree with the ratings applied to needle diseases in each of the seven categories, but do not agree that they are quarantine pests." (Cree/Watler)

"*Lophodermium australe* is a saprophyte or weak pathogen, distributed in the southeast and Gulf Region. *Lophodermium pinastri* is a weak pathogen, invading green needles and causing yellowing and casting of the oldest needles, and also invades dying needles as a saprophyte; it has a transcontinental distribution. *Lophodermium nitens* is a weak pathogen with a transcontinental (wide) distribution. *Elytroderma deformans* occurs in North America and is widespread in the USA; the host recorded (*P. jeffreyi*) has a restricted distribution (in Mexico); *P. jeffreyi* is under special protection in Mexico; a special permit is necessary to obtain any part of the tree; this disease should not be included in the risk assessment. *Lophodermella maureri* has not been found in natural stands; it is very important in Christmas tree plantations; it was recorded causing 3% infection of *Pinus ayacahuite* in the most important plantation in Mexico this year. *Hypoderma* has a wide distribution, but it's damage is confined to dead needles. *Dothistroma pini* is confined to plantations and there are records of important damage in urban areas. In the case of those (needle) diseases affecting *Pinus culminicola*. . .you can not obtain logs because the species is very small and its distribution is restricted." (Guerra Santos)

"This presentation seems to imply complete knowledge of needle fungi in Mexico and concludes that the species are all present in the U.S. I very much doubt it. It also concludes minimal damage from needle fungi to forests. This is generally true for native fungi on well adapted hosts, but the potential of exotics is clearly demonstrated by *Dothistroma* around the world." (Hansen)

"With respect to needle disease fungi, there are a few observations worth noting. First, we still have not a good grasp of the 'variability' within *Dothistroma septospora*. Three varieties have been described but, using the same criteria, others could be described. For example, the fungus in northern California has conidia substantially longer than any other variety; in Chile, there is a wide range of variability that could be associated with differences in precipitation. Until there is more information on the variability within *D. septospora* and how it related to host range and virulence, APHIS should be very cautious. As for the needle cast fungi, a phenomenon that has been observed many times is the increased susceptibility of trees when planted out of their natural range or on off-sites. A good example of this in north Idaho is the 'off-site' planting of ponderosa pine following the 1930s fires. The pine is now being destroyed by *Elytroderma*. A similar increase in disease might occur when one or more of these fungi is introduced into a new environment. We believe that the risk potential should be high until we have reasonable evidence to the contrary." (Cobb/Wood)

"Pest with host at origin: a rating of High would be reasonable to us since 'infested needles may easily lodge in the bark and be transported in log shipments.'" "Damage potentials can exceed a moderate level for some organisms and ecosystems, e.g., currently Swiss needle cast on the Oregon coast. We recommend a moderate/high rating would be more appropriate for all three damage potential ratings." (K. Johnson/Griesbach)

Response to comments—The individual pest risk assessment for needle diseases includes a discussion of both *Dothistroma*, a pathogen of worldwide importance, as well as the more benign needle cast fungi in the genera *Davisomycella*, *Hypoderma*, *Lophodermella*, and *Lophodermium*. It recognizes that needle cast fungi are widely distributed in the United States and that they are generally considered saprophytes or weak pathogens. The moderate pest risk potential is given primarily for *Dothistroma*, a destructive needle disease of pines throughout the world. There are known varietal differences within the genus, with at least three varieties having been described. The variety–strain of *Dothistroma* present in Mexico is unknown. In addition, the moderate rating is based on the very limited information available on needle diseases of Mexican *Pinus* and *Abies*. A previously undescribed, or even an already described, needle pathogen could become destructive when introduced into a new, favorable environment. Recognizing that *Elytroderma deformans* is limited to protected Jeffrey pine in Baja, we feel that a discussion of the pathogen in this section is appropriate to maintain completeness of the known literature of needle diseases in Mexico.

Pine Pitch Canker

Assessor—John Kliejunas

Scientific name of pest—*Fusarium subglutinans* (Wollenweb. & Reinking) P.E. Nelson, T.A. Toussoun & Marasas f. sp. *pini.* (Hyphomycetes).

Scientific names of hosts—*Pinus arizonica, P. ayacahuite, P. cembroides, P. discolor, P. douglasiana, P. durangensis, P. greggii, P. halepensis, P. hartwegii, P. leiophylla, P. maximinoi, P. michoacana, P. montezumae, P. oaxacana, P. oocarpa, P. pringlei, P. pseudostrobus, P. radiata,* and *P. rudis* in Mexico; numerous *Pinus* spp. and *Pseudotsuga menziesii* elsewhere.

Distribution—United States (coastal California and the southeastern states, from Virginia to Florida and west to Texas), Mexico (13 states, particularly in the northern and central regions), Haiti, and Japan.

Summary of natural history and basic biology of the pest—Pine pitch canker, caused by the fungus *Fusarium subglutinans* f. sp. *pini*, is a serious, insect-vectored disease of conifers. The pathogen infects branch tips, causing needle wilt and tip death. A characteristic symptom of infection on most hosts is a copious pitchy flow from cankers or necrotic tissue on limbs, trunks, roots, and cones. Symptoms vary by host. Infected Mexican pine species typically exhibit shoot dieback, with stem cankers being rare. Death of the tree or its tip may result from secondary attack by bark beetles. Naturally occurring wounds (hail, wind stress, and various animals) and insect-caused wounds are required as infection courts for the pitch canker fungus. Many insects are capable of causing wounds and some have been shown to transmit the fungus. In California, bark, twig, and cone beetles are implicated as vectors of the pathogen. Ips bark beetles (*Ips mexicanus* and *I. paraconfusus*) may transmit fungal spores to the main bole and large limbs. The two species have experimentally transmitted the fungus to seedlings and mature pines (Fox and others 1991). Adult twig (*Pityophthorus* spp.) and cone (*Conophthorus* spp.) beetles may transmit the fungus to the tips of branches and developing cones when they excavate feeding and egg galleries in twig bark and cone tissues (Hoover and others 1995). When artifically contaminated and confined to their host, *Conophthorus radiatae* transmitted the pathogen to healthy cones, and artificially contaminated, *Ernobius punctulatus* transmitted the fungus to cones attacked by uncontaminated *C. radiatae* (Hoover and others 1996). Dispersal of inoculum-carrying insects may result in the appearance of pine pitch canker disease in new locations. The pathogen can also be disseminated via airborne inoculum and is found in seed coats.

Pine pitch canker is apparently widespread in Mexico, being reported from the states of Distrito Federal, Durango, Guerrero, Hidalgo, Jalisco, Estado de Mexico, Michoacan, Morelos, Nuevo Leon, Puebla, Tamaulipas, Tlaxcala, and Veracruz (Guerra Santos 1995, Guerra Santos and Cibrián Tovar 1991). Most reports of the disease were in relatively isolated native stands, not plantations, suggesting that the disease may be native to Mexico. The fungus is considered a serious pathogen of *P. halepensis* in Chapingo and of pines in native forests in Jalisco (Blanchette 1989). The pine pitch canker disease was reported on 3,116 ha of *P. douglasiana* stands in Nayarit on the west coast of Mexico (Gutierrez–Rodriquez 1989).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *High* (*VC*)
   The pathogen has been reported on numerous pine hosts at numerous locations in Mexico. Potential insect vectors associated with pitch canker on Mexican pines are *Eucosma sonomana* and *Pityophthorus* sp. on *P. douglasiana, Dendroctonus frontalis* on *P. pringlei, Rhyacionia* sp. on *P. oocarpa,* and *Eucosma sonomana* on *P. maximinoi* (Guerra Santos 1995). Infection may result in bole cankers, with the pathogen colonizing sapwood. It is unlikely that Mexican pines with conspicuous, resin-soaked bole cankers would be harvested for export, but there is a high probability that the pathogen will occur on *Pinus* spp. logs.

2. Entry potential: *High* (*VC*)
   Fusarium subglutinans f. sp. *pini* would survive for some time in logs. The pathogen remains viable for more than 1 year in resin-impregnated tissues in small diameter (10 mm or so) shoots (Blakeslee, unpublished data). Bark removal would not prevent survival in transit, because the fungus may occupy the sapwood. The pathogen sporulates prolifically in insect galleries. Because the fungus also readily sporulates on the surface of infected shoots (Blakeslee and others 1978, Kuhlman and others 1982), the likelihood of spores being produced in or on untreated colonized logs once they have been delivered to ports is high. Insect vectors carrying spores of the pathogen could also be present on untreated logs.

3. Colonization potential: *High* (*RC*)
   Substantial inoculum can be expected to be present on arrival at the port of entry. Suitable pine and Douglas-fir hosts occur at western and southern ports, providing habitat for infection and establishment at ports of entry. Suitable insect vectors would also probably be present.

4. Spread potential: *Moderate* (*RC*)
   In California, the fungus infects wounds by both windblown or rainsplashed spores and is transmitted by insects (Correll and others 1991). Many of

the insect species that vector the pitch canker fungus in Monterey pine also breed successfully in other pine species. Considering the susceptibility of most pine species and Douglas-fir in laboratory trials and the efficiency of associated insects in finding suitable host material, the potential for spread is high. Environmental conditions may somewhat limit disease spread. Presently, pitch canker in California is limited to coastal areas with a mild climate. Similarly, disease distribution in the southeastern United States is associated with moderate temperatures that prevail most of the year. In laboratory tests, the fungus failed to establish infections at 10°C (McDonald 1994).

B. Consequences of pest establishment

5. Economic damage potential: *High* (*VC*)
The current distribution of the disease in the western United States is limited to coastal California. The potential damage that may result from the pathogen becoming established in additional areas is high. All economically important native pine species in California were susceptible in greenhouse inoculation tests (McCain and others 1987, Storer and others 1995). The report of the disease on Douglas-fir, a widespread North American tree species, is significant in terms of potential loss (the report was from twigs on one highly stressed tree surrounded by diseased Monterey pines). Economic losses would include tree mortality (in native stands, ornamental plantings, and Christmas tree plantations), reduced lumber quality, and seed contamination in seed orchards, among other things.

   The vegetative compatibility group(s) (VCG) of *F. subglutinans* f. sp. *pini* in Mexico is unknown. However, isolates from *P. pseudostrobus*, *P. arizonica*, *P. discolor*, and *P. leiophylla* were more pathogenic than isolates from other pines in inoculation studies (Guerra Santos 1995). Only five VCGs were identified in the California population, with one VCG representing 70% of all samples (Correll and others 1992). In contrast, 41 VCGs were present in 106 samples from Florida, suggesting that the pathogen is endemic to that area (Correll and others 1992). The potential for increased economic damage as a result of introducing different, and more virulent, VCGs into the United States exists. Although the pathogen has been present in southeastern United States for years, the potential for increased damage to the southern pine resource could be great, since the VCG character of the Mexican population is unknown and may contain virulent genes not present in southern United States.

   Pine pitch canker is established in the South and in California; however, the larger number of southern strains lead us to base our economic analysis on the damage that additional strains could cause in California. The course and eventual extent of the recently established pitch canker in California cannot be determined. The source of the present infestation is not known. For the purposes of this analysis, we assume that additional introductions could bring strains that would have a wider host range than the presently established types. If new introductions remained primarily a disease of *Pinus radiata* and other ornamental plantings of pines, impact costs would be the removal and replacement costs and the loss of amenity value while the replacement tree grew to the size of the replaced tree. Given the large number of residential street tree plantings in California, we assume losses of 10,000 trees per year caused by additional introductions. Removal and replacement costs of $1000 per tree would result in annual losses of $10 million per year. Assuming a 15-year period to reach this level of loss, the net present value of the losses could be $96 million over 30 years at a 4% discount rate. If forest crop trees were affected, the results could be considerably higher. There are about 28 million cubic meters (12 billion board feet) of pine on timberlands in California alone (Powell and others 1993). Late 1995 prices for California pine sold by the USDA Forest Service averaged from $114 to $188 per cubic meter ($270 to $443 per thousand board feet) (Warren 1996).

6. Environmental damage potential: *High* (*VC*)
Pine species with extremely limited native ranges, including Monterey pine and Torrey pine, are highly susceptible to the disease. The very limited native stands of Monterey pine represent an important genetic resource. Reduction of the genetic diversity of pine species with limited native distributions such as Monterey, Torrey, and bishop pines would cause a high level of concern among resource managers and various publics. The susceptibility of economically important conifer species such as ponderosa pine and Douglas-fir in inoculation studies suggests a potential for additional environmental damage as well.

7. Perceived damage potential: *High* (*MC*)
Environmental damage following successful establishment of the disease in new locations in southeastern United States or in western states as a

result of log importation would have a high social and political impact.

C. Pest risk potential: *High*

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Reviewers' comments—"The pitch canker has wide distribution in Mexico, especially in unispecific plantations; it occurs in natural stands but, isn't a problem there, and the fungus never kill the trees, only producing stem damage. In my opinion, this disease must be moderate; we need more research related with the strains aspects of the fungus." (Vazquez Collazo)

"Because of the fungus' wide distribution in southeastern United States and the lack of official regulatory control to prevent its further distribution, we do not consider that pitch canker can be considered a quarantine pest for the United States. We agree with the ratings applied for each category and agree that pitch canker has a high pest risk potential, but without regulations to prevent its spread from presently infested areas within the United States into new areas it may be difficult to justify regulations preventing its introduction from Mexico." (Cree/Watler)

"As you indicate, the pitch canker fungus can be insect vectored, however insect wounds are not required for infection. Naturally occurring wounds, such as those caused by hail, wind-stress, and various animals (including man, as in seed orchards), can be readily infected. It has been determined that the eastern pine weevil (*Pissodes nemorensis*) can serve both as a vector and as a simple wounding agent for the pitch canker fungus in slash pine. Weevil feeding punctures on slash pine shoots are readily infected by weevil-borne inoculum or by nonvectored inoculum reaching the wound site as might happen by wind-driven rain-splash from sporodochia that are readily produced on infected shoots. Although we have not conducted the rules of proof of insect transmission for the fungus with loblolly pine as we have with slash, I would assume the eastern pine weevil would play the same epidemiological role with loblolly as it does with slash. The key point here is that the fungus is also disseminated via airborne inoculum and is not restricted to insect-wounds for host infection. I think this broadens the concern. Especially when coupled with habit of sporulation on infected shoots."

"The pathogen readily sporulates on the surface (as opposed to entrapped in insect galleries beneath the bark) of infected shoots. We have also seen sporodochia on bole cankers on mature slash pines and on seedlings from nursery beds. I am not certain that fumigation targeted at insects would show efficacy for this fungus. Obviously this is very chemical, rate, and duration dependent. While we have not determined the ability of the fungus to remain viable in logs, we have determined that it remains viable for more than 1 year in the resin-impregnated tissues in small diameter (1 cm or so) shoots when these shoots are contained in piled logging slash on forest sites." "I think the exposure of the southern pine resource is particularly acute, given the virtually continuous forested character of the region and proximity of Mexico to the South. It seems this section (colonization potential) should increase consideration of the southern pine resource." "As suggested in the preceding, the southeastern United States should receive increased mention. While it is true that evidence from Correll's VCG work suggests the fungus is a long-time resident of the South, the VCG character of the Mexican population is unknown and may contain virulence genes that would be most unwelcome." "As suggested earlier, it seems very viable to include mention of the threat to the southern pine resource (in perceived damage potential section). . .a resource that attains greater economic importance to the nation each year. Obviously, this economic perspective should not prevail to the discredit of the myriad of social and environmental services provided by southern pine forests." (Blakeslee)

"With respect to the analysis of the pitch canker fungus, the results of the McDonald study showing that the fungus does not infect at 10°C may well be significant, but the temperatures in the upper Sierra Nevada and here in north Idaho are above 10°C during a substantial period of the year. The key to disease epidemiology in this case probably involves the insect vectors. We agree with the HIGH risk potential." (Cobb/Wood)

"What experimental data is there that the pitch canker fungus is transmitted by *Pityopththorus* and *Conophthorus*? Over a 2 year period, I was able to recover FSP from the surface of only 5% of the cone beetles sampled (unpublished data). I doubt if cone beetles are significant vectors of FSP. . . .there has been no research on twig beetles as wounding agents or vectors of the pitch canker fungus." "There is a paucity of information on inoculum sources. I'm not aware of any published data that would support many of the statements made concerning the survival and reproduction of the pathogen on bark and sapwood." "In California, pitch canker is a serious disease of Monterey pine and it has all the earmarks of having been introduced. However, whether or not it is now, or will become, a serious disease of Douglas-fir and ponderosa pine is debatable. The evidence that pitch canker will or could become epidemic on conifers in California other than Monterey pine is lacking." "Frankly, I have serious problems with the conclusions concerning vegetative compatibility groups. The isolates of FSP from the South were largely from Florida. It did not include 137 lypholized cultures I had collected over 10 years from a dozen hosts from Virginia to Texas and offered to make available to Correll." (Dwinell)

"The pitch canker fungus is placed in pest category 4. A pest category 2 would also be appropriate—this disease has not reached the probable limits of its ecological range in California." "Rather than 'Insect-caused wounds appear to be required as infection courts for the pitch canker fungus,' say 'Insect-caused wounds appear to be important infection courts. . . .' Similarly, rather than 'Ips bark beetles transmit fungal spores. . .,' say 'Ips bark beetles may transmit fungal spores. . .' "Damage potential: There are 10 plants in the native Monterey pine forest that are considered by the California Native Plant Society to be rare, threatened or endangered, including Monterey pine itself. Monterey pine is also on FAO's list of endangered tree and shrub species and provenances. The damage potential extends beyond just the tree and, because the tree is a world-wide resource, beyond the borders of the United States." "Suspected vectors of the pine pitch canker fungus have already been intercepted on wood products shipped from Mexico." (Owen)

". . .in the case of pitch canker there is clear evidence of a serious threat from the experience in California. Additional reasons for concern regarding pitch canker include: the disease is thought to be native to Mexico, close to 20 species of Mexican pine are infected by the disease, and there may be several races of the disease organism present. The threat posed by this disease alone should justify strong phytosanitary measures by APHIS on raw logs imported from Mexico." "Because of my concern with pitch canker, I think the conclusions portion of your report needs to be unambiguous and strong. Pitch canker is not a potential pest organism, but a demonstrated pest with significant impacts on forest and urban trees." (Overhulser)

Response to comments—Reviewers' comments generally support the high pest risk potential given to pitch canker. Although the disease is not considered a problem in native forest stands of Mexico, it has caused significant concern and damage when introduced into favorable environments of coastal California. The common occurrence of *Fusarium subglutinans* f. sp. *pini* on Mexican pine species and it's high entry potential, coupled with the existence of VCGs within the species, suggests that a high pest risk potential is warranted. Reviewer comments regarding the biology of the pathogen and the potential for economic damage to the southern pine resource following the introduction of new, more virulent strains were incorporated. Literature citations were added to support the statements regarding insect transmission of the pathogen in California and the sporulation of the fungus on the surface of infected shoots and bole cankers. The question of whether the pitch canker fungus can be considered a quarantine pest because of the current lack of regulatory control in the United States is beyond the scope of this document.

Diplodia Shoot Blight

Assessor—John Kliejunas

Scientific name of pest—*Sphaeropsis sapinea* (Fr.) Dyko & Sutton [= *Diplodia pinea* (Desm.) Kickx] (Coelomycetes).

Scientific names of hosts—*Pinus arizonica, P. eldarica, P. halepensis,* and *P. pseudostrobus* in Mexico; *Abies* spp., *Larix* spp., *Picea* spp., *Pinus* spp., *Pseudotsuga menziesii,* and *Chamaecyparis lawsoniana* in other countries.

Distribution—North America (including Mexico), Central America, South America, Europe, Africa, Asia, Australia, and New Zealand.

Summary of natural history and basic biology of the pest—*Sphaeropsis sapinea* is a cosmopolitan, opportunistic pathogen associated with a wide range of coniferous hosts (Swart and Wingfield 1991). It causes a stem and foliage disease that can result in defoliation, dieback, shoot blight, cankers, and mortality (Peterson 1982b). A blue to black stain of the wood is often associated with stem infection (Aguilar 1985, Chou and MacKenzie 1988).

In Mexico, *Sphaeropsis sapinea* has been reported on four species of *Pinus* but is present in only a few areas and is not considered a problem (I. Vasquez 1996, personal communication). The fungus has seriously damaged extensive exotic plantations of *P. radiata* in Australia, New Zealand, and South Africa (Peterson 1982b). Infection intensity varies with environmental and host conditions. Dieback tends to decrease with increasing tree size (Chou 1976a and b, Gibson 1979). The fungus readily fruits on diseased tissue, slash, and cones (Peterson 1981). Spread occurs primarily by rain splash of the spores (Peterson 1981), but spores can also be distributed by air currents. Infection occurs directly in unwounded, succulent shoots as they are expanding in the spring. Stems become infected through wounds.

Sphaeropsis sapinea is a highly variable species. Although Chou (1976b) did not find differences in pathogenicity or virulence among 18 New Zealand isolates, others have found differences among isolates in cultural characteristics, conidial size and morphology, and pathogenicity (Wang and others 1985, Palmer and others 1987, Swart and others 1988). Two distinct types of *S. sapinea*, denoted Types A and B, were identified from north central United States (Palmer and others 1987). The general pattern of isozymic diversity reflects relatively high levels of genetic variation within local populations but a lack of sharp dissimilarity between geographic populations (Swart and others 1992). The fungus may be a highly variable species that represents a continuum without defined types or strains (Swart and Wingfield 1991).

It should be stressed that the differences in strain characteristics must be determined between any strains that might be introduced and those already present in the United States. If the strains are the same, then there is no additional pest risk. However, it is known that the North American strains are significantly different among themselves (Palmer and others 1987) and that differences also exist between an isolate from New Zealand and one from the United States (G. Stanosz, 1996, personal communication). Recent research (Smith and Stanosz 1995) demonstrated two distinct groups of the pathogen on pine hosts in north central United States.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RC*)
   Sphaeropsis sapinea is apparently common in Mexico. Because limbs and branches will be removed at harvest, only stem infections will remain on the logs. However, most pines with stem infection will not reach rotation age or be harvested for sawlog exports.

2. Entry potential: *High (VC)*
   Transit of logs will not affect fungus survival. The likelihood that inspectors would detect the fungus is low. Points of infection include sapwood, crevices in the bark, and forest floor debris adhering to the logs. The fungus has been reported to inhabit asymptomatic stems of pine seedlings (Stanosz and others 1995). Considering these factors, entry potential is high.

3. Colonization potential: *Moderate* (*VC*)
   Pine and Douglas-fir hosts grow near ports of entry. Infection of these hosts would require the development of fruiting bodies of the fungus and subsequent spread of the spores to susceptible tissues. Pycnidia can develop on bark, dead shoots, and forest floor debris. These spores, transported either by insects or wind at the port of entry, could effectively inoculate susceptible hosts. However, infection of susceptible shoots would depend on favorable environmental conditions at the time of inoculum availability.

4. Spread potential: *Moderate* (*MC*)
   If colonization by *S. sapinea* occurs in native stands, it would spread principally on trees that are stressed and in places where environmental conditions are conducive for infection. The continuity of hosts in the United States would permit a moderate rate of continual spread.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*RC*)
   Sphaeropsis sapinea is present in the United

States. It causes damage primarily to ornamental and landscape trees and can be particularly devastating to trees planted off-site. In forest situations, damage is usually scattered and minimal (Sinclair and others 1987). However, because it is not known if the strain(s) in Mexico is different, and possibly more virulent, than those in the United States, there is a potential for increased economic damage. Until studies can be conducted to confirm that the strains are the same, a moderate rating is warranted.

6. Environmental damage potential: *Moderate* (*RC*)
Sphaeropsis sapinea causes significant damage only in stressed trees. Affected trees are commonly localized and widely scattered on poor sites and even in such situations, it rarely causes death (Sinclair and others 1987). Therefore, the impact on the associated ecosystems will be insignificant. However, information is available indicating that strains isolated from different parts of the world are genetically different (Swart and others 1992). Such differences may also be expressed in pathogenicity or virulence, which may have greater impact on the forest ecosystem and in ornamental plantings than will the native strains. Research into the differences in the exotic strains must be completed before firm conclusions regarding the actual impact can be stated. If Mexican strains are more virulent, the potential for environmental damage would be moderate.

7. Perceived damage potential: *Moderate* (*RC*)
Based on data regarding pathogenicity and virulence of the known strains of *S. sapinea*, further introduction of the species will not cause major impact on the forest ecosystem. Thus, the social and political impact should be minimal. However, the introduction of a more virulent strain of this fungus would have greater impact, particularly in ornamental plantings. Risk potential for perceived damage, in turn, would increase from low to moderate.

C. Pest risk potential: *Moderate*

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Reviewers' comments—"Diplodia Shoot Blight is not a problem in Mexico; this disease is present in few and restricted areas, then I think the PRA must be low." (Vazquez Collazo)

"Given the evidence provided for possible genetic diversity within *Sphaeropsis sapinea*, consideration of this as a potential quarantine pest may be justified. Quarantine regulation of a pest on the basis of genetic variability, however, is not easily accomplished and we consider that very strong evidence of 'real' differences should be presented, as has been done for gypsy moth." (Cree/Watler)

"*Sphaeropsis* has a wide distribution in the U.S., affecting several pines and other conifers, according to Peterson and Johnson (1986); in Riffle and Peterson (Diseases of trees in the Great Plains), the disease occurs in 30 eastern and central states and in Hawaii and California." (Guerra Santos)

"Stanosz has a very recent article in Plant Disease (we think) dealing with variability in *Sphaeropsis sapinea*. We believe that it supports our continuing concern about differences in this fungus (or fungi)." (Cobb/Wood)

Response to comments—The IPRA for diplodia shoot blight recognizes that the distribution of the disease in Mexico is limited and that the disease is already present in the United States. However, the known high variability of *Sphaeropsis*, the existence of different strains in the United States, and the lack of knowledge of what strain(s) is present in Mexico also need to be considered. Citations for the Stanosz article were added. Because of the variability question, the ratings for economic, environmental, and perceived damage potentials were originally given a rating of low–moderate; the low rating would apply if an existing strain were introduced and the moderate rating would apply if a different, more virulent, strain were introduced. We believe that these ratings, and the overall rating of moderate, should stand.

Stem and Limb Rusts

Assessor—Gregg DeNitto

Scientific names of pests—*Cronartium arizonicum* Cumm., *Cronartium conigenum* Hedgc. and Hunt, *Peridermium pini* (Pers.) Lev.(?), and *Peridermium harknessii* J.P. Moore (Uredinales: Melampsoraceae).

Scientific names of hosts—*Cronartium arizonicum* infects pines of the subsection Ponderosae, notably *Pinus arizonica* and *P. ponderosa* in the United States and *P. cooperi, P. durangensis, P. engelmannii*, and *P. michoacana* in Mexico; telial hosts include *Castilleja* spp., *Orthocarpus* spp., and *Pedicularis* spp. *Cronartium conigenum* infects most of the hard pine species in Mexico; the telial hosts are *Quercus* spp. *Peridermium pini* infects a wide range of species in the Dicotyledonae in Eurasia. An unidentifiable *Peridermium* was found on *Pinus lawsonii* in Mexico that had characteristics similar to *P. pini* (Peterson 1972). *Peridermium pini* resembles the aecial state of *Cronartium flaccidum,* which is found on members of all three subsections of hard pines. *Peridermium harknessii* has been identified on at least 14 *Pinus* species in Mexico. Little work has been done on the rusts of pines in Mexico. It is possible that additional species or varieties of known species are present that are not native to the United States (Salinas–Quinard 1991, Salinas–Quinard and Nieto 1987).

Distribution—*C. arizonicum*: widespread in Mexico with coniferous forests; Rocky Mountains from South Dakota south to Mexican border. *C. conigenum*: widespread in Mexico with coniferous forests; Arizona and New Mexico in the United States. *Peridermium spp.*: An unidentified *Peridermium* similar to *P. pini* was reported once in Oaxaca, but this identification has not been confirmed (Peterson 1972). *Peridermium harknessii* occurs across much of North America and into northern Mexico.

Summary of natural history and basic biology of the pests—The three *Cronartium* species are heteroecious rusts, alternating between an aecial (conifer) and telial (dicotyledonous) host. *Peridermium* includes autoecious rusts that infect from pine to pine and are known to only produce aeciospores as infective propagules. They are obligate parasites requiring living host tissue for survival and reproduction. They are perennial on the aecial host and annual (in most cases) on the telial host. Infection of the conifer host occurs through needles and succulent twigs, or conelets in the case of *C. conigenum*, in the summer or fall with progression of the fungus through the twigs and branches. Production of pycnia and aecia on the pine host occurs through the bark or on the cone scales in the spring. Aeciospores must be disseminated under the proper environmental conditions when the telial host is susceptible for infection to occur. This is a limited time in the spring or early summer when the dicotyledonous host leaves are expanding. Similarly, infection of pines by teliospores requires exacting environmental conditions for success. The timing of the proper moisture and environmental conditions for pine infection may differ between Mexico with its summer monsoon-type weather and much of the western United States with its Mediterranean climate and winter moisture. Aeciospores of *P. harknessii* infect through needles and succulent stem tissue in the spring or early summer directly from pine to pine.

Cronartium arizonicum causes a limb rust that is systemic in the wood of branches and the main stem. Sporulation occurs on infected branches. *Cronartium conigenum* infects primarily conelets, but it can also infect small twigs and branches (Peterson and Salinas–Quinard 1967). Both of these species infect only through the foliage of the telial host. The unidentified *Peridermium* was found on branches in the single report. *Peridermium harknessii* causes gall production on limbs and the main stem of trees.

Taxonomy of limb rust fungi is confused, including the relationship between the telial and aecial forms (Peterson 1967, 1968). There are considerable unknowns about the genetics of the pine rusts, including questions on formae speciales, races, and varieties. Neither genetic variation within the Mexican spp. of pine rusts nor the differences between Mexican spp. and the genotypes in the United States have been examined. Species differences are being recognized based on genetic analyses (Vogler and others 1996). It appears that genetic diversity both within and among rust species increases from north to south in the United States and probably into Mexico. Morphologically similar species differ between the southern Sierra Nevada and Rocky Mountains and the mountains of the Southwest. Variation in what has been referred to as *P. harknessii* is being recognized with possibly three species of gall rust present in southwestern United States (D. Vogler, 1996, personal communication).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*VC*) These fungi, except the unidentified *Peridermium*, are relatively common on pines in Mexico. The majority of the time, they are associated with limbs or cones and are not likely to be found on export logs that have been delimbed. Occasionally, they may grow into the main stem and be present in logs. They sporulate for only a limited time each year, and they are not known to infect other hosts except via airborne spores. Sporulation on an infected stem may be visible because of the peridium and colored spores that are produced through the bark. However, because of the

disturbance during harvest and transport, sporulation may not be evident and spores may be lodged on the bark and not be visible. The galls or swellings on most logs from *P. harknessii* would be readily visible to inspectors and may make the logs unsuitable as export material. Some infected logs may not be evident. However, *P. harknessii* is not common in Mexico, except in Baja California.

2. Entry potential: *Moderate* (*RC*)
   Stem deformities and sporulation would be visible on logs and would not be desirable for lumber production. Aeciospores produced by *Cronartium* and *Peridermium* spp. tend to be hardy and can survive harsh environmental conditions. Movement in ships may disrupt existing peridia, but spores released could survive transit and be available to infect hosts at the point of arrival. This possibility would only exist during the time of sporulation, probably no more than 1 to 2 months each year. Survival of the fungus in the log would be limited because of the obligate nature of the parasite. Fungal vigor and survival in the logs would decrease with time from tree felling. The specific telial hosts are not known from Mexico, but the host range is sufficiently broad that similar plants are present in the United States.

3. Colonization potential: *Low* (*RC*)
   The amount of inoculum on logs will be seasonally limited. It is not certain if the timing of aeciospore production in Mexico coincides with the susceptible stage of the telial host. The *Cronartium* species infect a relatively broad range of telial hosts, most of which are present near ports of entry in the West and East or have close relatives there. *Peridermium* also has hosts near to most ports.

4. Spread potential: *High* (*RC*)
   These fungi spread by airborne spores between hosts. Environmental conditions appear to have the most influence on success of infection and spread. Certain years have higher levels of infection than others. It is during the times of higher infection levels that spread is greatest. Rust spores have been found to spread great distances in upper air flows with subsequent infection. The host range is broad enough that host material will be available for infection to occur.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*MC*)
   Cronartium arizonicum, *C. conigenum,* and *P. harknessii* occur in certain areas of western United States. The first two are limited to the Southwest. It is not known if the strains of these fungi in Mexico differ substantially from those already present in the United States or if their introduction to other areas of the United States and exposure to new hosts might result in infection and damage. Rust fungi are known to rapidly develop new strains when selective pressures are present. If an existing more virulent strain from Mexico was introduced or one developed in the United States that attacked any of our commercial pines, there could be economic damage. Damage could be inflicted on the ornamental and Christmas tree industries as currently occurs from *P. harknessii.* Another limb rust fungus in commercial pine areas could add to the economic damage. Pines in southeastern United States may be at greatest risk because they have not evolved with any of these rust fungi and environmental conditions may be suitable for infection and spread. The introduction of the unidentified *Peridermium* or an undescribed rust fungus to the United States could have a significant economic impact similar to the introduction of another rust fungus, *C. ribicola,* the cause of white pine blister rust.

6. Environmental damage potential: *Moderate* (*RC*)
   If the two *Cronartium* species and *P. harknessii* are genetically similar to strains in the United States, any additional environmental damage from their introduction would be minimal. If they do differ and can become established in either the western or southeastern conifer forests, significant environmental damage could occur. The broad host range of both the telial and aecial forms and their widespread occurrence in Mexico suggests that they could adapt to conditions in the United States. Poorly defined species in Mexico would probably be new to the United States and could result in significant damage.

7. Perceived damage potential: *Moderate* (*RC*)
   Introduction of species already in the United States is likely to result in little increase in damage. The introduction of new strains of any of these fungi could cause some increased perceived damage if tree killing results. This would probably result in moderate levels of social concerns.

C. Pest risk potential: *Moderate*

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Reviewers' comments—"It seems to me that the important species are not *Cronartium arizonicum, C. conigenum,* and *Peridermium harknessii,* which already occur in the United States. . .but lesser-known Mexican species that have not been surely identified and which might sporulate on large stems without deforming them." (Peterson)

"I disagree that these fungi would be easily detected on logs. In many cases cankers are not associated with dramatic swelling of the stem, and in rough bark on large stems, sporulation is generally reduced and often difficult to detect." (Hansen)

"The draft PRA projects a Moderate (RC) rating for pathogen dissemination. Because this is an aerially dispersed pathogen capable of traveling great distances we recommend that a high rating would be more appropriate." (Johnson and Griesbach)

" . . .chosen to lump several potentially damaging fungi under *Peridermium harknessii*. . . .potential of different and damaging rust fungi in Mexico." "Our scientists in the United States are just beginning to clarify some of the problems in the taxonomy of this group. What was thought to be one fungus (*P. harknessii*) a short while ago is now known to be at least 3 and possibly as many as 6." (Cobb and Wood)

"The limb rust can certainly be in the main stem. The gall rust also occurs in the main stem and in some cases would not be readily visible to inspectors. We believe that the probability of pest with host at origin would be high." (Cobb and Wood)

Response to comments—It has been recognized in this assessment that additional rust fungi probably exist on Mexican pines, but they are currently poorly identified. Without additional information, a more thorough assessment cannot be made. It is unlikely that their characteristics would differ significantly enough to alter the outcome of this risk assessment. In response to reviewer suggestions, the Pest with Host at Origin Potential was increased from low to moderate to reflect the potential for logs with limb or gall rust to pass by inspectors undetected or for aeciospores to be transported on logs with bark. The spread potential has also been increased from moderate to high in recognition of the significant potential for these fungi to disperse once they have colonized an area. The potential for genetic variation in the rust fungi, and possibly differences in virulence, is recognized in this assessment. Based on this recognition, the environmental damage potential was increased to moderate, which resulted in the overall pest risk potential increasing to moderate without mitigation measures.

Root and Stem Rots

Assessor—Harold Burdsall

Scientific names of pests—*Armillaria* spp.; *Phellinus* spp. (Basidiomycota, Holobasidiomycetidae).

Scientific names of hosts—Most conifer and deciduous tree species.

Distribution—Throughout Mexico; various species of these genera have worldwide distributions.

Summary of natural history and basic biology of the pests—*Armillaria* and *Phellinus* species are being treated together here because they function similarly in the ecosystem and any mitigation procedures taken against one will be equally effective or ineffective against members of both genera. Little information is available in the literature regarding the species of *Armillaria* and *Phellinus* that occur in Mexico. Most information indicates that they are the same as several of those occurring in the United States. The literature indicates the existence of *A. mellea* and *A. ostoyae* occurring in Mexico (Shaw 1989, Marmolejo 1989). Several species of *Phellinus* are also found in Mexico (Larsen and Cobb 1990). However, so little survey work has been done in Mexico that the mycota is virtually unknown for these groups. The ones of concern cause a characteristic root or heartrot in living trees. As soilborne fungi, *Armillaria* and *Phellinus* species exist to 1 degree or another as rhizomorphs or mycelium (possibly chlamydospores), either in the soil itself or in woody debris and stumps. Recent data indicate that at least some species of *Armillaria* depend almost entirely on rhizomorphs as their principal means of dispersal (Smith and others 1992). *Phellinus* species rely on root contact for spread. There is great likelihood that other species of root and stem rots act similarly. The soil- or debris-borne mycelium and rhizomorphs attach to the root system of the tree and wait until the tree is in a stressed condition. At this time, the root is penetrated and the mycelium grows through the root. It continues growth toward the root crown, killing roots until the complete root system, and thus the tree, is killed. Spread occurs by means of growth from one root system to another, causing "infection centers" that increase in size with time. Mushrooms and conks, the spore-bearing part of the life cycle, are formed in the fall and discharge spores into the air, where they are carried by wind. Whether the spores are effective in inoculation of the host is questionable. No conidiospore state exists in the life cycle of *Armillaria* species, but there are indications that some *Phellinus* species may form chlamydospores in the soil.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *High* (*RC*)
   Because *Armillaria* and *Phellinus* species are common in Mexico and occur as cambium, root, and butt rots, any log that is infected would be able to carry the fungus when it is transported to the United States. A log from a tree with an incipient infection would be difficult to detect, would probably go unnoticed in an inspection, and would be transported with uninfected logs. During the site visits, little damage from root rot fungi, other than that from *H. annosum*, was observed.

2. Entry potential: *High* (*VC*)
   Although advanced decay would be visible at cut ends of logs, incipient decay would not. Also, some root rot species (*Armillaria*) can exist as rhizomorphs, as mycelial fans under the bark, and as mycelium in the outer sapwood or heartwood. They can also live as saprophytes when the situation demands. Therefore, they would easily be able to survive during harvest and transport to the United States. Additional entry potential exists because rhizomorphs, mycelium, and chlamydospores of these species present in the soil and debris on the forest floor might adhere to the outer surface of the logs and act as inoculum in poorly handled material.

3. Colonization potential: *Low* (*RC*)
   Because *Armillaria* and *Phellinus* species do not produce conidiospores or other easily disseminated propagules and are not vectored by insects, the probability of dissemination of these fungi from imported logs to appropriate substrates in the United States is low. Basidiomes and spores may be produced if logs are maintained for long periods of time prior to processing or if slabs from processed logs are not destroyed. Nevertheless, opportunities for colonization are low.

4. Spread potential: *Low* (*RC*)
   The mechanisms for spread of these species are not well understood. In fact, all species may not depend on the same means of dispersal. We do know that some species in the United States and Canada do not require spores for spread, at least on the local level (Wargo and Shaw 1985, Smith and others 1992). If the Mexican species spread in the same manner as those in the United States, the spread also will be slow and restricted to infection centers.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*RC*)
The species of root rot fungi in Mexico appear to act the same as those in the United States. The majority of the economic damage would be to existing plantations and new outplantings. The establishment of these fungi could reduce productivity by causing tree mortality in the first several years after planting. These fungi could also cause some tree mortality through root rots on stressed trees. However, because of the slow spread potential of these species and the usual restriction to infection centers, spread would be slow. The economic impact also would be slow to develop and probably never be major.

6. Environmental damage potential: *Low* (*MC*)
The environmental damage caused by root rot species likely to be imported on Mexican logs is low because of their ability to spread at only slow rates (Smith and others 1992). The probable restriction to infection centers will cause minor environmental damage. However, the impact on outplanted nursery stock may reduce the recovery of harvested sites, thus having some impact on the recovery of the vegetation and on other elements of the ecosystem.

7. Perceived damage potential: *Low* (*MC*)
Increased mortality in native conifer stands could have significant social and political impacts if the fungus spreads rapidly, which is not known for an *Armillaria* species.

C. Pest risk potential: *Low*

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Reviewers' comments— "…we believe that to lump 10–20 or more organisms together and to cover the natural history and biology of the pests in little more than 1/2 page is ridiculous. To claim that 'all available evidence' supports…2 species of *Armillaria* in Mexico is also ridiculous." (Cobb/Wood)

"We all know that the probability of the pest with host is high; even the narrative in the analysis supports that …These fungi produce millions, even trillions of spores, many of which are surely on the log surfaces waiting to be resuspended in the atmosphere as the log trucks travel at 60+ MPH down America's highways. How can colonization potential and spread potential be low?" (Cobb/Wood)

"We are dealing with some of the most destructive forest tree pathogens in the World in these genera. How can one state that the damage potential is LOW? The risk potential is **HIGH, NOT LOW**, based on all available evidence. I (Fields) sincerely believe that the credibility of this risk analysis and assessment, though weak to this point has now been destroyed." (Cobb/Wood)

"The discussion covers only root rotting species. It is not relevant to trunk rots. These do not seem to be covered in the analysis." (Hansen)

"Spread [potential] may be low, but is sure. We suggest this be noted." (Johnson/Griesbach)

"…I think there should be a high for 'pest with host at origin' for *Armillaria*…" (Jacobi)

Response to comments—As with addressing all of the potential pests in this assessment, it is necessary to treat those that have similar life cycles together. The potentials for the various aspects of introduction and establishment are believed to be similar despite some variation in particulars of the life cycle. As indicated, it is recognized that in the case of successful introduction of a virulent foreign pest of this group, spread would be probable but very slow.

The evaluation of Pest with Host at Origin Potential was increased to high because of the common occurrence in Mexico. However, selection of sound logs can reduce the likelihood of the association. The likelihood that incipient decay by either *Armillaria* or *Phellinus* species could develop in transit to the point of fruit body production and release of spores is extremely low and reduces significantly the chance of an introduction of these species. And the chance of introduction as hitchhikers by means of basidiospores is very unlikely. The basidiospores are not known to be resistant to drying as would occur in transit.

A common problem encountered in evaluating all of the Mexican pests is that the literature is greatly lacking. This is true of the *Phellinus* species as well. However, with regard to *Armillaria*, the mushroom mycota of Mexico is probably better known than any of the fungal groups and there are no records of major pathogenic species in North America other than *A. mellea, A. ostoyae,* and *A. tabescens*. *Armillaria tabescens* is known to be conspecific from all parts of the United States and into Europe. It is very unlikely that another highly pathogenic species of *Armillaria* is extant in Mexico.

With regard to the heartrots and other decay fungi, they do have much the same means of existence as the root rots. They would be evident in logs with advanced decay and difficult to observe as incipient decay, whether a brown or white rot. Restrictions are in place to disallow the import of decayed logs where the decay is obvious, and there is little chance that such fungi causing incipient decay would escape their location in the interior of the logs being transported because of the lack of vegetative propagules in most species. The drying of the cut ends during transport will strongly reduce the possibility of fruiting of these fungi and the production of basidiospores.

Stain and Vascular Wilt Fungi

Assessor—Harold Burdsall

Scientific names of pests—*Ophiostoma piceae* (Munch) Syd. & P. Syd. [= *Ceratocystis piceae* (Munch) Bakshi]; *Ophiostoma piliferum* (Fr.:Fr.) H. Syd. & P. Syd. [= *Ceratocystis pilifera* (Fries) C. Moreau]; *Ceratocystiopsis collifera* J.G. Marmolejo & H. Butin; *Ophiostoma conicolum* J.G. Marmolejo & H. Butin; *Ophiostoma abietinum* J.G. Marmolejo & H. Butin (Ascomycota, Euascomycetes).

Scientific names of hosts—*Pinus* spp.; *Abies* spp.; hardwood species.

Distribution—*Ophiostoma piceae* and *O. piliferum* are widespread throughout North America, whereas *Ceratocystiopsis collifera, O. conicolum,* and *O. abietinum* are restricted to Mexico in the state of Nuevo Leon.

Summary of natural history and basic biology of the pests—Blue stain fungi, most of which belong to the ascomycetous genus *Ophiostoma* (*Ceratocystis sensu lato*), cause defect and loss in wood products by discoloring logs and lumber. The blue stain fungi addressed in this section certainly occur on numerous conifer species and certain native hardwoods in Mexico in spite of the fact that few reports address them. These fungi have been previously discussed as potential pests on imported logs from New Zealand (USDA Forest Service 1992) and Chile (USDA Forest Service 1993) and have been identified on native trees in the United States and Canada (Hepting 1971, Farr and others 1989). While some species of *Ophiostoma* cause blue stain, other species in the genus, or its anamorphs, *Leptographium* and *Graphium*, can cause disease in standing trees (Boyce 1961, Upadhyay 1981). Many species are associated with bark beetle vectors. Virtually all bark beetles (family Scolytidae) as well as some cerambycids, curculionids, dipterans, predatory beetles, mites, and nematodes have one or more *Ophiostoma* species associated with them (Francke-Grosman 1963b, Dowding 1984, Harrington 1988). *Ophiostoma* spp. form fruiting bodies in insect galleries under bark or in wood. Spores are produced in sticky masses, and these adhere to emerging insects. The insects transport the spores and inoculate new hosts with the fungi when feeding or constructing galleries. When introduced into a host by bark beetles, these fungi invade the sapwood, occlude water conducting vessels, and contribute to death of the tree. Some *Ophiostoma* spp. with *Leptographium* anamorphs are root pathogens (Alexander and others 1988, Wingfield and others 1988). Strains of *Leptographium wageneri* cause a damaging black stain root disease of several conifers, primarily pines and Douglas-fir, in western North America (Cobb 1988). The fungus is vectored by root-feeding bark beetles and weevils and also spreads from tree to tree via root contacts and by growing short distances through soil. The fungus causes tree decline and death in radially expanding disease centers.

A particularly critical consideration in this assessment is the lack of information regarding the stain and wilt species known to occur in Mexico. Reports of less than a half dozen species in a country this size and with this variety of habitat types points to an obvious knowledge gap between the known and undiscovered species of these genera. Such a paucity of information requires significantly more caution in evaluating the risks than if more data were available.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *High* (*VC*)
   Ophiostoma conicolum, *O. abietinum*, and *Ceratocystiopsis collifera* all have been reported from Mexico. Because of their occurrence in Nuevo Leon, it is likely that they also occur in the United States just accross the Mexican–United States border. *Ophiostoma piceae* and *O. piliferum* have not been reported from *Pinus* spp. or *Abies* spp. in Mexico although they are certainly present. Although vectors have not been identified for these particular species, this group of fungi is usually vectored by bark beetles and possibly other insects found in beetle galleries (Harrington 1988). There is a high probability that these species, and perhaps other yet unidentified species, will occur with pine and fir logs.

2. Entry potential: *High* (*VC*)
   These fungi survive well in logs for more than a year with favorable temperatures and moisture regimes. The short trip from harvest to processing sites in the United States could not be expected to kill them. They thrive in conditions that prevail during transport of the logs (many logs packed close together in a moist environment). Bark removal would not prevent survival in transit, because these fungi occupy the entire sapwood cylinder of the logs. These fungi fruit prolifically in insect galleries, bark or wood cavities, and on the undersides of logs, bark, or wood scraps, especially in moist situations. The likelihood of spores being produced in or on untreated colonized logs once they have been delivered to ports is high.

3. Colonization potential: *High* (*VC*)
   Under the conditions of transport, substantial inoculum in the form of conidiospores or ascospores can be expected to be present on arrival at the port of entry. The probability of these organisms coming into contact with a suitable host is high because of the presence of the appropriate vectors near these ports. The proximity of suitable hosts to many of the west coast ports makes contact likely if vectors are present. In this regard, imported logs

with fresh bark attached are very likely to be visited by native bark- and wood-boring insect vectors once the logs arrive in the United States.

4. Spread potential: *High* (*MC*)
Many of these fungi are not particularly host specific. The comparable climates of Mexico and the western United States, especially on the Pacific Coast, suggest that environmental conditions would be conducive to spread of the fungi. Potential vectors native to the United States (e.g., bark beetles of the genera *Dendroctonus*, *Ips*, etc.) could be more efficient at spreading these fungi than existing vectors in Mexico. If established, these fungi have great potential to spread because fungi associated with insect vectors are not limited in their spread by their own growth rates. Rather, the distance traveled by their insect associates is the critical factor. Bark beetles and cerambycids are capable of flying several kilometers and can be carried even farther by winds. Some of these insects have two or more generations per year, so it is possible that there could be two or more increments of vector spread annually. Also, spread of these fungi and associated insects can be increased substantially by human transport of harvested logs and firewood.

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*MC*)
Two of the *Ophiostoma* species known to attack pine in Mexico are already present in the United States. Economic damage from the introduction of a new blue stain fungus would be minimal, meriting a low risk. However, increased damage to conifer forests in the United States could result from the introduction of a pathogenic strain of one of the already present *Ophiostoma* species, a *Leptographium* anamorph, or an as yet undescribed species (of which there are certainly many). To date, no tree-killing *Ophiostoma* species have been reported or observed on native or exotic conifers in Mexico. However, knowledge of the stain and vascular wilt fungi in Mexico is minimal, so much so that many dangerous species are likely to be there but still undiscovered. For example, *Ophiostoma ulmi* was not a major pathogen in Europe but when placed in contact with the highly susceptible American elm, the result was disaster. Consequently, a new species from this virtually unstudied area or a species of *Ophiostoma* perceived to be inocuous in Mexico could well have the same effect as *O. ulmi* when encountering species in the interior west of the United States. On this basis, a moderate rating is justified.

6. Environmental damage potential: *Moderate* (*MC*)
To date, there is no evidence or documentation of tree-killing strains of *Ceratocystis* or *Ophiostoma* in Mexico. If the strains of *Ophiostoma* in Mexico are the same as those already in North America, the introduction of these fungi poses no additional threat. Clearly, however, the introduction of a new tree-killing strain or species of *Ceratocystis, Ophiostoma*, or *Leptographium* or transporting a species into the interior Northwest where the host species are susceptible but have been isolated from the pathogen has the potential of causing significant environmental damage. Loss of trees in ornamental plantings and in areas of noncommercial conifers, such as in wilderness, would cause considerable impact.

7. Perceived damage potential: *Moderate* (*MC*)
An accidental introduction of another blue stain fungus into the United States is unlikely to cause increased social or political impacts beyond those already caused by native species. However, mortality in native conifer stands associated with a tree-killing *Ophiostoma* (not known to be so in Mexico) and an insect vector could be disasterous, justifying a rating for perceived damage of moderate.

C. Pest risk potential: *High*

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Reviewers' comments—"In the analysis of stain and wilt fungi. . ., it is pointed out that no tree-killing *Ophiostoma* species have been reported on conifers in Mexico…, that *L. wagenerii* was first discovered by accident in the 1930s, that its widespread occurrence came to light in the 1960s and 1970s, that it was first discovered in Douglas fir in the mid 1960s and that the general recognition of the importance of the 3 varieties of the fungus is occurring only now…The lack of reports [from Mexico] must not be construed to mean that there are none there." (Cobb/Wood)

"Also, we believe that an analysis should include a reasonably accurate description of the exotics from the U.S. planted in Mexico if you are going to use absence of 'major disease problems' on them to imply that we in the U.S. have little to worry about. By description, we mean the following: what species are being grown; are they being used in aforestation or reforestation; if so, how many hectares and where; how close are these plantations to native stands; if some are being used as ornamentals, etc., under what conditions and in what environments are they being grown; are these latter trees in or near native stands, etc. Only with a clear understanding of the conditions can we judge the validity of your thesis." (Cobb/Wood)

Response to comments—These points are valid. The information regarding the identity and distribution of the stain and vascular wilt fungi is lacking. Because of this, caution is being recommended (see previous discussions) and the rating is a high, which requires mitigation to reduce the risk of introduction of the pest.

Annosus Root Rot

Assessor—Harold Burdsall

Scientific name of pest—*Heterobasidion annosum* (Fr.) Bref. [= *Fomes annosus* (Fr.) Cooke] (Basidiomycota, Holobasidiomycetidae). Anamorph = *Spiniger meineckellus* (A. Olson) Stalpers [= *Oedocephalum lineatum* Bakshi].

Scientific names of hosts—Numerous *Pinus* spp. and *Abies* spp. throughout Mexico. *Pseudotsutsuga menziesii* in Mexico is a probable host. Annosus root rot has also been reported on some scattered hardwoods.

Distribution—Throughout the United States; western, south central, and southeastern Canada; Alaska; and Mexico.

Summary of natural history and basic biology of the pest—*Heterobasidion annosum* causes a root rot of numerous hosts throughout North America and Europe. It is especially devastating in areas where selective harvesting is practiced. Affected trees support the fruiting of the basidiomes that are the source of basidiospore inoculum. Stumps are infected by these propagules and are decayed. Depending on the host species, the decay may be restricted to particular tissues or be dispersed throughout the stump. Conifer species are particularly susceptible depending on the host genus and the strain of *H. annosum* involved. The strains known to date are rather specific in their pathogenicity to pines (P strain), spruce (S strain), and fir (F strain) (Korhonen and others 1989). The identity of the strains found in Mexico on fir proved to be the fir strain found in the United States (David Rizzo, University of California-Davis, 1996, personal communication). The pathogen also reproduces by the production of an anamorph, producing conidiospores that are wind-transported potential infective agents.

Annosus root rot is widespread in western United States in nearly all conifer ecosystems with pine and spruce strains of the pathogen represented. The pathogen is well distributed in Mexico and was found by the pest risk assessment team during the site visit. *Heterobasidion annosum* was found on *Abies religiosa* in the state of Hidalgo and on a *Pinus* sp. in Durango.

Specific information relating to risk elements

A. Probability of pest establishment:

1. Pest with host at origin potential: *High* (*VC*)
   The pest has been reported to occur commonly in Mexico on both of the host genera to be imported and was observed by the team on both *Pinus* and *Abies* during the site visit. Incipient decay being caused by *H. annosum* might be easily overlooked in a cursory inspection of the logs after harvest.

2. Entry potential: *High* (*VC*)
   As a fungus exceedingly capable of living saprophytically, *H. annosum* is well adapted to successful transport in logs across a substantial distance, and incipient decay would be difficult to recognize in the logs intended for export to the United States.

3. Colonization potential: *High* (*VC*)
   Heterobasidion annosum possesses the ability to produce conidiospores as a part of its *Spiniger* anamorph. These conidiospores are produced in substantial quantity and are potential inoculum for establishing the fungus in a new environment.

4. Spread potential: *High* (*VC*)
   Heterobasidion annosum is well adapted for dissemination of both spore states of the life cycle. The basidiospores and the conidiospores are effective infection agents especially in areas where fresh stumps are available.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*RC*)
   Strains of *H. annosum* affecting both *Pinus* and *Abies* are well established in North America. Therefore the introduction of more populations from Mexico would probably have no impact economically. Only in the case that a more virulent strain were present in Mexico and imported with logs would any economic (or other) impact be expected. The evidence available from the specimens collected during the Burdsall–Rizzo site visit indicates that the strain collected from *Abies religiosa* is the same as the fir strain in the United States. The strain infecting the Mexican *Pinus* spp. is not known.

6. Environmental damage potential: *Low* (*RC*)
   All indications are that the fungus in Mexico is the same as that already found in other parts of North America. The pest is widespread in North America and the reintroduction from Mexico appears to be of little environmental consequence.

7. Perceived damage potential: *Low* (*RC*)
   With little expected increase in forest damage and no forseen damage to the environment, the potential social and political impact is also considered to be negligible.

C. Pest risk potential: *Moderate*

Selected bibliography

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Reviewers' comments—"The statement says that the fungus produces 'conidia' that are easily transported as infective agents. We know of no evidence that the conidia are easily wind transported. If we have missed the report of this fact, we stand corrected and would appreciate the reference." (Cobb/Wood)

"Of a more serious nature, why is it that we must prove that the Mexican populations differ from those already present before we can consider the fungus a threat to our forest resources." (Cobb/Wood)

Response to comments—*Heterobasidion annosum* does produce conidiospores. It is an assumption made here that these conidiospores are windborne because of their morphological characteristics. There is no reason to assume that they are not capable of being carried by air currents and could not act as infective agents. Also, since the initial draft was submitted for review, the Mexican specimens from *Abies* have been found to be the same as the isolates on fir in the United States (David Rizzo, University of California-Davis, 1996, personal communication). Variability certainly occurs as with all species, but there is no evidence to indicate that a rating greater than moderate is warranted.

Dwarf Mistletoes

Assessor—Gregg DeNitto

Scientific names of pest—*Arceuthobium* spp. (species list in Table 12) (Santalales: Viscaceae).

Scientific names of hosts—Pinaceae (host list in Table 12).

Distribution—Northern hemisphere.

Summary of natural history and basic biology of the pest—Dwarf mistletoes are highly specialized obligate parasites of conifers in much of the northern hemisphere. They are small dicotyledons with explosive, bicolored fruits (Hawksworth and Wiens 1972, 1996). These parasites cause tree mortality, branch and main stem swellings, and branch mortality. They reduce rates of tree growth, seed production, and wood quality.

Dispersal of dwarf mistletoes occurs by the forceful discharge of seeds. Some seed dispersal is animal vectored, although infections from such vectoring are probably infrequent (Nicholls and others 1984). Most seeds mature in the summer or fall. The distance of seed dispersal depends on the height of the source plant, angle of seed discharge, and wind velocity. The average horizontal distance of seed flight of *A. vaginatum* in a ponderosa pine stand was between 4.5 and 6 m, but some seeds did fly as far as 30.5 m (Hawksworth 1978). Most infection takes place through the needle-bearing parts of the twig, and the youngest growth is most susceptible. Germination usually takes place in the spring after a dormancy-inducing substance in the seed coat breaks down with time at temperatures near freezing (Hawksworth 1978). Most dwarf mistletoe plants that produce seed develop from thinner-barked, younger host tissue. Ponderosa pine infected by *A. vaginatum* subsp. *cryptopodum* produced few mistletoe shoots and seeds from main stem infections where the point of infection was 125 mm or larger in diameter (Mark and Hawksworth 1974).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*RC*)
Fourteen species of dwarf mistletoe not present in the United States have been identified in Mexico. Seven other Mexican species can also be found in parts of the United States. See Table 12 for the species and hosts. Dwarf mistletoes are present in most states of Mexico that have conifers. The plants bear mature seeds for a relatively short period in the fall. The vast majority of seeds are produced by dwarf mistletoe plants on tree branches, and very few seeds are produced from infections on boles, especially those boles that are of a size large enough to be exported. When the fruits are mature, they become very susceptible to physical disturbance, which causes seed expulsion.

2. Entry potential: *Low* (*RC*)
Between logging activities and transport, any mistletoe plants present on the logs will probably fall off or be displaced. Once the host xylem loses water potential, dwarf mistletoe shoots shrivel and abscise. The loading of logs onto ships, railcars, or other forms of transport would probably knock off many of the remaining plants. Agitation that would occur in transit would result in discharge of any mature seeds.

3. Colonization potential: *Low* (*RC*)
Very few, if any, seeds of dwarf mistletoe would survive to the port of importation. Most of the year, there would be no mature seeds. Those few mature seeds that might survive must be delivered to susceptible host tissue, namely foliage. Since the dispersal mechanism will have been disrupted, the only reasonable possibility for dispersion is if birds or other animals were to pick up the seeds and transport them. Birds have been identified as vectors by making physical contact with mature plants and seeds, not from feeding on them (Nicholls and others 1984). Examination of seed that had been ingested by birds and that were whole when excreted revealed that the seed was not viable (Hudler and others 1979).

4. Spread potential: *Moderate* (*RC*)
Dwarf mistletoes spread slowly. If any were to become established on conifers in the United States, they would be readily visible and could be easily removed before the area of colonization was significant. However, because of the morphological similarities to native species in the United States, they may not be recognized until a sizable area is infested. The hosts expected to be affected in the United States depend on the species introduced. Some of the Mexican dwarf mistletoes appear to have a broad host range, while others are quite limited. The effect of climate and habitat on the ultimate distribution of any introduced dwarf mistletoe is difficult to predict. Some species in the United States are known to be limited by climatic factors or habitat types (Hawksworth and Wiens 1996), but comparable information for Mexican species does not exist. There would probably be some limitation, especially by cold temperature, since this has been identified as a limiting factor on the distribution of several dwarf mistletoe species in the United States (Hawksworth and Wiens 1996).

Table 12—Hosts and distribution of Mexican *Arceuthobium* species

Arceuthobium species	Principal, secondary, and occasional Mexican host species	Distribution by state (Mexican or U.S.)
A. abietinum f. sp. *concoloris*	*Abies concolor, A. durangensis*	Chihuahua, Arizona, California, Nevada, Oregon, Utah, Washington
A. abietis-religiosae	*A. religiosa* var. *emarginata, A. religiosa* var. *religiosa, A. vejarii*	Distrito Federal, Hidalgo, Jalisco, Mexico, Michoacan, Nuevo Leon, Puebla, Tamaulipas, Tlaxcala
A. apachecum	*Pinus strobiformis*	Coahuila, Arizona, New Mexico
A. aureum subsp. *petersonii*	*P. michoacana, P. montezumae, P. oaxacana, P. oocarpa, P. patula, P. pseudostrobus*	Chiapas, Oaxaca
A. blumeri	*P. ayacahuite* var. *brachyptera, P. strobiformis* var. *potosiensis, P. strobiformis* var. *strobiformis*	Chiapas, Coahuila, Durango, Nuevo Leon, Sonora, Arizona
A. campylopodum	*P. jeffreyi*	Baja California, California, Idaho, Nevada, Oregon, Washington,
A. divaricatum	*P. quadrifolia*	Baja California, Arizona, California, Colorado, Nevada, New Mexico, Utah
A. durangense	*P. douglasiana, P. durangensis, P. montezumae, P. michoacana, P. pseudostrobus, P. herrerai, P. oocarpa* (?)	Durango, Jalisco, Sinaloa
A. gillii	*P. leiophylla* var. *chihuahuana, P. lumholtzii, P. herrerai, P. leiophylla* var. *leiophylla*	Chihuahua, Durango, Sinaloa, Sonora, Arizona, New Mexico
A. globosum subsp. *globosum*	*P. cooperi, P. engelmannii, P. durangensis, P. arizonica, P. rudis* (?), *P. arizonica*	Chihuahua, Durango, Jalisco, Sonora
A. globosum subsp. *grandicaule*	*P. douglasiana, P. durangensis, P. hartwegii, P. lawsonii, P. maximinoi, P. michoacana, P. montezumae, P. patula, P. pringlei, P. pseudostrobus, P. rudis, P. teocote*	Distrito Federal, Guerrero, Hidalgo, Jalisco, Mexico, Michoacan, Oaxaca, Puebla, Tlaxcala, Veracruz
A. guatemalense	*P. ayacahuite* var. *ayacahuite*	Chiapas, Oaxaca
A. nigrum	*P. lawsonii, P. leiophylla* var. *chihuahuana, P. leiophylla* var. *leiophylla, P. lumholtzii, P. oaxacana, P. patula, P. teocote, P. montezumae, P. pseudostrobus*	Chiapas, Durango, Guanajuato, Hidalgo, Mexico, Michoacan, Oaxaca, Puebla, Queretaro, Tlaxcala, Veracruz, Zacatecas
A. oaxacanum	*P. lawsonii, P. michoacana, P. pseudostrobus, P. oaxacana*	Oaxaca
A. pendens	*P. discolor, P. orizabensis*	Puebla, San Luis Potosi, Veracruz
A. rubrum	*P. cooperi, P. durangensis, P. engelmannii, P. herrerai, , P. teocote*	Durango, Sinaloa
A. strictum	*P. leiophylla* var. *chihuahuana, P. teocote*	Durango
A. vaginatum subsp. *vaginatum*	*P. arizonica* var. *arizonica, P. arizonica* var. *stormiae, P. cooperi, P. durangensis, P. engelmannii, P. hartwegii, P. herrari, P. lawsonii, P. montezumae, P. patula, P. rudis, P. teocote*	Chihuahua, Coahuila, Distrito Federal, Durango, Hidalgo, Jalisco, Mexico, Nayarit, Nuevo Leon, Oaxaca, Puebla, Queretaro, Sinaloa, Tamaulipas, Tlaxcala, Veracruz, Zacatecas
A. vaginatum subsp. *cryptopodum*	*P. arizonica* var. *arizonica, P. arizonica* var. *stormiae, P. durangensis, P. engelmannii, P. ponderosa* var. *scopulorum, P. cooperi*	Chihuahua, Coahuila, Sonora, Arizona, Colorado, New Mexico, Texas, Utah
A. verticilliflorum	*P. arizonica* var. *arizonica, P. cooperi, P. durangensis, P. engelmannii*	Durango
A. yecorense	*P. durangensis, P. herrerai, P. leiophylla* var. *chihuahuana, P. lumholtzii, P. engelmannii*	Chihuahua, Durango, Sonora

B. Consequences of pest establishment

5. Economic damage potential: *Moderate* (*MC*)
Dwarf mistletoes are considered the most damaging group of pathogens on conifers in the western United States because of their common occurrence and effect on tree growth and mortality. The damage is not as readily visible as defoliation or large areas of mortality from insects. Depending on the species that might become established, a commercially valuable host may be infected. If mistletoe is allowed to spread, growth reduction and possible tree mortality would result. The host specificity of most species of dwarf mistletoe may limit spread and the amount of damage that occurs. However, some of the Mexican dwarf mistletoe species have a wide host range and could infect a number of United States conifer species. It would probably take many decades and possibly centuries for introduced Mexican dwarf mistletoe species to have effects comparable with native species.

6. Environmental damage potential: *Moderate* (*MC*)
It is possible that an introduced species of dwarf mistletoe could replace or at least compete with an existing species of dwarf mistletoe. The long-term effects of dwarf mistletoes and the limited amount of damage could result in some environmental damage to forest ecosystems. Native dwarf mistletoes have a significant influence on stand structure, composition, and development and provide habitat for a wide range of fauna.

7. Perceived damage potential: *Low* (*RC*)
The need for extended periods of time for spread and damage to occur and the limited amount of highly visible damage suggests that little if any perceived damage would occur.

C. Pest risk potential: *Low*

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Nicholls, T.H.; Hawksworth, F.G.; Merrill, L.M. 1984. Animal vectors of dwarf mistletoe, with special reference to *Arceuthobium americanum* on lodgepole pine, In: Hawksworth, F.G.; Scharpf, R.F., tech. coord. Biology of dwarf mistletoes. Proceedings of the symposium. Gen. Tech. Rep. RM–111. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 102–110.

Reviewer's comments— "I agree with the conclusion that mistletoes are overall a low risk, but disagree with several of the justifications. The long latent period and morphological similarity of species would make identification of introductions difficult. I agree that mistletoes are easily controlled, but only by clearcutting and stand replacing fires. I can't agree with the conclusion of limited environmental impact from dwarf mistletoes. Existing species mold the structure and composition of many western forests, as well as being the number one cause of economic loss in the region." (Hansen)

"I was unclear on why some principal hosts or occasional hosts of dwarf mistletoes were omitted from the tables." (Mathiasen)

". . .you could include the fact that once the host branch or main stem is cut, the material begins to dry and this places a tremendous water stress on the dwarf mistletoe's 'system.' Dwarf mistletoes react to water stress (drought stress if you will) by shedding their aerial shoots." (Mathiasen)

"If dwarf mistletoes are potentially damaging then why is the potential for economic damage, etc. low? Hypothetically, if a species like *A. vaginatum* subsp. *vaginatum* or *A. globosum* var. *grandicaule* were accidently introduced and started spreading on one of the hard pines occurring in the western or southeastern United States it might prove to be very damaging over time, if not controlled." (Mathiasen)

"You have stated that 'dwarf mistletoes are the most damaging group of pathogens on conifers in the western United States' and yet you have rated economic damage potential *Low*. Under environmental damage potential you have stated that '. . .the limited amount of damage [of dwarf mistletoes] would not result in significant environmental damage. . ..' Perhaps the statements for these two categories could be re-examined and elaborated upon in order to eliminate this ambiguity." (Cree and Watler)

Response to comments—A complete list of known principal, secondary, and occasional hosts in Mexico has been added to the table. Some of these may also be hosts in the United States, but the table is not a complete representation of United States hosts. Dwarf mistletoes are fairly common in Mexico, and infested stands are likely to be harvested for export. Some trees with bole infections may be shipped to ports for export to the United States. The Pest with Host at Origin Potential has been increased to moderate to reflect this. It is recognized that dwarf mistletoes are not easily distinguished morphologically and the recognition of their presence in the United States may take many years, allowing them to spread a significant distance. The Spread Potential therefore has been changed to moderate. Changing both of these Probability of Pest Establishment categories does not alter the overall rating of low. If dwarf mistletoes from Mexico did become established, they would cause some economic and environmental damage to United States forests. It is uncertain how much damage this would be, but it would probably take many decades and possibly centuries until they had sufficient widespread distribution to have comparable effects with native species. There is no time limit on this assessment, however, and the ratings for Economic and Environmental Damage Potential have been changed to moderate. This does not alter the Pest Risk Potential of low for this group of pathogens.

Leafy Mistletoes

Assessor—Gregg DeNitto

Scientific names of pest—*Phoradendron abietinum* Wiens, *Phoradendron pauciflorum* Torrey, *Psittacanthus americanus* (Jacq.) Martinus, *Psittacanthus calyculatus* (DC.) Don, *Psittacanthus macrantherus* Eichler, *Psittacanthus schiedeans* (Cham. & Schlecht) Blume, *Struthanthus deppeanus* (Schltdl. and Cham.) Blume in Schult. and Schult., *Struthanthus interruptus* (Kunth) Blume in Schult. and Schult., *Struthanthus microphyllus* (H.B.K.) G. Don, *Struthanthus quercicola* (Schltdl and Cham.) Blume. (Santalales: Loranthaceae and Viscaceae)

Scientific names of hosts—*Phoradendron abietinum* infects only *Abies durangensis*. *Phoradendron pauciflorum* is found on *A. concolor*. The five Psittacanthus species infect the following conifers:

Psittacanthus americanus: Pinus teocote, P. montezumae
Psittacanthus calyculatus: Pinus douglasiana, P. herrerai, P. leiophylla, P. michoacana, P. montezumae, P. pringlei, P. pseudostrobus, P. rudis, P. teocote, Abies religiosa
Psittacanthus macrantherus: Pinus engelmannii, P. herrerai, P. lawsonii, P. lumholtzii, P. oocarpa, P. pseudostrobus
Psittacanthus schiedeans: Pinus leiophylla, P. montezumae, P. teocote

The following *Struthanthus* species have been reported on pines in Mexico:

Struthanthus deppeanus: Pinus patula
Struthanthus interruptus: Pinus lawsonii
Struthanthus microphyllus: Pinus leiophylla, P. montezumae, P. pseudostrobus
Struthanthus quercicola: Pinus spp.

Distribution—*Phoradendron abietinum* is found in the Sierra Madre Occidental from southern Chihuahua through Durango to northern Jalisco. *Phoradendron pauciflorum* occurs in Baja California, Arizona, and California. *Psittacanthus americanus* is found in Chiapas, Guerrero, Michoacan, Tepec, and Veracruz. *Psittacanthus calyculatus* occurs in Chiapas, Guanajuato, Mexico, Michoacan, Morelos, Oaxaca, Tamaulipas, and Yucatan states. *Psittacanthus macrantherus* is distributed in Jalisco, Michoacan, and Oaxaca. *Psittacanthus schiedeans* occurs in Michoacan. *Struthanthus deppeanus* occurs in Chiapas, Oaxaca, Puebla, and Veracruz. *Struthanthus interruptus* and *S. microphyllus* are in Michoacan, and *S. quercicola* is in Veracruz and Puebla.

Summary of natural history and basic biology of the pests—The leafy mistletoes are dicotyledonous plants that parasitize living trees. The plants possess chlorophyll and photosynthesize. The principal requirements from their host are for water and mineral nutrients. The plants are dioecious, producing separate male and female plants from each infection. Flowers are insect pollinated in *Phoradendron* and *Struthanthus* and bird pollinated, mainly by hummingbirds, in *Psittacanthus*. Spread is mainly by birds that feed on the berries and defecate seeds onto host material. Seeds germinate and produce a radicle that penetrates the bark and enters living host tissue of susceptible branch material. A root system develops in the branch xylem from which aerial shoots develop after several years. Most infections occur on branches, although main stem infections can occur when infected branches become overgrown. *Struthanthus* plants have long branches that produce shoots that anchor themselves to branches in various places in the host (Kuijt 1969).

Infections may result in reduced growth rate, top kill, decreased seed production, and tree mortality. High levels of infection are required in a tree before damage occurs (Hawksworth 1979, Hawksworth and Scharpf 1981).

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Low* (*RC*)
Leafy mistletoes bear plants mainly on branches. A few logs may have plant-bearing infections, but these would be infrequent. Mature seeds on these plants are quickly consumed by birds. Infections in cut logs would rapidly die before seed production because of the drying and death of the host tissue.

2. Entry potential: *Low* (*RC*)
Between logging activities and transport, any plants that might be present on the logs will probably fall off or be displaced. The loading of logs onto ships, railcars, or other forms of transport would probably knock off many of the remaining plants. Infections in logs would slowly die as host tissue deteriorates and dies. Leafy mistletoe plants are more visible on the outside of logs than most insects and pathogens and might be observed by inspectors.

3. Colonization potential: *Low* (*RC*)
There would be little inoculum available for colonization of hosts near the ports of entry. The few fruits that might be present on logs would probably not be found by resident birds in the ports or mill yards. Since separate male and female plants are produced, separate infections would be necessary for successful pollination and seed production on any plants that might become established. It is not known if colder climates might limit shoot production as occurs with native leafy mistletoes on some conifers (Wagener 1957).

4. Spread potential: *Moderate* (*RC*)
Spread of leafy mistletoes is dependent mainly on birds. If seed producing plants were produced, it is likely that local bird populations would consume and transport seed to other hosts. It is unknown if any conifers in the United States are susceptible to these parasites. Because of the large host ranges of *P. calyculatus* and *P. macrantherus,* it is possible western or southeastern United States pines and true firs could be susceptible. Since these mistletoes are highly visible, they could be readily detected and removed quickly before the area of colonization was significant. Another leafy mistletoe, *Viscum album*, that was introduced into California in the early 1900s spread a maximum distance of only 5.6 km in about 75 years (Scharpf and Hawksworth 1976). The rate of spread increased the next 15 years, with an average annual spread of 0.26 km in 1986 and 0.35 km between 1986 and 1991 (Hawksworth and others 1991).

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*RC*)
Leafy mistletoes in the United States generally have little economic impact. Infections take so long to build up that they can be dealt with through management activities before impact occurs. It is expected that this would be the same for these leafy mistletoe species if they were introduced.

6. Environmental damage potential: *Low* (*RC*)
Little to no environmental damage is expected because of the limited impact on hosts. It is possible any successful introductions could provide an additional food source for birds.

7. Perceived damage potential: *Low* (*RC*)
There has been little social or political damage from the introduction of European mistletoe into an urbanized setting in California. It is unlikely that the limited damage expected from any introduction of additional leafy mistletoe species would be noticed by the public. Because of the brightly colored flowers on some of the *Psittacanthus*, there might be a positive perception of appreciation by the public.

C. Pest risk potential: *Low*

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Reviewer's comments—"With respect to the comment, under entry potential, that true mistletoe plants would be readily visible on the outside of logs, we would remind you of the great difficulty inspectors face when they are asked to inspect shipments containing large numbers of logs." (Cree and Watler)

Response to comments—The difficulty of observing any pest in a large shipment of logs is recognized, and the likelihood of an inspector making such an observation of leafy mistletoe shoots has been reduced. This does not alter the probability that the vast majority of any leafy mistletoe shoots would be lost during harvest and shipment prior to arrival at the port of entry.

Pine Wood Nematode

Assessors—Joe O'Brien and Jim Hanson

Scientific name of pest—*Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle (= *B. lignicolus*), (Tylenchida: Aphelenchoididae).

Scientific names of hosts—Pathogenic under some circumstances on almost all pines (*Pinus* spp.), as well as larch (*Larix* spp.), spruce (*Picea* spp.), and fir (*Abies* spp.).

Distribution—The pine wilt disease caused by *B. xylophilus* occurs in portions of North America, Japan, and China (Rutherford and others 1990). In North America, the nematode is assumed to be indigenous but causes significant disease only in introduced pines, especially Scots pine (*P. sylvestris* L.) and Austrian pine (*P. nigra* Arnold). Even in these species, the disease occurs only when the mean temperature exceeds 20°C in July (Rutherford and Webster 1987). The nematode has been reported from 40 states in the United States, from 7 Canadian provinces (Tainter and Baker 1996), and from northeastern Mexico (Dwinell 1993).

Bursaphelenchus xylophilus and *B. mucronatus* Mamiya and Enda appear to be very closely related and, in some instances, may have the capacity to interbreed (Bolla and Boschert 1993). *Bursaphelenchus xylophilus* has been reported from the United States, Canada, Mexico, Japan, and China, while *B. mucronatus* has been reported from Europe, Japan, and China (Rutherford and others 1990). *Bursaphelenchus mucronatus* is widely held to be saprophytic and does not cause pine wilt disease. All pine wilt disease occurring worldwide to this point has been attributed to *B. xylophilus*. However, there is considerable genetic variation within the currently accepted bounds of *B. xylophilus*, including morphological and virulence differences among populations (Bolla and others 1986, Bolla and Boschert 1993, Kiyohara and Bolla 1990). Additional populations of nematodes have been identified that are similar to *B. xylophilus* but do not interbreed with known *B. xylophilus* or *B. mucronatus* isolates. The single isolate obtained from Mexico has not been genetically characterized or analyzed for virulence. It is described as the morphological "r" form of the nematode that is common in the United States (L.D. Dwinell, 1996, personal communication).

The nematode was first identified in Japan in 1971 but may have been introduced there from North America sometime around the turn of the century (Mamiya 1987). It is currently the most serious disease of native pines in Japan, causing extensive mortality in Japanese red pine (*P. densiflora* Sieb.) and Japanese black pine (*P. thunbergii* Parl.). *Bursaphelenchus xylophilus* has recently been implicated in the death of 600,000 pines in China between 1983 and 1988 (Cheng and others 1988, as cited in Rutherford and others 1990; Yang and Wang, personal communication, as cited in Rutherford and others 1990). The disease appears to be currently limited to the Nanjing province, although *B. mucronatus* has been isolated from wilting pines in several other provinces (Cheng and others 1988, as cited in Rutherford and others 1990). Pathogenicity studies for these Chinese isolates of *B. mucronatus* have not been reported.

Summary of natural history and basic biology of the pest—The pine wood nematode is associated with wood boring beetles, mainly those in the genus *Monochamus* (Cerambycidae), both in North America and in Japan. These beetles carry the nematode from dead trees, and by one of two behaviors, transmit them to either healthy trees or to dead, dying, or stressed trees. Both behaviors result in the continuation of the pine wood nematode life cycle. In transmitting the nematode to healthy trees, emerging *Monochamus* spp. carry the nematode in their tracheae. The beetles may feed on the young twigs of a healthy pine (a behavior known as maturation feeding), causing wounds that the nematodes exploit by leaving the insect through its spiracles and entering the feeding wound. The nematodes mature, mate, and reproduce in the host, feeding on parenchyma cells of the tree. This is known as the phytophagous phase of the pine wood nematode. The nematodes induce a wilt in the tree, which attracts the wood boring beetles that will vector the next generation of nematodes to new trees.

The other behavior exhibited by the beetles is ovipositing in dead or dying trees, regardless of whether these trees have been affected by pine wilt. Nematodes may be deposited in the tree during beetle ovipositing. These nematodes feed on the blue stain fungi that are carried by other bark beetles and other wood-boring beetles. Once the tree dies and is colonized by the wood-boring vectors, the nematode produces a special larval stage (dauerlarva) characterized by larvae that are attracted to and enter the pupae of the *Monochamus* spp. that will carry them to new hosts.

In this way, trees that were not killed by *B. xylophilus* may still hold a significant reproducing population that increases the inoculum potential of the nematode. These trees serve as reservoirs for the dissemination of nematodes that will infect healthy trees, when carried by wood-boring beetles exhibiting the first emergence behavior.

Specific information relating to risk elements

A. Probability of pest establishment

1. Pest with host at origin potential: *Moderate* (*MC*) The nematode and its vector, *Monochamus* spp., has a good chance of being with the hosts in Mexico. Although there is no detailed information on the distribution of this nematode in Mexico, it was found there after a cursory search. We assume that it has wide distribution throughout the country.

2. Entry potential: *High* (*MC*)
Because *Monochamus* females oviposit in freshly cut or recently cut timber, either the eggs or larvae could be transported with the logs. It is assumed that if the wide distribution of the nematode is correct, the pine wood nematode would be introduced at the time of oviposition. The pine wood nematode could also be introduced during maturation feeding. It is possible that if the logs are shipped with bark and are not infested by *Monochamus*, they could be infested by *Monochamus* species in the United States and, in turn, transport the nematode to suitable hosts within the United States.

3. Colonization potential: *High* (*MC*)
Monochamus species are strong flyers and should find suitable hosts within the vicinity of port or other entry sites. Once established, the pine wood nematode could be vectored by native Cerambycid species in addition to any introduced species of wood borers. This association would increase the likelihood of colonization of the pine wood nematode.

4. Spread potential: *Moderate* (*MC*)
Once established, the spread potential of the pine wood nematode could be high because of the flight habits of its vector and the possibility of infested material being transported during normal commerce. Native insect vectors could increase the rate of spread of the pine wood nematode from colonized areas. Pine wood nematode, however, has been in the United States for quite some time, so it has possibly reached its ecological range.

B. Consequences of pest establishment

5. Economic damage potential: *Low* (*MC*)
The pine wood nematode and its vectors are common in North America. There is currently no evidence suggesting that any strain of *B. xylophilus* or *B. mucronatus* might be virulently pathogenic on any native species in North America. Because the nematode in Mexico is quite probably similar or identical to *B. xylophilus* in the United States, importing the nematode into this country from Mexico probably carries a low risk to native trees.

6. Environmental damage potential: *Low* (*MC*)
The pine wood nematode probably would not cause any more environmental damage than has already occurred in the United States. The nematode is not regarded as a major pest in the environment by most forest health specialists in the United States. There is always the contention, however, that there could be a genetic variability in the pine wood nematode in Mexico that would make it more pathogenic in the United States. To date, no evidence regarding this nematode supports this.

7. Perceived damage potential: *Low* (*RC*)
Introductions of the pine wood nematode from Mexico are unlikely to cause increased social or political impacts beyond those already caused by this pest. The nematode already has wide distribution throughout the United States, and the assessors believe that the introduction of a more virulent strain of the nematode is not likely.

C. Pest risk potential: *Moderate*

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Reviewers' comments—"What if the pine wood nematode populations in Mexico are genetically different from the populations already in the U.S.?" (Seybold)

"I maintain the pine wood nematode should be viewed with concern, especially considering the fact there most likely are strain differences and with those differences there are risks." (Bergdahl)

"Is there enough evidence (e.g. DNA analysis) to show that the *Bursaphelenchus* in Mexico are no different from the ones in the U.S.?" (Cobb)

Response to comments—There is always a chance that there may be genetic variability in almost any pathogenic organism. There has been no evidence, however, suggesting that any strain of *B. xylophilus* or *B. mucronatus* might be virulently pathogenic on any native species in North America. The single isolate obtained from Mexico has not been genetically characterized or analyzed for virulence. It has been described as the morphological "r" form of the nematode that is common in the United States. The writers have no knowledge of surveys in Mexico regarding the distribution of this nematode or its variability in Mexico. Also, there have been no recent surveys of this nature in the United States to determine variability. The two places that have current problems with the nematode are Japan and China. The nematode problem in Japan may have been introduced from North America.

Chapter 4. Summary and Conclusions

Background

Several U.S. forest industries propose to import logs of *Pinus* and *Abies* for processing in various localities in the United States. Current regulations require that unprocessed logs from Mexican states that do not border the contiguous United States be debarked and heat treated to eliminate all pests (Title 7, CFR Part 319.40-6). However, a general permit was issued to import logs and other wood articles from Mexican states adjacent to the U.S. border (Title 7, CFR Part 319.40-3). There is little biological support for such a regulation because plant pests are not confined to political boundaries. Therefore, the Animal and Plant Health Inspection Service (APHIS) requested that the Forest Service prepare a pest risk assessment that identifies the potential pine and fir pests throughout Mexico, estimates the probability of their entry on logs of these species into the United States, and estimates the potential for these pests to establish and spread within the United States. The pest risk assessment also evaluates the economic, environmental, social, and political consequences of the introduction. The assessment and conclusions are expected to be applicable to the entire United States.

The pine forests of Mexico are extremely diverse and cover a large portion of the country. More than 40% of the world's pine species occur in Mexico. Many of the pine species growing in the United States are closely related to the pines in Mexico. The insects and pathogens associated with Mexican pines often occur on a variety of hosts, which elevates the concern that these organisms could also adapt to pines in the United States if given the opportunity. Some of the organisms in Mexico occur not only on a variety of pines but are found in other genera, such as *Abies*, as well. In some cases, geographic isolation may be the only reason that a pest–host association between Mexican organisms and pines in the United States has not already occurred.

Pest Risk Assessment

This pest risk assessment was compiled by the Wood Import Pest Risk and Mitigation Evaluation Team, a group of pest specialists from various USDA Forest Service offices. The team of specialists provided technical expertise from the disciplines of forestry, entomology, pathology, mycology, and economics. All team members worked on previous pest risk assessments related to log imports. The team was assisted by representatives from APHIS, the USDA Forest Service, and the Mexican government. In July 1996, five members of the team traveled to Mexico, accompanied by an APHIS representative (Appendix A). The site visit in Mexico was coordinated by officials of the Forest Protection division of the Ministry of the Environment, Natural Resources, and Fisheries (SEMARNAP). In Mexico, the team visited various pine and fir forests, harvest areas, processing plants, and port facilities to gain an understanding of local forest management, associated pest problems, and capabilities of addressing importation requirements.

The team began the risk assessment process by compiling a list of organisms known to be associated with *Pinus* spp. and *Abies* spp. in Mexico. From this list, insects and pathogens having the greatest risk potential as pests on logs were identified using risk analysis procedures recommended by APHIS (Orr and others 1993). This pest risk assessment expanded two of the five criteria for identifying potential pests of concern (Table 7). Criterion 2a includes pests that are present in both Mexico and the United States but with restricted distribution in the United States and little chance of being spread within the United States because of the lack of reason for movement of contaminated material from the restricted area. Imports of such materials could well traverse and break these barriers. Criterion 4a was expanded to recognize the ability of forest pests to change in virulence and be better adapted to a foreign host, thus resulting in an innocuous organism in Mexico becoming a pest of concern to the United States.

Twenty-two individual pest risk assessments (IPRAs) were prepared for pests of *Pinus*, twelve dealing with insect pests and ten with pathogens. Six IPRAs were prepared for pests of *Abies.* The organisms from these assessments are grouped in Tables 13 (*Pinus*) and 14 (*Abies*) according to the host species and the substrate they are likely to occupy (on bark, in or under bark, inside wood). The team recognizes that these organisms may not be the only ones associated with logs but they are representative of the diversity of insects and pathogens that inhabit logs. The lack of biological information on a given insect or pathogen should not be equated with low risk (USDA Forest Service 1993). However, by necessity, this pest risk assessment focuses on those insects and pathogens for which biological information is available. By developing IPRAs for known organisms that inhabit a variety of niches on logs, APHIS can subsequently identify effective mitigation measures to eliminate the recognized pests and any similar unknown organisms that inhabit the same niches.

Major Pests of *Pinus* Species on Imported Logs

Some of the organisms of concern on pines (e.g., *Pineus* spp., *Pterophylla* sp., *Lophocampa* sp., *Dothistroma* spp.) would only be associated with logs as hitchhikers, most likely confined to the bark surface. Although these hitchhiking organisms are generally not considered likely to be found on logs, several were identified in the risk assessment as a moderate or high risk potential. These include the fungi that cause needle diseases and certain insects such as *Pterophylla beltrani*, which feeds on trees other than pines but lays eggs in pine bark. The tettigoniid *P. beltrani* is representative of organisms that could use pines as a vehicle to gain access to their host plants of a different genus. The needle diseases merit a moderate rating only because of their likely association with pine bark and not because of high consequences once introduced.

Insects and pathogens that inhabit the inner bark and wood (e.g., *Dendroctonus* spp., *Gnathotrichus* spp., and *Fusarium subglutinans* f. sp. *pini*) have a higher probability of being imported with logs than do organisms on the bark, particularly in the absence of mitigation measures. Among the insects and pathogens found in the bark and wood of Mexican pines, eight species were rated a high risk potential. *Dendroctonus mexicanus* is a concern because of its broad host range and importance as a mortality agent of pines in Mexico. Its pine hosts include the entire range of subgroups in the genus. *Ips bonanseai* was one of several engraver species that we encountered commonly on fresh pine logs in mill yards. Given its broad host range in Mexico and high degree of association with fresh logs, it would be a likely candidate for introduction into parts of the United States where it does not presently occur. Four or more species of Mexican *Gnathotrichus* do not occur in the United States and also are likely associates of freshly cut logs. These ambrosia beetles as well as *Ips bonanseai* are considered potentially more important from an environmental (ecological) perspective than from an economic standpoint. Termites, especially *Coptotermes crassus*, are a concern because of the potential economic damage they could cause to wood in use. Termites already cause a total economic impact of $1.5 billion per year in the United States. One of the most damaging termites in the United States is a nonindigenous insect that belongs to the genus *Coptotermes*, which is the reason for our concern about the species found in Mexico. *Fusarium subglutinans* f. sp. *pini*, which causes pitch canker, is widely distributed in Mexico and has already demonstrated an ability to colonize pines beyond its natural range once it was introduced into California. Introductions of climatically adapted strains of pitch canker into the Sierra Nevada of California or the Cascades of California and Oregon could be devastating if high-value pines such as *P. lambertiana*, *P. ponderosa*, and *P. jeffreyi* were to become infected. Of additional concern is that *Pseudotsuga menziesii* also has been reported as a host for *F. subglutinans* f. sp. *pini*. Pitch canker in Mexico appears to have numerous and diverse insect vectors, including *Pissodes* weevils and shoot borers, which increases the likelihood of spread in Mexico. Accidental importation of new insect vectors for pitch canker from Mexico may increase the likelihood of spread of pitch canker to new regions of western United States. The stains and vascular wilts in Mexico include one species that does not occur in the United States (*Ceratocystiopsis collifera*) and another *Ophiostoma* species that is not unique to Mexico but might be different genetically, based on the fact that *Ophiostoma* is known to be highly variable.

Nine other bark- and wood-associated organisms in pine were rated as having a moderate risk potential. *Heterobasidion annosum* (which causes annosus root disease) and *Sphaeropsis sapinea* (which causes diplodia shoot blight) are of concern because they may be genetically different strains from those present in the United States. They were rated moderate risk potentials based on this premise. Pitch moth, *Synanthedon cardinalis*, by itself is a relatively minor concern, but it may be able to vector or produce entry courts for the pitch canker fungus, which significantly increases its level of risk. The consequence of establishment of pine wood nematode, *Bursaphelenchus xylophilus*, is considered low. However, the likelihood of entry and colonization into the United States is high enough to raise the overall risk potential to moderate. Stem and limb rusts are relatively common on Mexican pines, and their spores are readily dispersed in the air. The known species of rust fungi in Mexico have limited distribution (*Cronartium arizonicum* and *C. conigenum*) or are not present (*Peridermium pini*) in the United States. Their genetic variation across large geographic areas is increasingly being recognized (Vogler and others 1996). It is this potential genetic variation and the differences in virulence that caused them to be rated a moderate risk.

In assessing the risk of potential pests, the fact that insects and microorganisms invade logs in a predictable temporal sequence, dictated by the condition of the host, is important. At the time of felling, logs will contain any pathogens present in the bole of the living tree. Also, certain life stages of defoliating insects may be attached to the bark. Within the first several weeks after felling, logs may be colonized by blue stain fungi and beetles such as *Ips* and *Gnathotrichus* spp. Also, certain wood borers may deposit eggs on the bark of logs shortly after harvest. Whether blue stain fungi or bark- and wood-boring insects will be common on export logs will depend in part on how rapidly the logs are removed from harvest sites and loaded onto ships, trains, or trucks for transport to the United States. We recognize that other potential pathways exist for the introduction of forest pests. Though deserving of examination, these pathways may be difficult if not impossible to predict and are not a focus of this assessment.

Even though many of the harvest sites in Mexico are not far from processing sites and logs are generally moved in a timely manner, there are situations where longer distances and time frames are involved that would enable certain damaging organisms to be associated with the logs. The time required to move logs from the forest to a processing or export facility presents another dilemma. Although the timely removal and transport of logs would serve to avoid infestation by those organisms that require aged logs, it could lead to the inadvertent introduction of those organisms already in the bark or wood that have a short life cycle and would otherwise emerge before transport if the movement of logs were delayed. With time in storage, logs could accumulate more and more pests associated with urban or commercial environments. These could include termites, carpenter ants, or even household ants. These variables in the time between harvest and transport further complicate the prediction of the entry potential of pest organisms.

Several factors suggest that pine logs destined for export from Mexico would probably be relatively free of most damaging organisms. Commercial pine forests appear to be well managed and grow under conditions that do not generally lead to a high incidence of damage by forest insects or pathogens. In addition, Mexican professionals seem to have a good working knowledge of forest insects along with an ability to recognize problem situations. However, some concerns do exist about the comparatively less well-developed knowledge of pathogens of pine. Important diseases of pine do occur but have not been investigated as intensively as insect pests. Of even greater concern is the lack of knowledge of pests on tree species that grow in association with pines that could use pine logs as a vehicle for entry into new habitats in the United States.

Major Pests of *Abies* Species on Imported Logs

Much more is known about organisms associated with *Pinus* spp. than about those associated with *Abies* spp. For *Abies* spp., the team was able to identify only one organism of high risk potential, the stain fungus *Ophiostoma abietinum*, and six organisms of moderate risk potential. The six moderate organisms are the tiger moth, *Lophocampa alternata*, with potential as a hitchhiker; the fir bark beetles, *Scolytus mundus*, *S. aztecus*, *Pseudohylesinus variegatus*, and *P. magnus*; and the cause of annosus root disease, *Heterobasidion annosum*. The fir bark beetles in Mexico are considered less aggressive than the beetle species associated with fir in the United States (*Scolytus ventralis*), although three lesser known Mexican species of *Scolytus* have been reported to attack *Pseudotsuga* spp. in addition to *Abies* and may in fact be more aggressive tree killers than the more broadly distributed and better known *S. mundus* and *P. variegatus.* Again, *H. annosum* is a moderate risk potential based on the possibility that it is genetically different from the strains present in the United States, an assumption that is being made but has not been tested. Few insects have been documented as occurring in the sapwood of *Abies* in Mexico (one of the few is the ambrosia beetle). The team suspects that this may reflect the lack of knowledge about the insect associations with the tree species.

Conclusions

There are numerous potential pest organisms found on both *Pinus* and *Abies* spp. in Mexico that have a high probability of being inadvertently introduced into the United States on unprocessed logs. Some of these organisms are attracted to recently harvested logs while others are affiliated with logs in a peripheral fashion but nonetheless pose serious threats to forest or agricultural hosts in the United States. Thus, the potential mechanisms of log infestation by nonindigenous pests are complex. Further complicating the issue is the presence of many of the pests of potential concern in Mexican states immediately adjoining the United States. For example, the following organisms with a moderate or high pest risk potential occur in one or several border states: the adelgids (*Pineus* spp.), La Grilleta (*Pterophylla beltrani*), pine bark beetle (*Dendroctonus mexicanus*), pine engraver beetle (*Ips bonanseai*), pitch moth (*Synanthedon cardinalis*), ambrosia beetle (*Gnathotrichus perniciosus*), organisms that cause assorted needle diseases, (e.g., *Sphaeropsis sapinea* and *Cronartium* spp.), and pine wood nematode (*Bursaphelenchus xylophilus).* Due to their size, and spatial configuration in some cases, these adjoining Mexican states have ecological and geographic features that do not resemble the bordering U.S. states. The shared border regions where the features are similar can be quite small. Current import regulations provide a general permit for unprocessed wood products from these border states. The issue of pests of concern in adjacent states of Mexico should be considered in any review of log import regulations.

The forest situation in Mexico has some important differences that distinguish it from the situations in New Zealand and Chile, where previous risk assessments have been done (USDA Forest Service 1992, 1993). Plantation-grown Monterey pine (*Pinus radiata*) is an exotic species in both Chile and New Zealand and is relatively free of insects and pathogens. In both Chile and New Zealand, there have been relatively few native organisms that have demonstrated a capability of adapting to their new potential pine host, and many of the insects and pathogens associated with Monterey pine are ones introduced from the northern hemisphere. In Mexico, the heart of diversity for *Pinus* spp. in the world, the number of native organisms associated with pine is far greater than that associated with pine in Chile and New Zealand. This inherent complexity of native pine forests in Mexico leads to more organisms with higher risk potentials than in Chile and New Zealand. Furthermore, an additional source of concern is that Mexico could have genetic variants of species that already occur in both Mexico and the United States.

For those organisms of concern that are associated with Mexican pines and firs, specific phytosanitary measures may be required to ensure the quarantine safety of proposed importations. Detailed examination and selection of appropriate phytosanitary measures to mitigate pest risk is the responsibility of APHIS as part of the pest risk management phase (Orr and others 1993) and is beyond the scope of this assessment.

Table 13—Summary of risk potentials for Mexican pests of concern for unprocessed *Pinus* spp. logs (on bark, in or under bark, or inside wood)[a]

	Probability of establishment				Consequences of establishment			
Common name (*Scientific name*)	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environment damage	Perceived damage	Pest risk potential
On bark								
Insects								
La grilleta (*Pterophylla beltrani* Bolivar y Bolivar)	M	H	H	M	H	M	M	H
Adelgids (*Pineus* spp.)	L	H	M	H	H	H	H	M
Tiger moth (*Lophocampa alternata* (Grote))	M	M	M	M	M	M	L	M
Giant silkworm *(Hylesia frigida* Schaus)	M	M	M	M	L	M	M	M
Pathogens								
Needle diseases (*Davisomycella* sp., *Dothistroma* spp., *Elytoderma deformans*, *Hypoderma* spp., *Lophodermella* spp., *Lophodermium* spp.)	M	M	M	M	M	M	M	M
In or under bark								
Insects								
Pine bark beetle (*Dendroctonus mexicanus* Hopkins)	M	H	H	H	H	H	M	H
Ips (*Ips bonanseai* (Hopkins))	H	H	H	H	M	L	L	H
Bark insects of saplings (*Pissodes* spp. *Dendroctonus rhizophagus* Thomas & Bright)	L	H	M	M	L	L	L	L
Pitch moth (*Synanthedon cardinalis* Dampf)	M	M	M	M	M	M	M	M
Pathogens								
Dwarf mistletoes (*Arceuthobium* spp.)	M	L	L	M	M	M	L	L
True mistletoes (*Psittacanthus* spp., *Struthanthos* spp.)	L	L	L	M	L	L	L	L

Table 13—Summary of risk potentials for Mexican pests of concern for unprocessed *Pinus* spp. logs (on bark, in or under bark, or inside wood)[a] —Con.

	Probability of establishment				Consequences of establishment			
Common name (*Scientific name*)	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environment damage	Perceived damage	Pest risk potential
Inside wood								
Insects								
Subterranean termite (*Coptotermes crassus* Snyder)	M	M	M	M	H	L	M	H
Ambrosia beetles (*Gnathotrichus nitidifrons* Hopkins *G. perniciosus* Wood)	H	H	H	H	M	L	L	H
Round-headed wood borer (*Monochamus clamator rubigineus* (Bates))	M	M	M	L	L	L	L	L
Ambrosia beetle (*Xyleborus volvulus* (F.))	L	H	L	L	L	L	L	L
Pathogens								
Pine pitch canker (*Fusarium subglutinans* (Wollenweb. & Reinking) P.E. Nelson, T.A. Toussoun & Marasas f. sp. *pini*)	H	H	H	M	H	H	H	H
Stains and vascular wilts (*Ophiostoma* spp. *Ceratocystiopsis collifera*)	H	H	H	H	M	M	M	H
Annosus root rot (*Heterobasidion annosum* (Fr.) Bref.)	H	H	H	H	L	L	L	M
Diplodia shoot blight (*Sphaeropsis sapinea* (Fr.) Dyko & Sutton)	M	H	M	M	M	M	M	M
Pine wood nematode (*Bursaphelenchus xylophilus* (Steiner & Buhreer)Nickle)	M	H	H	M	L	L	L	M
Root and stem rots (*Armillaria* spp. *Phellinus* spp.)	M	H	L	L	L	L	L	L
Stem and limb rusts (*Cronartium* spp. *Peridermium* spp.)	M	M	L	H	M	M	M	M

[a]H, high rating; M, medium rating; L, low rating.

Table 14—Summary of risk potentials for Mexican pests of concern for unprocessed *Abies* spp. logs (on bark, in or under bark, or inside wood)[a]

Common name (*Scientific name*)	Probability of establishment				Consequences of establishment			
	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environment damage	Perceived damage	Pest risk potential
On bark								
Insects								
Tiger moth (*Lophocampa alternata* (Grote))	M	M	M	M	M	M	L	M
Defoliador del oyamel (*Evita hyalinaria blandaria* Dyar)	M	M	L	L	M	L	L	L
In or under bark								
Insects								
Fir bark beetles (*Scolytus mundus* Wood, *S. aztecus* Wood, *S. virgatus* Bright, *S. hermosus* Wood, *Pseudohylesinus variegatus* Blandford, *P. magnus* Wood)	H	H	M	M	L	M	L	M
Pathogens								
Dwarf mistletoes (*Arceuthobium* spp.)	M	L	L	M	M	M	L	L
True mistletoes (*Phoradendron abietinum* Wiens)	L	L	L	M	L	L	L	L
Inside wood								
Pathogens								
Annosus root rot (*Heterobasidion annosum* (Fr.) Bref.)	H	H	H	H	L	L	L	M
Vascular stain and wilt (*Ophiostoma abietinum*)	H	H	H	H	M	M	M	H

[a]H, high rating; M, medium rating; L, low rating.

Chapter 5. Bibliography

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Appendixes

Appendix A—Reports on Team's Site Visits to Mexico

First Visit, July 14–26, 1996

July 14

Five of the seven members of the Wood Import Pest Risk and Mitigation Evaluation Team (WIPRAMET) (Borys Tkacz (Team Leader), John Kliejunas, Gregg Denitto, William Wallner, and Andris Eglitis), accompanied by APHIS/PPQ representative Jane Levy, arrived in Mexico City. Upon arrival, the team was met by Jesus Jaime Guerra, the coordinator of our site visit in Mexico. Mr. Guerra is in charge of the Risk Assessment Program for the Forest Health (Sanidad Forestal) staff within the Division of Forest Protection in the Ministry of the Environment, Natural Resources and Fisheries (SEMARNAP (Secretaria del Medio Ambiente, Recursos Naturales y Pesca)) for the federal government of Mexico.

July 15

The team met with Mr. Guerra (SEMARNAP) who reviewed the itinerary and other details of the site visit. The site visit to Mexico included trips to representative pine and fir forests, sawmills, and port facilities that could be used for the potential storage and treatment of logs prior to exportation.

As an introduction to the site visit, Mr. Guerra discussed some of the primary forest health problems in the pine forests of Mexico. The most important forest pests include the bark beetles of the genus *Dendroctonus* (11 species) and the dwarf mistletoes (*Arceuthobium* spp.; 60% of these species are in the state of Durango). Mr. Guerra also discussed pitch canker, a disease of concern to many pathologists in the United States. We learned that although pitch canker is found in 13 Mexican states and affects 19 different species of pines, it is not considered a major forest pest problem in natural stands in Mexico.

The team met with SEMARNAP officials including Oscar Cedeno, Director of Forest Protection (forest fires, insects, and diseases) and Jose Cibrian, Subdirector of Forest Health. Mr. Cibrian described the structure and function of SEMARNAP at both the national and state levels. At the national level, SEMARNAP is headed by Secretary Julia Carabias Lillo who oversees several subsecretaries including Natural Resources, which contains the General Directorate of Forestry. Subdivisions of the Forestry Directorate include Harvesting, Forest Development, Plantations, and Forest Protection. Forest Protection includes forest fires as well as insects and diseases. Within the Forest Health section of Forest Protection, there are six divisions headed by the following people (in parentheses): Diagnostic (Ruben Gutierrez), Regulation (Maria Eugenia Guerrero), Risk Analysis (Jesus Guerra), National Center of Reference in Forest Parasitology (Consuelo Pineda), Forest Nursery Pests (Edgar Patino), and Official Norms (Gustavo Hernandez). At the state level, SEMARNAP offices are headed by delegates who oversee the Forest Protection staff, which includes a Forest Health section.

The team provided an overview of the objectives of the WIPRAMET and described the pest risk assessment process.

Mr. Cibrian provided an informative overview of forests and forest pest problems in Mexico. He pointed out that the forests of Mexico cover 10 to 12 million ha or 20% of the country. The most important timber-producing states are Chihuahua and Durango. There are more than 200 important insects and diseases in these forests, representing 18 major groups. Most prominent of these are the bark beetles (*Dendroctonus* spp.) and mistletoes (*Arceuthobium* spp.). Defoliators such as *Pineus* spp. on pine and *Evita hyalinaria blandaria* on fir are also of concern. In addition to the native pests, there are also six exotic forest pests that have become established in Mexico. Four of these are urban pests and two are forest pests, including a Lepidoptera (*Paranthrene* sp.) that infests poplar. Mexico recently completed a risk assessment in which it identified a concern for the potential introduction of additional exotic pests from the United States, including gypsy moth, pine shoot beetle, white pine blister rust, and pales weevil.

Mr. Cibrian also discussed the phytosanitary requirements for forest products moving into and out of Mexico. Import regulations follow international guidelines (FAO 1992), which specify certification of origin and treatment at origin for quarantine organisms on Christmas trees, pallets, live plants, and seeds. Lumber is the most important import–export forest product in Mexico.

The team also met scientists and researchers from the National Institute for Forestry and Agricultural Investigations [INIFAP (Instituto Nacional de Investigaciones Forestales y Agropecuarias)]. The INIFAP belongs to the Secretary of Agriculture (not SEMARNAP) and is charged with providing research expertise to the government. We were introduced to Rafael Zavala, Director of INIFAP's Center for

Investigation and Development, and two research biologists, Francisco Resendiz and Patricia Olivera.

The team presented the preliminary list of potential pests of concern and discussed them with the officials and scientists that were present.

The team was accompanied throughout the site visit by Armando Equihua, entomologist, and Dionicio Alvarado, plant pathologist. Both of these forest pest specialists are employed at the Colegio de Postgraduados in Montecillo, Mexico, and both have recently completed their doctorate studies in the United States.

In the afternoon, the team departed Mexico City for Morelia in the state of Michoacan.

July 16

In Morelia, the team met with Carmen Trejo, special secretary to the state delegate for SEMARNAP in Michoacan. The State Delegate Luciano Grovet was unable to meet with us, so we met instead with Subdelegate Rosendo Caro. We also met with Alberto Gomez-Tagle, the regional director of the forestry research division in the Central Pacific Region for INIFAP. Mr. Gomez informed us that there are four research scientists stationed in Uruapan working on the major forest pests of Michoacan. Two of these researchers, Ignacio Vazquez and Renato Sanchez, are pathologists working on mistletoes, stains, and wood decay. Adolfo Del Rio is an entomologist working with bark beetles in Michoacan.

Mr. Caro described the major forest pest problems for the state of Michoacan. Bark beetles including *Dendroctonus mexicanus, D. valens,* and *D. adjunctus* are the most important forest pests. These beetles are especially important in the center of the state throughout the transition zone between the productive temperate high elevation pine forests and the tropical semihot lower elevations. The long needle pines appear to be most resistant to bark beetles, while short needle pines such as *Pinus oocarpa* are susceptible. Mr. Caro noted that some pines are exploited for resin production and that they eventually become weakened to the point that they are attacked and killed by bark beetles. Other insects of significance include shoot moths (*Rhyacionia* spp.) in young plantations and occasionally a pine sawfly (*Zadiprion vallicola*) at high elevations (last reported in the 1970s). At this time, no diseases are being controlled, although dwarf mistletoes are important in pines and true firs in the eastern part of the state. We learned that the incidence of pitch canker is spotty and localized in Michoacan, and the symptoms are sometimes confused with those of bark beetle attacks. There are few, if any, problems with decay. Harvested wood is generally very sound; in fact there is more defect resulting from post-harvest staining of wood than from inherent pre-harvest defect.

Mr. Caro pointed out that more than 90% of the commercial species in Michoacan are pines. Most of these pines (predominantly *Pinus douglasiana* and *P. pseudostrobus*) generally come from areas where growth and management are very good and, as such, there are relatively few associated pest problems. In addition, there are ~700 ha of pine plantations in the state, also growing under very good conditions.

Areas south of the Sierra Madre are geographically isolated and appear to have few pest problems.

We learned that ~80% of the 1.5 million ha of forested land in Michoacan are privately owned, under a communal form of ownership called the ejido. (The ejidos were formed after the Mexican Revolution of 1910 when large haciendas were divided among private citizens interested in managing those lands and their resources.) Among these forest ownerships in Michoacan, there are ~30 commercial companies.

A federal law in Mexico requires that private landowners obtain permission from their state office of SEMARNAP to cut trees (including ones infested by bark beetles) from their property. Previously, there was extensive cutting of dead and infested wood; permit requests for infested trees have recently declined since green wood permits can now be obtained from other areas. About 400,000 ha are currently under permit for the harvest of green trees. Harvesting of the hardwood resource, predominantly species of oak, is not expected in the foreseeable future. The greatest limitation is that kiln drying techniques are currently not available for oak.

The team traveled to the community of Villa Madero and visited El Roble sawmill, owned and operated by Celso Ortega Barriga. Mr. Ortega informed us that the sawmill operates throughout the year and processes ~50,000 board feet per week [~120 m^3]. The production includes both true fir (*Abies religiosa*) and pines (*Pinus douglasiana* and *P. pseudostrobus*). Logs are brought in from nearby forests, with average haul distances of 10 to 20 km. The processed lumber is sent to Mexico City and Queretaro. Five similar sawmills are found in the area.

We examined logs in the storage yard at El Roble sawmill and were able to identify the following agents on fresh logs: pines contained fresh attacks of *Ips lecontei, I. integer,* and *I. bonanseai.* Other insects included *Dendroctonus valens, D. mexicanus,* and *Cossonus* sp. True fir logs contained evidence of decay fungi, *Lentinus* spp., *Fomitopsis pinicola*, and white pocket rot, possibly from *Heterobasidion annosum*. The decays were mainly associated with basal wounds.

Following the sawmill tour, we visited a private parcel of forested land typical of the smaller ownerships in the area. The 60-ha parcel, Rancho Santa Viviana, is owned by Alberto Villasenor who described management activities on his land. Primary species include *Pinus pseudostrobus* and some *Abies religiosa*, with both species demonstrating extremely good rates of growth. After cutting permits are received from local SEMARNAP officials, the trees are harvested in a selective manner and sold to local mills for processing. In this area, the typical cutting cycle involves selective cuts over a 7-year period, followed by 3 years of inactivity for that property.

Two decay organisms were found on stumps of *Abies*: *Laetiporus sulphureus* and *Armillaria* sp. Samples of these were collected by Dionicio Alvarado for identification.

We also had the opportunity to speak with Gomero Trujillo and his brother Joel Trujillo, consultants to a wood products company that is particularly interested in exporting to the United States true fir logs (*Abies religiosa*) from this area because of their excellent growth rates and the high quality of the logs. Time required to transport them from the forest to the port at Lazaro Cardenas ranges from 3 days to 2 weeks. According to Gomero Trujillo, fir logs are not affected by stain but blue stain rapidly develops on pine logs.

We were told that relatively pure stands of fir can be found in the area, although we were only able to view these stands from a distance due to heavy rains at the time of our visit.

We were also told by the Trujillo brothers that their company is interested in white oaks from this area as well. At this time, ITT Rayonier is importing finished lumber into the United States from the state of Michoacan.

In the evening, we traveled to Apatzingan for lodging.

July 17

The team traveled from Apatzingan to Coalcoman, an area that produces half of the wood that comes from the state of Michoacan. The annual harvest from Coalcoman is 120,000 m^3 of wood, with the entire state of Michoacan producing 250,000 m^3 per year. The primary pine species for this region include *Pinus michoacana, P. leiophylla, P. oocarpa, P. douglasiana, P. rzedowskiP. herrerai, P. pseudostrobus, P. montezumae*, and *P. teocote*. Most important is *P. douglasiana*, which makes up ~80% of the total volume of these nine species. Some of the land is so productive that avocados are planted after *P. pseudostrobus* is harvested.

We examined some harvested areas in the Coalcoman area accompanied by state SEMARNAP forester Ramon Jimenez and his assistant Francisco Pastor. We were also accompanied by Raul Colin Mondragon, a consulting forester who assists local landowners with forest inventory and the development of management plans leading to timber harvest.

We learned that no resin collection occurs in the area and as a result, there are relatively few insect problems. In addition, a key species, *Pinus michoacana*, is relatively resistant to the primary bark beetle, *Dendroctonus mexicanus.*

On the way to the first of the two private landholdings that we visited (Las Aguitas), we noted a significant amount of defoliation and dieback on the oaks that grow on hillsides at elevations slightly below the pine zone. The cause of this defoliation is unknown. This defoliation probably receives little attention since oaks are not exploited commercially to any significant degree. Nonetheless, the 26 species of oaks form a significant part of the transition zone that grades into pine, and even at the highest elevations, oaks can still be found as an important component of the pine stands. Some of these oaks are harvested and processed into furniture and flooring.

Mr. Colin described the process by which private landowners, either individually or as a group, solicit permission from SEMARNAP to harvest trees from their lands. The request is followed by a study carried out by consultants such as himself. The study consists of collecting stand inventory information and assembling a recommended management plan that describes the appropriate level of tree harvest based on tree species, stocking levels, growth rates, and stand structure. The SEMARNAP officials review the plan as well as the site proposed for treatment and then, if they approve, issue the permit for harvest. After the harvest, the landowners are required to plant five trees for every cubic meter that was harvested. (This procedure is followed not just in Michoacan but throughout the forested areas of Mexico, which are almost entirely private, communal holdings).

The private land at Las Aguitas, considered fairly typical of forest land in this region, is managed on a 60-year rotation with 30% of the volume removed in each 10-year entry. The best trees are left in the stand until the final harvest at age 60. Because of the steep slopes involved, trees are moved to a roadside landing by means of a cable and power winch system. Primary tree species harvested are *Pinus douglasiana* and *P. oocarpa*.

Since Las Aguitas was recently harvested, we were able to inspect fresh stumps for signs of stain and/or insect activity. We found evidence of *Ips calligraphus, I. grandicollis,* and *Dendroctonus valens* in slash and stumps. All three insects are considered secondary in this area. In addition, some of the standing trees were slightly damaged when the skidding cable rubbed off some bark. Some of these wounded areas had been attacked by a pitch moth, possibly *Synanthedon cardi-*

nalis. We examined a pile of pine bolts, destined for pulp, and found them to be infested with *Ips* and *Gnathotrichus sulcatus* (according to Dr. Equihua) and stained by *Ophiostoma* sp.

We also visited La Nieve, another private holding of 275 ha, situated at 2000 m in elevation. The primary tree species in this area is *Pinus herrerai*, also managed on a 60-year rotation because of its excellent growth rate. Again, harvest entries are made at 10-year intervals, and intermediate cuts are an important part of the stand treatment. As in the case of Las Aguitas, the smaller material and log ends are removed for subsequent pulping. At this location, the team found cones of *Pinus douglasiana* infected by *Cronartium conigenum*, a common cone rust.

The team returned to the community of Coalcoman and visited two sawmill facilities. The first, Productora Forestal Quocoman, managed by Angel Perez, receives wood from the forests we had visited previously. The mill produces lumber and cants. Cants are sold on the Mexican domestic market. The lumber is shipped to the United States through ITT Rayonier, the company that handles the majority of the exported lumber from this area. Lumber at this mill is air dried. The cants are normally treated with Busan, a fungicide applied to reduce staining. Some cants we examined showed evidence of a variety of fungi including bluestain, a white pocket rot similar to decay caused by *Phellinus pini*, and an unidentified brown cubical decay. We examined some oak logs in the mill yard and found them to be infested with an ambrosia beetle, *Platypus parallelus*.

The second mill, owned by Guillermo Vega, is equipped with the only dry kiln in the area. The newly installed kiln has the capacity to dry ~12,000 m^3 per year but actually operates at about half of that capacity, producing ~6,000 to 7,000 m^3 per year of dried lumber. Mr. Vega ships much of this kiln-dried lumber directly to the United States. Within the log yard, we examined logs from trees that had been killed by *Dendroctonus mexicanus*. Some of these logs also contained larval galleries of cerambycid wood borers. There was also ample evidence of fresh attacks by several *Ips* species including *I. calligraphus, I. grandicollis*, and possibly *I. integer*. One log with heartrot contained some large red and black ants resembling *Camponotus* spp. These ants were nesting in the rotten wood inside the log. Decays encountered in some of the logs included heartrots caused by *Phellinus pini* and *Fomitopsis pinicola* and saprots caused by *Schizophyllum* sp., *Trichaptum abietinum* (=*Polyporus abietinus*), and *Polyporus* sp.

July 18

The team traveled to Atenquique in the morning and met with Jalisco state representatives of SEMARNAP, including Miguel Corona Vallejo, head of the state program for Forest Protection, and Ramon Muro, head of the Forest Health section for the state. We also met INIFAP research scientist Jaime Villa from Ciudad Guzman and Jaime Bocanegra, General Director of Silvicultura Productiva de Jalisco, a large private consulting firm that provides forestry consulting services to landowners in the state of Jalisco.

The team visited a mill facility belonging to Grupo Atenquique, which is a subsidiary of Grupo Industrial Durango, the largest forestry company in Mexico. Gilberto Reyes Escamilla, manager of a timber supply company called Forestal Jalisco, S. A., described the organizational structure for Grupo Atenquique, which includes several companies involved in the production of paper, paper bags, and lumber. These companies are located in various parts of the country. Within the city of Atenquique, there are three Grupo Atenquique companies, one producing paper, another producing lumber, and a third that supplies raw materials to the other two. The pulp mill, at 50 years old, is the oldest company in the Grupo Industrial Durango. The paper mill produced 108,000 metric tons of paper in 1995 and projected a production of 120,000 metric tons for 1996. Paper from this company is exported to England, Japan, and the United States. The Atenquique sawmill produces ~118 m^3 of lumber per day, 75% of which is 3/4-in. [19.5-mm] boards, and 25% is 1-1/4-in. [32-mm] boards. The third company, Forestal Jalisco, S. A., which supplies the other two, delivered 340,000 m^3 of wood to the pulp company in 1995, and projected delivery of another 380,000 m^3 in 1996. They also delivered 12,000 m^3 to the sawmill in 1995 but projected only 6,000 m^3 for 1996. The supplying company obtains 30% of the wood from local sources, and 70% comes from other states (Michoacan, Guerrero, Mexico). About 80% of the wood imported from other states is of low quality.

The companies of Atenquique also operate a dry kiln facility that can process 71 m^3 of 3/4-in. [19.5-mm] lumber every third day and 47 m^3 of 1-1/4-in. [32-mm] lumber every third day.

The Atenquique companies own two plots of land totaling 2,500 ha. They believe that they have control over wood quality from the nearby holdings but not over wood from the more distant lands. However, wood from the more distant forests is often directed to the pulp mill, where quality is less critical. The average time from harvest to arrival at the mills is 1 to 2 weeks for the local sources and up to 2 months for the more distant sources. In the past, the Atenquique group has had access to as much as 500,000 m^3 of logs and does have interest in exporting logs to the United States if the price was right.

Key pine species for Grupo Atenquique include *Pinus douglasiana, P. pseudostrobus, P. maximinoi,* and *P. michoacana.*

Jaime Bocanegra (forestry consultant) and Jaime Villa (INIFAP) discussed the results of an intensive study carried out in the southern part of the state of Jalisco. This study covered 224,000 ha, which produce 315,000 m^3 of growth per year (60% of the total forest production for the state of Jalisco). The study described the forest conditions of the area and their management potential. Jaime's brother, Jose Villa, a pest management specialist for the consulting firm Silvicultura Productiva de Jalisco, presented a list of insects collected during that study and discussed their importance to the forest resource. The most important insect pests were determined to be *Dendroctonus mexicanus* and *D. adjunctus*. *Dendroctonus adjunctus* is important at high elevations in *P. hartwegii*, whereas *D. mexicanus* occurs in *P. leiophylla, P. oocarpa,* and *P. michoacana* at lower elevations. In 1993, an outbreak of *D. adjunctus* resulted in the loss of ~40,000 m^3 of *P. hartwegii*. Similarly, a recent outbreak of *D. mexicanus* caused the death of 20,000 m^3 of *P. oocarpa* and *P. michoacana*. Other bark-inhabiting insects of lesser importance include *Ips integer, Hylurgops* sp., *Pityophthorus* sp., and *Cossonus* sp., all of which are usually associated with logs and stumps. Ambrosia beetles of the genus *Platypus* are abundant but are apparently less important than those of the genus *Gnathotrichus*. Assorted defoliators and cone insects were also mentioned, but except for *Zadiprion vallicola*, these are not considered to be significant pests.

The team raised questions regarding the important diseases. The consultants noted that root pathogens such as *Heterobasidion annosum* occur in pines and true fir, and *Armillaria* sp. might be present at low levels. In pine, mortality is associated with regeneration around stumps. In true fir, they have not observed root disease centers. Pitch canker can be found as well, most predominantly in plantations where it is vectored by the shoot borer *Eucosma sonomana* and less so in natural stands where its effects are limited to producing branch dieback in infected trees. Bluestain is common, but species have not been identified. The pests of fir receive less attention that those of pine but appear to be limited to those trees growing under stressed conditions. Root diseases including *Heterobasidion annosum* have been noted in *Abies religiosa,* as have some secondary bark beetles including *Scolytus mundus* and *Pseudohylesinus variegatus*, with the latter being slightly more important and associated with root disease. Oaks are affected by a decline of unknown cause.

Ramon Muro discussed the SEMARNAP procedure for issuing phytosanitary certificates for exportation. These certificates identify the origin of products, their inspection for pests by SEMARNAP officials, and recommended treatments when deemed necessary. The inspections by SEMARNAP officials occur in the forest and the mills but not at the ports.

At lunch, we met Aldo Rivera, silviculturist for the private consulting forestry company, and Jalisco State SEMARNAP foresters Adolfo Arrechega Guzman and Agustin Quinones Nevares. They provided additional information relating to the forests and companies of this area. They pointed out that at this time in 1996, SEMARNAP had already issued phytosanitary certificates for lumber exports totaling 5,500 m^3. These permits are not required in the United States, but we were told that importers often request them nonetheless as an assurance that material will be more likely to be pest free. We also learned that the entire parent company (Grupo Industrial Durango) produces 1 million m^3 of pulp per year.

In the afternoon, we visited a sawmill, Empresa Mexicana Central de Maderas, owned and operated by Humberto Salazar. The sawmill produces railroad ties and lumber. Eighty percent of the production (189 m^3 per week) is exported, primarily through three companies - ITT Rayonier, Costa Grande Forest, and Monte Timber. Export lumber is kiln dried locally. At the mill site, we observed flying adults and fresh attacks of *Ips integer* and several fresh pitch tubes of *Dendroctonus mexicanus* on pine logs. Some logs were also decayed by *Polyporus* sp. and a fungus forming a large white conk that resembled *Fomitopsis officinalis*. Dionicio Alvarado collected samples of these fungi for identification.

Next, we visited another sawmill (Maderas del Sur), owned by Juan Jose Toscano. Similarly, we found fresh pitch tubes on logs of *Pinus maximinoi.* The logs were probably attacked while still in the woods. In addition, there were numerous attacks by *Ips integer* on very fresh logs. Dead trees had been salvaged from nearby forests after a recent fire.

Later in the afternoon, we traveled to the city of Tapalpa and met with municipal officials including mayor Luis Arias. Also present in the meeting were Raul Sanchez, treasurer of a local forestry protection committee, and Joaquin Venegas, president of that committee (Comite de Proteccion y Fomento de Recursos Naturales Meseta de Tapalpa). Several people representing forest industry and private landowners were also present including Julio Rodriguez Garcia and Javier De La Torre as well as SEMARNAP officials Miguel Corona and Ramon Muro. A key member in this meeting was Raul Michel, a forestry consultant who led the discussion and described various aspects of forestry for the area around the community of Tapalpa. The WIPRAMET team also had an opportunity to describe its goals and objectives to the group.

July 19

The team traveled to the field and met with several property owners representing the community forest land known as Conjunto Predial El Carrizal. Key people in attendance from this community ownership included Luis Vasquez, general director of the group of owners, and Jose Luis Toscano, president of the administrative council for the group. The ownership group within El Carrizal watershed consists of 42 owners and covers 5,800 ha of land. About half this land is considered commercial forest. Resin extraction is a key activity in this watershed, along with commercial timber harvest. The primary commercial species include *Pinus michoacana*, *P. oocarpa*, and *P. douglasiana* growing at an elevation of ~2400 m. The most commonly used silvicultural treatment is the seed tree method, leaving 15 to 25 of the best trees per hectare and removing ~85% of the volume in the harvest entry. Harvested volumes range from 80 to 250 m^3 per hectare. Logs are skidded to a landing using a cable and power winch system and remain in the woods no longer than 2 to 3 days before being transported to the mill. Five years prior to the seed tree cut, the parent trees are selected and marked, and the remaining trees are exploited for resin production. The combined 42 ownerships produce 200,000 tons of resin per year, primarily for domestic use. In addition, the group receives authorization from SEMARNAP to harvest 15,000 to 18,000 m^3 of wood per year. An adjoining landowner, Javier De La Torre, not connected with this group, has an additional authorization to cut 10,000 to 15,000 m^3 per year from 8,000 forested hectares. Growth rates in this area are quite good, as we saw in a 48-year-old second growth pine stand with average tree diameters of 375 mm dbh. Natural regeneration also seems to be plentiful. The group currently exports railroad ties and 1-1/4-in. [32-mm] lumber to the United States through the port of Manzanillo.

Unlike other areas we visited (Michoacan), the owners in El Carrizal had not experienced problems with bark beetles attacking trees weakened by extensive resin extraction. Other pest problems also appeared to be minimal, according to the discussion. At the lower elevations, we observed alder growing in mixed stands with pines and being defoliated by a small green chrysomelid beetle. (Since most of the hardwoods including oaks are viewed as weed species of limited utility, there is little time spent collecting insect and disease information from them).

We were informed that little stem decay is observed in pines, but blue stain is common once the trees are felled.

On pine, we extracted a weevil larva from a sapling with a dead top.

The team also visited a sawmill on the outskirts of Tapalpa (Industrias Forestales de Tapalpa). In addition to producing 1-1/4-in. [32-mm] lumber, the mill also processes low quality logs from resin extraction into crating material for domestic use. Carlos De La Torre states that resin extraction is compatible with timber production from the same trees if resin extraction is limited to 4 years or less. The high-quality lumber is treated with Busan to prevent staining. The mill produces ~24 to 28 m^3 per day of lumber, and the local dry kiln can handle 47 m^3 per day. About 20% of the lumber is kiln dried and either exported or shipped to Chihuahua.

Some interesting observations at this mill yard included 2-month-old logs of *Pinus leiophylla* with heavy sprouting of foliage from adventitious buds on the bole; fresh attacks on logs by turpentine beetle (*Dendroctonus valens*), *Ips integer,* and *D. mexicanus*, as well as heartrot resembling that caused by *Phellinus pini*.

We also learned that the El Carrizal watershed has been the subject of a large-scale cooperative study involving the USDA Forest Service, Rocky Mountain Experiment Station, in Arizona.

In the afternoon, the team traveled to Ciudad Guzman for a closeout session with personnel from SEMARNAP and forestry consultants from the State of Jalisco. We were told that SEMARNAP officials could certify that logs destined for export were harvested from healthy forests. We pointed out that our initial impressions were positive with regard to the level of forest management that occurs in the area, the degree of governmental oversight in how the forests are managed, and in the relatively pest-free conditions under which the pines grow. We expressed some concerns, however, about the lack of knowledge relating to organisms on trees other than pines, the limited awareness of diseases compared with insects, and the fact that numerous organisms can be found on logs in sort yards. Dionicio Alvarado reminded us that although pathogens in Mexico are not as spectacular as insects, several are important. He pointed out that there needs to be further investigation of the taxonomy of pathogens, especially *Armillaria* and the organisms causing bluestain. In the closeout session, we also described our timetable for preparing the document that summarizes the risk assessment findings.

July 20

The team traveled to the port of Manzanillo, Colima. We visited this port because it is the most likely to be involved in the export of logs to the United States. We were met by Fernando Orozco, head of Forest Health for the Colima state delegation of SEMARNAP, Moises Cibrian and Jose Espino, both inspectors of forest products for PROFEPA

(Federal Attorney General for Environmental Protection), and Gonzalo Ramirez, Chief of Inspectors for the Port of Manzanillo. Later in the visit, we were joined by another inspector, Vidal Guerrero.

Mr. Ramirez explained the port operations as well as the capabilities for storing and treating logs for export. Two companies are currently authorized to carry out methyl bromide fumigation procedures in Manzanillo. These companies are capable of fumigating ~1,500 m^3 of logs at one time beneath tarps provided by the port. Since the capacity of a typical ship is 50,000 m^3, there would be some lag time (2 to 3 weeks) between treating a load of logs and having the ship ready for departure. Mr. Ramirez pointed out that debarking and short-term storage of logs would have to be done somewhere outside the port facility and mentioned that such storage facilities exist near the port itself. The region immediately surrounding the port is forested with tropical hardwoods and palms; therefore, the chance of pests from these forests invading stockpiled conifer logs is probably very low.

The port of Manzanillo currently receives plywood from Indonesia, lumber from Equador and Peru, and kiln-dried lumber and pressure-treated telephone poles from Chile. In total, 5,000 m^3 of lumber were imported last year. This material arrives in containers and could be exported in that manner as well. Lumber is also currently being exported from Manzanillo, but no logs have been exported to date.

July 21

The team traveled by air to Durango with a brief stop on the way in Guadalajara.

July 22

We met in the offices of the SEMARNAP delegation for the state of Durango. We were received by Alfonso Castillo, state delegate for SEMARNAP in Durango, Guillermo Mathus, state subdelegate for natural resources, and Arturo Marrufo, head of forest protection for the state.

Forest products constitute ~50% of the local economy of Durango. The authorized annual harvest for the state is 2.2 million m^3 of pine. Actual production is 1.9 million m^3, 30% of which is Grade 3 or better (exportable) and 90% of that amount is actually exported. While the yearly allocation for cutting is rarely met for pine species, the firs are protected and harvesting of *Abies* is limited to salvage cuts. The team was informed that there are currently two sawmills in Durango that are producing kiln-dried lumber for export to the United States. To date, 93 import certificates have been granted for importation into the United States from these two mills. Approximately 300,000 to 400,000 m^3 of lumber are exported annually from Durango. Exports are almost entirely of pine, since the technology does not exist for properly drying oak and not much fir is being processed.

A Durango paper company, Celpap, receives an annual supply of 600,000 m^3 of pine and also processes a small amount of oak (100–150 m^3), although markets have not been developed for oak.

Forest ownerships are all private, with ~2 million ha held as ejidos (distributed among 173 owners); 2.3 million ha as communal forests (63 owners); and another 1.3 million ha as individual properties (662 owners). All of the ownerships undergo similar forms of management and have similar pest problems.

Forests are highly diverse, with more than 20 important species of pine and an equal number of species of oaks found at the mid to high elevations. There are also isolated pockets of *Abies*. Management systems include a variety of treatments derived from extensive involvement with foresters from Finland, Oregon, and Arizona. About 2 million ha are under timber management. Typically, ~120,000 to 150,000 ha are treated annually with a variety of treatments ranging from thinnings to regeneration harvests and "liberation cuts" to remove seed trees after understories are established.

Insects and diseases are not considered a problem in forest management. Bark beetles are uncommon and outbreaks are rare. The last report of a significant pest problem was a recent outbreak of *Dendroctonus mexicanus* covering ~40 ha. Currently, there are ~300 ha of scattered active bark beetle spots. There are also periodic problems with *Rhyacionia* spp. in pine plantations. Although diseases are generally considered a minor problem, problems do occur with stem decays. Even though Durango is considered the center of dwarf mistletoe diversity, the parasite is controlled by silvicultural treatments. Pitch canker is present in natural stands but at low levels.

The three most important forest industry companies in Durango are Forestal Halcon (plywood), Alfa (plywood and lumber), and Bosques Durango (plywood and lumber). (Bosques Durango is part of the large group of companies known as Grupo Industrial Durango.) Together, these three companies process ~400,000 to 500,000 m^3 of wood per year.

We met with Gerardo Peyro, president of the group of companies belonging to Forestal Halcon. We toured his plywood mill (Productora de Triplay), which employs 300 workers and produces various grades of plywood including high-quality material for export. Logs arrive at this mill from various parts of Durango, including some from great distances (500 km). *Pinus durangensis* and *P. ayacahuite* are the principal species. The company pays $50 to $70 per cubic meter for the logs and receives $2500 per thousand board feet [2.4 m^3] of plywood. Only the best logs are used for plywood that is destined for high-quality furniture uses. Daily production for the plywood mill is 94.4 m^3. Some plywood is made with solid core stock; other products have an exterior layer of mohagany (*Swietenia*) from Africa. The highest quality plywood is exported to the United States.

We learned that logs are sometimes stored in the woods, but rarely for more than 1 month. Rains dictate the time in the woods, since roads can become impassable at any time between mid-July and mid-September. Harvesting is suspended during the rainy season to ensure that logs do not remain in the field too long. Total time between tree felling and processing can be 2 to 3 months. Resin extraction is not conducted in Durango.

In the sort yard, we examined lower quality logs and found evidence of fresh attacks by *Ips lecontei, I. calligraphus*, and *I. integer.* We were told that attack levels and subsequent brood survival are much lower than in the moister areas we had visited previously. In fact, the attacks from *Ips* were indeed harder to find than they had been elsewhere. Some logs with fire scars were decayed by *Lentinus lepideus* and *Phellinus pini.*

We also visited a sawmill–plywood plant of Forestal Alfa and met with the chief of the engineering department, Oscar Lara, and with the head of the storage yards, Norberto Vazquez. The company operates a rough-cut sawmill in the woods and sends the best material into the city to the mill. Pentabor preservative is applied to the lumber to prevent staining. This relatively efficient mill processes the rounds from peeler stock into boards, operates a dry kiln that produces 118 m^3 every 4 to 5 days (up to 590 m^3 per month), and uses a shaver system to produce high-quality veneer for exportable plywood. They have also experimented with oak veneer but have had problems with staining and splitting. During the examination of the sort yard, we found a few fresh attacks on pine logs by *Ips lecontei, I. mexicanus,* and *I. integer*.

The team also visited a mill yard belonging to Productos Forestales de Durango. We were shown around by Armando Delgado, the person in charge of log supply. This company (under the new name of Productos Forestales Ponderosa) provides forest products for the states of Chihuahua and Durango. Primary pine species that are processed by the company include *Pinus teocote, P. herrerai, P. arizonica, P. pseudostrobus, P. oocarpa, P. engelmannii, P. cooperi, P. durangensis, P. lumholtzii, P. leiophylla*, and *P. ayacahuite*. The mill attempts to process logs within 15 days of their arrival from the woods. We examined several logs that had been in the yard for 2 to 3 weeks and noted extensive basal fire scars with wood borer galleries in the dead wood and decay. A log cut from a standing dead tree contained galleries of an ambrosia beetle, *Gnathotrichus sulcatus*. We also found a secondary curculionid, probably a species of *Cossonus*. A few logs were decayed by *Fomitopsis pinicola* and *Phellinus pini.*

Another sawmill in the Durango area, Forestal Vizcaya, produces lumber from some distant sources of *Pinus douglasiana* and *P. engelmannii*. We learned from Armando Reyes, head of the sawmill, that some of these logs require 4 days on the road for transport from the woods. This mill produces ~47 m^3 of lumber per day. Most of the wood is for domestic use. Mr. Reyes mentioned that they have few problems with staining of the wood, and the few problems are limited to periods of rain. To avoid staining, the mill personnel apply Pentacroz to exposed portions of logs where the bark is missing. We inquired about the incidence of heartrot and learned that there is high incidence in *Pinus lumholtzii*, especially on poorer sites. As we examined logs in the sort yard, we found live specimens of *Dendroctonus mexicanus* on a log of *P. cooperi*, *D. valens* on *P. engelmannii,* and *Ips lecontei* on an unidentified host. We also found sporophores of *Lentinus lepideus* associated with a brown cubical rot on a *P. durangensis* log.

July 23

Accompanied by Arturo Marrufo of SEMARNAP, the team traveled to the community of El Salto. Traveling from the valley bottom into the mountains, we passed through a series of vegetative zones. Scattered pinyon pine (*P. cembroides*) was the first pine we encountered after rising above fields of cacti and low-growing shrubs. At higher elevations (2600 m), we saw a mixture of *P. engelmannii* and *P. leiophylla* as pine became the predominant vegetation along with various species of oaks.

In El Salto, we met with local forestry consultant Felipe Coria Quinones, from Unidad de Prestacion de Servicios Ejidales del Salto, and Pedro Hernandez Diaz, the secretary of a local union of property owners. Mr. Coria briefed us on the forest ownerships in the area and clarified the differences between ejidos and comunidades, which are the two key forms of group forest ownership in Mexico. Ejidos originated immediately after the Mexican Revolution of 1910, when large, once private, haciendas were claimed by the federal government and divided among private parties interested in managing them. A group of interested parties were allowed to ask for a certain property that they desired and were awarded that property by the government. The ejido property can have as many title holders as originally made the land request, and the title can be handed down from one generation to another but cannot be sold. The comunidades, although very similar, have existed since long before the revolution, and the participating ownership grows in number as family members more than 18 years old are added into the community. In both cases, decisions are made by the collective group of owners and profits are shared among all members. Private industrial companies must deal with the landowners themselves and usually contract for the rights to the timber. The forestry consultants are the intermediaries between the landowners, forest products industry, and the government (SEMARNAP), which oversees management and issues harvesting permits in accordance with advice and site information provided by the consultants.

In 1976, a union of owners (both ejidos and comunidades) was formed to help guide management for the forested land. The union is involved in several programs including formation of management plans, forest protection, and production enhancement.

Mr. Coria also described the history of forestry and exploitation in the area of El Salto and the community of La Ciudad, 45 km further away. Forestry activity began in this area in 1918 when the United States and Canada collaborated to build a railroad between Durango and Mazatlan. Two sawmills were established, one in El Salto and one in La Ciudad, to deal with the wood generated from building the railroad. At one time, the sawmill in La Ciudad was the most important one in the nation. Currently, the La Ciudad community owns 224,000 ha and the El Salto community owns 535,000 ha (95% of the area in El Salto is under the ejido and comunidad form of ownership). Among the El Salto ownerships, there are 360,000 forested hectares, of which 230,000 are commercial and produce an annual volume of 460,000 m^3 of pine, 92,000 m^3 of oak, and 13,250 m^3 of other species including juniper, madrone, and alder. Of the total population of 43,644 people, 11,822 are employed in some aspect of forestry or forest products. Most workers are employed in processing wood products, not in the extraction of wood from the forests. At this time, there are 34 sawmills, 23 of them belonging to the ejidos; 153 companies manufacturing fruit boxes and pallets from scrap wood (branches and tree tops); 14 furniture companies; and 6 dry kilns.

Key tree species in the area include *Pinus cooperi* (most important), *P. durangensis, P. engelmannii, P. leiophylla, P. herrerai* (greatest growth rate), and *P. teocote*. Pines represent 86% of the volume of log production in El Salto, with oaks comprising 10% (used for pulp, pallets, and charcoal), and 4% in other species.

Early harvesting from forest lands was done by the Mexican Method of Reforestation. The principal treatment was an overstory removal, harvesting the largest trees available. This method was employed from 1918 until 1978. Now, small-dimension material is being extracted, and the most common approach in the future will be a series of five intermediate cuts (thinnings) followed by a regeneration cut with a rotation age of 60 years. On poorer sites, the most commonly used harvest method is a selection cut. Pines range from 40 to 60 cm in diameter at rotation age. Typically, 20 m^3 per hectare are extracted per entry.

Mr. Coria discussed the primary insect and disease agents associated with forests of the El Salto area. They consider shoot borers (*Rhyacionia* sp. and *Dioryctria* spp.) and dwarf mistletoes (*Arceuthobium* spp.) their most important pests. A small 5-ha infestation by a defoliating sawfly (*Zadiprion falsus*) was noted in the past on three species of pine (*P. durangensis, P. herrerai*, and *P. lumholtzii*) in the transition zone. There has also been defoliation of *Arbutus* by *Eucheira socialis*. Bark beetles are not considered important pests, except following fire.

We traveled to the field to examine conditions in the forest. At the first stop (Ejido La Victoria), we examined a mixed-species stand that had been treated in 1987 with a seed tree method. Regeneration had been very good. We found numerous stumps of *P. teocote* and *P. cooperi* with decay typical of that caused by *Heterobasidion annosum*. We found pine saplings near some of the rotting stumps, and several of these saplings contained button conks on the outer bark surface at ground level. Symptoms were similar to P-type annosus in western United States. Other organisms of interest included *Rhyacionia* shoot moths in *P. cooperi* and *P. durangensis* saplings (on occasion producing forked leaders); dwarf mistletoe (*Arceuthobium* spp.) in pines; *Phoradendron* sp. on oaks, and bark beetles in several seedlings and saplings of pine (*Hylurgops planirostris*, *Dendroctonus rhizophagus*). We also noted defoliation on oaks caused by a metallic blue flea beetle. In a plantation, we found *H. annosum* on the roots of seedlings of *P. cooperi* var. *ornelasi* and evidence of *Rhyacionia* sp., *Dioryctria* sp., and the pine pitch moth, *Synanthedon cardinalis* .

Next, we traveled to Ejido La Campana and examined an experimental stand where various thinning regimes have been applied. The area has been set aside as a study and as a demonstration area for showing the effects of thinning on tree growth. It is known locally as Sitio Finlandia. Growth on the pines was exceptionally good, and no pest problems were detected.

The team traveled to the community of La Ciudad and met with several of the property owners associated with Ejidos La Ciudad. A sawmill at that location (El Mexiquillo) processes ~40,000 m^3 of pine per year, or about 10% of the output for the entire El Salto area. The mill is about to be relocated to develop a large tourist facility that has been approved at the federal level by the board of tourism but has not yet been funded.

The team returned to Durango for the evening

July 24

The team left Durango and flew through Mexico City to Oaxaca.

In the afternoon, we met with SEMARNAP personnel Juan Carlos Lepe, in charge of forest protection for Oaxaca state, Roberto Garcia, harvesting specialist, and Ruben Garcia, fire specialist.

We learned that there are at least 22 important species of pines and 6 to 8 oak species in this area. *Pinus oaxacana* is the most common pine, and *P. ayacahuite* has the highest value. About 500,000 m^3 of pine are harvested annually from the state, largely for production of lumber and moldings. Harvest of oaks is limited (2,000 m^3 per year), and the wood is used entirely for fuel.

Two key insect problems in the state of Oaxaca are the bark beetles *Dendroctonus mexicanus* and *D. frontalis. Dendroctonus mexicanus* generally occurs in scattered spots. Currently, ~1,000 ha are infested in the state. *Dendroctonus frontalis* reached outbreak levels 2 years ago, killing various species of pines across 1,500 ha. A small sawfly (*Zadiprion*) is occasionally found in young recently regenerated stands. Dwarf mistletoes are also important on several pine species.

We visited a sawmill in Oaxaca and met with Juan Morales who provides wood for the mill. Mr. Morales named the key species received in the mill from the northern Sierra Madre mountains *(Pinus patula, P. pseudostrobus*, and *P. teocote*) and the southern Sierras (*Pinus pseudostrobus, P. douglasiana, P. teocote, P. oaxacana, P. leiophylla, P. ayacahuite, Abies religiosa, A. oaxacana*, and a tropical hardwood *Enterolobium huaxacaxtla*). At least 12 species of oaks are also received at the mill, including *Quercus rugosa*, which has the best growth rate. Wood arrives at the mill from 40 to 250 km away, the longest distances requiring up to 15 days from harvesting to processing. The longest time spent in the yard before processing is about a month. Wood is generally processed for the local market in 2.4-m lengths, with diameters >0.3 m destined for the highest grades, and 0.15- to 0.3-m logs as secondary products. Slabs and beetle-killed wood are sent to Atenquique for pulping.

Many of the logs we examined showed extremely rapid growth, including *Pinus teocote* (23 years old, 0.6-m diameter) and *P. pseudostrobus* (20+ years old, 0.6-m diameter).

A common problem in mill yards appears to be bluestaining of wood, especially when logs are stored for a while before being processed. Attacks by *Ips integer* are also common on logs with bark. Material stored for 2 months will often have ambrosia beetle damage.

Part of the team visited two other sawmills in Magdalena outside of Oaxaca. Mr. Cisternas Garcia and Encarzado Salvador Perez escorted the team through Madera Dimensional de Oaxaca. This mill processes green *Pinus pseudostrobus* and *P. patula* logs purchased from landowners. The haul distance is ~50 km and requires 5 to 6 h. They estimated that the time from harvest to processing is 2 to 15 days. The mill exports green lumber and pallets to the United States. The primary pest problem they experience is bluestain when logs are sawn and left in cant form without further processing into boards for drying. The team examined newer logs that had fresh boring dust of *Ips integer*. Older logs are set aside to be manufactured into fruit boxes. In these, we found evidence of *Ips mexicanus* and some boring dust typical of cerambycid wood borers. The second mill, Maderas y Servicios de Oaxaca, processes green *P. patula* and *P. pseudostrobus* logs from San Miguel Avejiones, ~70 km away. The team met with mill manager Jose Rosario Perez and Adolfo Cuervas. Presently, the lumber produced is sold locally for furniture production. Daily mill capacity is 70 m^3. Here, the main problem is also bluestain in the lumber but not in the logs. They noted that logs that remain in the forest for more than 3 weeks will develop stain.

We were told that earlier this year, the Japanese visited Oaxaca and purchased raw logs. They bought 3,000 m^3 of raw logs along with some rough cut lumber. The Japanese requested a phytosanitary certificate for the logs from SEMARNAP, and one was issued after 200 m^3 were withdrawn for phytosanitary reasons. In the recent past, several other firms have sold logs to Japan, and there appears to be potential for future exportation of unprocessed wood. The greatest local interest may come from small communal owners who do not have their own processing facilities, whereas larger ownerships are prepared to process their own logs locally. We were also told that a company in Guerrero exported pine logs to Peru with Boise Cascade acting as the intermediary.

Production in the local Oaxaca mill has declined since 1986, leaving an oversupply of logs that are now being made available to other states and countries.

July 25

The team traveled to the forests around Oaxaca with SEMARNAP personnel Juan Carlos Lepe and Eduardo Lopez, head of Forest Health for Oaxaca State.

Mr. Lopez elaborated on the recent *Dendroctonus frontalis* outbreak. Following a drought, the outbreak began in 1991 as a series of small spots. Primary species affected were *Pinus pringlei* (80%), *P. oocarpa, P. teocote*, and *P. leiophylla*. The infestation grew well ahead of the control efforts that were undertaken. Before long, 23 municipalities were affected and in November 1994, the municipal governments organized to seek help at the national level. SEMARNAP became involved, and a private consulting company (Infosur) was hired to develop a management plan for dealing with the infestation. The resulting management plan consisted of several steps that involved identifying the most active infestation centers and salvaging them first. The first step treated 751 ha in December of 1994, 400 additional hectares were treated in the second step, and now the control plan has entered the final step. This plan was designed to surround the infestation and treat green infested trees, rather than reacting in a purely after-the-fact salvage manner. The control effort costs about 900,000 pesos (US$120,000) per year. Extracted material was used for pulp.

Mr. Lopez pointed out that most of the bark beetle problems in this area occur in the transition zone (1200 to 2000 m in elevation), which also coincides with the zone that receives the least management. The high level of species diversity limits the spread of beetle infestations, since the pine species vary in their susceptibility to beetles. For example, *Pinus pringlei* is very susceptible to *Dendroctonus frontalis*, whereas *P. oaxacana, P. michoacana*, and *P. patula* are quite resistant. There is also altitudinal variation in the occurrence of the *Dendroctonus* species around Oaxaca. *Dendroctonus frontalis* (eight generations per year) occurs at the lowest elevations that support pine. Primary hosts for *D. frontalis* are *P. pringlei, P. teocote, P. oocarpa*, and *P. leiophylla*. Further upslope, *D. mexicanus* (two to three generations per year) is prominent, attacking *P. patula, P. oaxacana*, and *P. pseudostrobus*. At the highest elevations, *D. adjunctus* (one generation per year) is most important, especially in *Pinus rudis* and *P. hartwegii*.

Our SEMARNAP hosts said that many of the local forest landowners do not have the knowledge or a strong desire to manage their holdings, and therefore, dead trees, either insect infested or burned in fires, often remain in the woods. Nonetheless, there are those who manage their lands intensively, including some who have received an international certification of well-managed lands from the Forest Stewardship Council in Oaxaca.

We traveled to a high elevation site, Las Guacamanas, which had been treated for salvage of pines killed 2 years ago by *Dendroctonus mexicanus.* In spite of a relatively complete salvage of dead trees, a team member found a green-crowned *Pinus oaxacana* with fresh galleries of *D. mexicanus*. We also observed the mistletoe *Psittacanthus* sp. and cone rust caused by *Cronartium conigenum* on *P. oocarpa*.

Next, the team traveled to Santa Catarina Ixtepeji, a community forest property that is one of the more intensively managed properties in the area. We met with Macario Perez Lopez, a consulting forester, Angel Leon Chavez, in charge of forest pest survey, and Paulino Marquez Mendez, treasurer for the community organization. The property is located at an elevation of 2800 m and covers 21,000 ha, of which 17,800 ha are considered commercial forest. The owners have permits to harvest 12,000 m^3 per year during a 5-year period. The primary pine species are *Pinus pseudostrobus, P. oaxacana, P. douglasiana, P. teocote, P. leiophylla*, and *P. patula*. Growth rates are excellent with average height growth of 1 m per year and volume growth of 2 m^3 per hectare per year. The management includes a series of thinnings followed by a regeneration harvest when pines are 90 to 120 years old. The harvest plan and permits for the ownership authorize annual harvest of 12,000 m^3 of pine, 1,450 m^3 of fir, and 4,000 m^3 of oak. Annual harvest of pine is nearly 1500 m^3, largely to supply a local sawmill belonging to the same ownership. Recently, some larger pine logs have also been exported to Japan.

Some oaks are harvested as well (~4000 m^3 in a typical year). Only smaller trees are harvested (<30 cm diameter) since they are most readily made into charcoal. In the past, charcoal made from oak has been exported to Germany from this property. Some oaks are also used for making posts.

Other species of interest on this property include a small parcel of *Pseudotsuga* sp. and some *Abies religiosa*. At present, the *Pseudotsuga* only covers 40 ha, but there are plans to plant more.

Pest problems include *D. mexicanus* bark beetles in *P. teocote* and *P. douglasiana*, but infestations have been relatively small. Some brown cubical rot is occasionally noted in trees >100 years old (primarily in *Pinus pseudostrobus* and *P. oaxacana*). In the past, they noted problems with staining and *Ips* if logs were stored for 2 weeks or more. Although dwarf mistletoes are present, they are not considered a problem.

The final stop on the field trip was to the sawmill belonging to Santa Catarina. Although the 2-day-old logs present in the sort yard showed no evidence of pests, we were able to observe some interesting things in slabs and edgings from logs recently processed at the mill. Many fresh slabs contained extensive bluestaining as well as galleries of ambrosia beetles (*Gnathotrichus sulcatus*). The form of many of these galleries suggested that the ambrosia beetles had been in the logs prior to sawing, while others looked as if the attacks occurred after the slabs were cut. Some *Cossonus* weevils were found in sapwood beneath the bark of 2-week-old slabs.The team returned to Oaxaca for the evening.

July 26

The team returned, through Mexico City, to the United States.

Second Visit, August 4–8, 1996

Harold Burdsall did not accompany the team on the July trip to Mexico because of another trip to Mexico scheduled right after for the purpose of collecting forest pathogens and saprophytes as a part of an Organization for the International Cooperation and Development (OICD) agreement. Dr. Burdsall's trip covered a different route and served both purposes, collecting forest fungi for OICD and observing the pest problems for this assessment in the areas visited.

August 4, 1996

Accompanied by Dr. David Rizzo from University of California, Davis, I (H. Burdsall) arrived in Mexico City and was met by Dr. Armando Equihua and Dr. Dionicio Alvarado, mentioned earlier. We were escorted to the hotel in Texcoco and spent several hours discussing the reasons for the visit and the final arrangements for the stay.

August 5, 1996

We traveled with Dr. Alvarado to a collecting site (19 km marker) on the road from Ajusco to Toluca in the Ajusco Mountains southwest of Mexico City. The site was old growth *Abies religiosa*. No diseases of particular note were evident but the impact of air pollution was obvious.

We continued along the same road and collected again at the 25-km marker under the same conditions. Several saprophytic species of *Phellinus* and one species of *Pholiota* apparently causing a heartrot were collected.

The next stop was in Morales at the National Park called Laguna de Zempaola. The trees here were not as old as at the previous stops. No pathogens were noted, but several saprophytic species of *Phellinus* were collected.

August 6, 1996

We visited the Colegio de Postgraduados in Montecillo, Mexico, with Dr. Alvarado. He showed us the facilities for their research and teaching. While there, we also saw the effects of pitch canker disease on the *Pinus* spp. on campus. The disease was common on those trees.

From the Colegio, we traveled to a place called Llano Grande in the El Chico National Park, Hidalgo. Here we searched for and collected fungi in the mixed forest of *Abies religiosa* and *Juniperus monticola*. There were many signs of root infection by *Heterobasidion annosum* but no specimens were found.

We also collected near Pueblo Nuevo on the road to El Chico National Park. Here the forest was dry with several *Quercus* spp. and scattered *Pinus* spp. and *Juniperus deppiana*. A number of fungi were collected but all were saprophytes except for one member of the polyporaceae that may have been causing a heartrot of living *Quercus*.

The next site, south of El Chico, was not unlike a Sonoran Desert site, with *Yucca* and *Opuntia* spp. common. No fungi or disease problems were encountered at this site.

We also collected near Tetla, in Puebla, in a young forest of *Pinus patula* and *P. leiophylla*. Disease problems were not evident here, and the fungi found were all saprophytes.

August 7, 1996

We collected on the Xalapa–Veracruz road ~25 km east of Xalapa, in Veracruz. The vegetation was made up of numerous species of legumes in a rather dry site. Serious diseases of these species were not evident. Later in the day, we took a flight from Veracruz to Villa Hermosa.

August 8, 1996

From Villa Hermosa, we traveled west into Chiapas. We collected at the 25-km marker on the Tialpa–Tuxtla road where the dominant tree in the area was cocoa. No serious diseases were evident.

We then collected along the road from Tiapa to Tapilula ~5 km east of Tapilula. The species of trees were not known to us but were definitely old growth. The fungi found were all considered to be saprophytes.

The next stop was in the first scenic overlook in the Canon del Sumidero National Park in Tuxtla Gutierrez. The vegetation was mainly scrubby legumes of various descriptions. No particular disease problems were seen and the fungi collected were saprophytes.

August 9, 1996

We returned by air to Mexico City. On arrival, plans were made for the transport of specimens back to the United States and the group dispersed for the trip home.

Appendix B—Plant Pest Interception Records

Plant pest interception records for wood products from Mexico, 1985–1995[a]

Pest	Host	Where[b]	Total
Acrididae spp.	Woodenware	05	1
Arctiidae spp.	Wood	05	1
Cerambycidae spp.	Automobile (crating)	03	1
Cossidae spp.	Housewares	01	1
Dysmicoccus neobrevipes	Wood	01	1
Gnathotrichus sp.	*Glycyrrhiza lepidota* (bagging)	06	1
Gnathotrichus sp.	*Pinus* sp. (dunnage)	01	1
Incisitermes sp.	Crating	01	1
Incisitermes sp.	Crating	06	1
Pityophthorus sp.	Artware (crating)	03	1
Pityophthorus sp.	Machinery (crating)	03	1
Rhyssomatus sp.	Wood	01	1
Scolytidae spp.	At large	01	1
Scolytidae spp.	Crating	03	1
Scolytidae spp.	Lumber	03	1
Scolytus sp.	Lumber	03	1

[a]Source: Animal and Plant Health Inspection Service records.
[b]01, baggage; 03, general cargo; 04, permit cargo; 05, mandado; 06, miscellaneous.

Plant pest interception records for plants or nursery stock from Mexico, 1985–1995[a]

Pest	Host	Where[b]	Total
Chrysobothris sp.	*Prosopis* sp.	01	1
Cermatogaster sp.	*Prosopis juliflora* (stem)	03	1
Cermatogaster sp.	*Prosopis* sp.	04	1
Crophius sp.	*Pinus* sp. (stem)	05	1
Gnathotrichus sp.	*Pinus* sp.	03	1
Gnathotrichus sp.	*Pseudotsuga* sp.	04	1
Heterotermes sp.	*Prosopis* sp.	04	1
Hylastes sp.	*Pinus ponderosa*	04	1
Ips sp.	*Pinus* sp.	04	1
Lyctidae spp.	*Prunus* sp.	01	1
Membracidae spp.	Plant	01	1
Miridae spp.	*Pinus* sp.	05	1
Nasutitermes nigriceps	*Pinus* sp.	01	1
Olethreutinae spp.	*Terminalia cattapa*	01	1
Oligonychus sp.	*Pinus* sp. (stem)	01	1
Phaedon sp.	*Prosopis* sp.	04	1
Phlaeothripidae spp.	*Pinus* sp. (leaf)	05	1
Phloeosinus sp.	*Pinus* sp.	01	1
Phyllachora texana	*Acacia* sp.	01	1
Pseudopityophthorus sp.	*Quercus alba*	03	1
Riodinidae spp.	*Prosopis* sp,	06	1
Scolytidae spp.	*Quercus* sp.	01	1
Tolype sp.	*Acacia farnesiana* (stem)	01	1
Tortricidae spp.	*Prosopis* sp. (stem)	06	1
Trimerotropis pallidipennis	*Prosopis* sp.	01	1

[a]Source: Animal and Plant Health Inspection Service records.
[b]01, baggage; 03, general cargo; 04, permit cargo; 05, mandado; 06, miscellaneous;

Appendix C—Summary of Reviewers' Comments and Team's Responses

Introduction

A draft of the Mexico pest risk assessment was provided to reviewers in the United States, Canada, and Mexico (see pages **ii-iv** for their names and addresses). Individual reviewers were selected on the basis of their interest and participation in previous pest risk assessments for imported logs, their expertise in specific taxonomic groups of pest organisms, or their knowledge of forest pests in Mexico. Responses were received from 29 reviewers: 22 from the United States, 2 from Canada, and 5 from Mexico.

The pest risk assessment team read all reviewer responses and, as a group, discussed the comments or concerns of each reviewer. Where deemed appropriate, the team made changes to the document using information derived from the reviewers' comments as well as additional information the team members had developed after distribution of the draft. Comments from reviewers that pertain to specific pests are included at the end of individual pest risk assessments, followed by a brief response from the assessment team.

General Comments from Reviewers

In summarizing their general impressions of the draft document, most reviewers were favorably impressed with the quality and comprehensiveness of the draft document. A representative sample of reviewer comments is listed below.

"Overall, the Wood Import Pest Risk Assessment Team had done a credible and comprehensive job of identifying those pests most likely to be introduced on *Pinus* and *Abies* logs from Mexico and evaluating the consequences of their establishment in the U.S." (Billings)

"…I wish to compliment the author(s) of Appendix A (team site visit). This section is impressively detailed and well written, providing valuable insight into current forest practices, mill operations, and pest observations made during the site visit. This is a valuable contribution to the PRA [pest risk assessment]." (Billings)

"Overall I found the report to reflect a thorough and careful examination of the situation with a very reasoned and, in my view somewhat understated or conservative, summary… .I would like to add my personal 'Thank You' to you and your committee for your very fine efforts in protecting the function, utility and value of our forest resources." (Blakeslee)

"First, we would like to congratulate you on a very interesting and readable report. The general background information on the forest resources of Mexico is in itself very valuable." (Cree/Watler)

"In spite of our critical critique of the risk assessment draft, the conclusions that you appear to have drawn are those that I believe we can support, albeit that we would have been less compromising in our choice of words." (Cobb/Wood)

"I am impressed with the amount of information contained in this risk assessment. I have read the disease section of the document over and found it easy to read and well done. You and your team have spent a lot of effort and for this you should be commended." (Jacobi)

"We have reviewed this work and find that it is both very informative and well written. We also concur in the main with the conclusions and with the assessments that the team proposed. Much of the data you present is very enlightening. It appears from the information that you have provided that the actual pest risk is much different than was assumed by regulators. We are very pleased that your team was able to undertake this project and to do such a thorough job in such a short time." (Johnson/Griesbach)

"Let me say that you and your colleagues did an excellent job selecting examples of insects and pathogens known from Mexico that might pose a threat to the forests of the United States should they be introduced via these unprocessed logs." (Lattin)

"Overall I think it is an excellent report and you and your team have done a very good job of addressing the potential for importing damaging pests into the United States from Mexico on unprocessed logs." (Mathiasen)

"Your team had done a good job with the unenviable task of assessing which pests from Mexico might enter the United States and develop into a serious problem." (Overhulser)

"The target analysis of representative species at this time is the best and most credible means of analyzing the broad pest risk potentially associated with unprocessed wood products, particularly when, as in this situation, there is a profound paucity of information available for analysis. The individual assessments included were well done and informative. Accordingly, the data presented here should provide APHIS with some good information upon which to base mitigation measures." (Zadig)

Major Issues of Reviewers

Other comments from reviewers not pertaining to specific pests were condensed into eight major and recurring issues. The following section identifies these issues, summarizes specific reviewer comments with respect to each issue, and provides a response to each major issue from this Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET).

Issue 1: Inadequacy of the Pest Risk Assessment Process

Reviewers' comments—Certain reviewers believed that the pest risk assessment process used in this document was not adequate to identify all the potential risks associated with the importation of unprocessed logs from Mexico.

"The risk assessment used by APHIS [Animal and Plant Health Inspection Service] for agricultural pests simply is not appropriate to protect forest resources," (Cobb/Wood)

"A major problem still rests with the APHIS assessment process itself. It is astounding that APHIS cannot see that we simply do not possess enough knowledge to apply their process effectively. Until we do possess the knowledge, it is dangerous to apply when we have so much to lose." (Cobb/Wood)

"Our concern here (method for determining pest risk potential) is with the footnote to Table 1-3 [Now Table 3]: 'If two or more of the single elements that determine probability of establishment are low, pest risk potential is considered low, rather than moderate, for this assessment.' And the subsequent lowering of the pest risk potential from M to L. For instance the occurrence of a pest with a host at origin may be relatively 'low' (due to time of year or frequency of occurrence in host, etc.), but with a large quantity of material being imported throughout the year, the likelihood of infested (infected) material being exported to the U.S. becomes high. Further if another element, spread potential was low, a disease, for instance, could colonize and then spread slowly but still have devastating consequences as it spread. Port Orford cedar root rot would be a good example." (Johnson/Griesbach)

"There are two separate parts to the risk assessment: (a) the risks of introduction and (b) the socio-evaluation of a condition. To average both sections obscures and reduces the biological and ecological risks involved. They should be listed separately. This is a serious flaw in the USDA/APHIS risk assessment procedure." (Lattin)

Response to comments—The risk assessment process used by the WIPRAMET team originated from the workshops and meetings of the National Research Council's (NRC) Committee on Risk Assessment and Management. The NRC's final conclusions were published (NRC 1993).

Although the basis of the risk assessment is historically tied to the work conducted by the NRC, the continued growth of the timber risk assessment process has been synchronously connected to the development of a number of ecological risk assessment projects including the Generic Non-Indigenous Pest Risk Assessment Process (Orr and others 1993) and Proposed Guidelines for Ecological Risk Assessment (EPA 1996). This constant reevaluation of the risk process has resulted in numerous refinements since its original use in 1991.

The USDA Forest Service and APHIS recognize that the risk process currently used is not perfect and that its evolution will continue to be necessary. The risk assessment process is being and will continue to be modified and improved to make sure that it is the best that the science of risk analysis can provide.

The ratings for probability of establishment (risks of introduction) and for consequences of establishment (socio-evaluation of a condition) are technically not averaged to obtain an overall pest risk potential for a specific pest organism or group of organisms with similar habits (Table 13). Rather, the two ratings are weighted to reflect a balance of likelihood and consequences.

Issue 2: Definition of a Quarantine Pest

Reviewer's comments—Several reviewers pointed out differences in the definition of a quarantine pest and that the term was used differently in different parts of the risk assessment.

"Your definition of a quarantine pest, as stated in B on page 3, differs from the internationally accepted definition in a couple of ways. The North American Plant Protection Organization (NAPPO) and Food and Agriculture Organization (FAO) definition states that a quarantine pest is 'a pest of potential economic importance to the area endangered thereby and not present in that area, or present there but not widely distributed and being officially controlled' (Hopper 1996). The USDA criteria for quarantine pest would appear to encompass only geographic distribution, without consideration either economic impact or domestic 'official' control for pests already present in the US. In Section C, however, the text speaks of evaluating the plant pests according to pest risk based on biology and 'demonstrated or potential plant pest importance.' Does that mean economic importance? If so, it should perhaps be included in section B."(Cree/Watler)

“Although several species in a genus or genera in a family may act similarly, have common climatic or host requirements and cause similar damage, domestic pests do no qualify as quarantine pests. In a number of the IPRA’s completed for disease-causing organisms, the list of pests in the assessed group contains both organisms reported widely in the United States and organisms known to occur only in Mexico. We believe that the IPRA’s should focus only on those pests that meet the definition of a quarantine pest, and should therefore concentrate on pests not present in the United States, or present and of limited distribution and under official control.” (Cree/Watler)

“I would recommend that you replace ‘quarantine pests’ with ‘pests of concern’ throughout the document. The definition of a quarantine pest and the pests that you identified using the regulation criteria are not exactly the same. A ‘quarantine pest’ is a mixture of biology and plant protection policy. The criteria used to identify timber pests is strictly biological.” (Orr)

Response to comments—The term potential quarantine pests used in the draft PRA was changed to potential pests of concern throughout the document to reflect the fact that criteria used to select the organisms were biological and do not strictly reflect plant protection policy. The APHIS definitions of quarantine pests were expanded for this risk assessment to address issues of organisms having the capability of causing damage because of genetic variation exhibited by the species or because of the increased opportunities for native organisms to exploit additional environments. This is more clearly explained in Chapter 1 as part of the pest risk assessment process. Organisms that fit this expanded category have been identified as pests of concern rather than quarantine pests. Determination of quarantine pests is the responsibility of APHIS and is beyond the scope of this assessment.

Issue 3: Unknown (Sleeper) Pests

Reviewers’ comments— A concern among reviewers was organisms that are not recognized as pests in their country of origin (in some cases due to lack of information) but may reach pest status when introduced into a new environment.

“This draft assessment only assesses the current or known pests of Mexico.” (Bergdahl)

“As we have stated numerous times in forums with APHIS and in comments with respect to previous assessments, to the EIS [environmental impact statement], and to the regulations, there is no way to be reasonably assured that we can identify the problem pests in natural forest ecosystems until they are introduced into new environments, e.g. the fungus causing dogwood anthracnose.” (Cobb/Wood)

“Some of the most damaging, introduced organisms in the U.S. were not known to exist in their native habitats prior to their arrival here.” (Cobb/Wood)

“I do want to express a general concern with the process. It is based on identifying and evaluating known risk agents, but as we all know, most examples of successful and damaging introductions to this country have involved previously unknown or unappreciated agents. The theory is that mitigation against known agents will also be effective against the unknowns. The logic holds, so long as mitigation is in fact ordered and effectively applied. If the known agents are not deemed to pose a significant risk, then no mitigation will be ordered and there will be no barriers to the unknowns.” (Hansen)

“You cited some known potential and actual insect and pathogen pests — there are surely many more we don’t yet know on forest tree species and even some of our agricultural crops.” (Lattin)

“I think the assessment would be stronger if there were a disclaimer which addresses the limitations of the assessment, i.e. there is no satisfactory way to predict which specific exotic organisms have the potential of becoming established and causing damage in the U.S. Past experience tells us that there are little known or unknown organisms in the country of origin that when introduced into a new environment are capable of becoming serious pests. This may be very significant for Mexico because many of its timber-producing forests are ecologically similar to forests in the U.S., while at the same time having evolved in isolation from our forests.” (Owen)

Response to comments—Members of the assessment team, and APHIS, recognize that unknown organisms may pose the greatest risk to our forests. One of the main functions of preparing this assessment is to address the issue of uncertainty. If uncertainty did not exist, there would not be a need for a risk assessment. One of the risk assessment team’s responsibilities is to communicate this concern about unknowns to APHIS. From the standpoint of APHIS, a pest risk must be demonstrated in order to regulate a commodity. The reason for this is that a regulation takes away the freedom of an individual or individuals to do something they wish to do. Therefore, APHIS must show an absolute demonstrable pest risk to meet the legal requirements of placing a regulation into law.

Issue 4: Unknown Virulence of Pathogens

Reviewers' comments —Several reviewers commented that the individual pest risk assessments for certain pathogens should include more consideration of unknown virulence and should assume existence of different strains. In contrast, Mexican specialists believe the strains of pathogens in Mexico are the same as those already present in the United States and present no additional risk.

"Quarantine regulation of a pest on the basis of genetic variability, however, is not easily accomplished and we consider that very strong evidence of 'real' differences should be presented, as has been done with gypsy moth." (Cree/Watler)

"I don't understand very well the reason to determine high the pest risk potential for stains and vascular wilts as well as for annosus root rot, because they have wide distribution in the U.S. and Mexico. I hope this is due to the fact that strains could be different, but nobody knows about that." (Guerra Santos)

"I am concerned that many of these pathogens may seem the same as what we have in the U.S. but may offer genetically different strains that are more virulent. You mentioned this in the assessments several times but I am worried that the significance of this may be missed. We see dramatic changes in fungi when we have the means of measuring virulence such as with genetically improved trees (Dutch Elm Disease) or with crops such as wheat and wheat rusts." (Jacobi)

Response to comments—The individual pest risk assessments for fungal pathogens discuss the possibility of more virulent strains in Mexico. The possible existence of virulent strains, and lack of specific studies, was the basis for increases in the economic, environmental, and perceived damage potentials in individual pest risk assessments. Whether the strains of fungal pathogens are different than those in the United States, and if so, whether the different strains are more virulent remains unknown. When uncertainty as to virulence was encountered, a higher rating was assigned.

Issue 5: Paucity of Biological Information

Reviewers' comments —Many reviewers commented on the recognized scarcity of biological information on known insects and diseases in Mexico, particularly those associated with *Abies* spp., and cautioned against assuming that little information equated to low risk.

"This pest assessment provides very limited pest information for *Abies* species, in fact, even stated that 'information was not available at this time'. This *Abies* pest information needs to be thorough and complete, especially, considering the vast fir resources we have on higher elevation sites and throughout the northern boreal region of North America." (Bergdahl)

"With respect to the pathogen lists in Tables 3–1 and 3–2 [now Tables 9 and 11], I (Fields Cobb) do not have access to the literature and have no firsthand experience in Mexico. However, I am 'as certain as I am going to get' (very certain, according to the APHIS system) that it is a grossly incomplete listing. For instance you list only one species of *Ophiostoma* on one species of pine. We all know that this is ridiculous." (Cobb/Wood)

"As you fairly point out in the assessment…, there is an enormous lack of information on the pests of true fir (*Abies*) in Mexico. This lack of information is severe even with the insects; with the disease agents, it is much worse. With such unknowns, there appears to be only one reasonable approach to importation of logs; i.e., if logs must be imported, treat them to exclude all potential pests that could occur on or within the logs." (Cobb/Wood)

"…the lack of information regarding Mexican forest insect and pathogen pests cannot be understated and could perhaps be more strongly stated in this document." (Zadig)

Response to comments—The limited literature and personal knowledge of insect and pathogen pests on Mexican species of pine and true fir is important information for APHIS to use when formulating possible mitigation measures. The mitigation measure(s) required for a variety of well-documented pests is likely to also impact other organisms (of which little is known) that occupy similar locations on the commodity to be imported. Therefore, the risk assessment team, and APHIS, feel that conducting a few individual pest risk assessments on those organisms for which information is available will be much more productive than spending time attempting to assess many organisms for which little or nothing is known.

Issue 6: Risks Do Not Apply to the Entire United States or Canada

Reviewers' comments—Reviewers expressed concern that the draft risk assessment did not adequately discuss resources at risk throughout the United States and Canada and, in some sections, was limited to western conifer forests.

"In short, the potential threat to the northern boreal forests of North America was not adequately addressed." (Bergdahl)

"It seems very viable to include mention of the threat to the southern pine resource…a resource that attains greater economic importance to the nation each year." (Blakeslee)

"On page 18, the draft apparently implies that only the U.S. southern states may be favorable for survival and spread of pests from Mexico. There is nothing presented to support this implication. To the contrary, on page 11 you state that Mexico has a "great variety of climates" from tropical to arctic. Hence, it is reasonable to assume that there are insects and especially pathogens that are potential threats to every forest in the U.S." (Cobb/Wood)

"Resources at Risk, Pacific Northwest region (p. 9): hardwoods in riparian (alder, willow, etc.), logged, and plantation (e.g., poplars) areas are also resources at risk." (Johnson/Griesbach)

"P. 18, 1.11-12: If the southwestern and southeastern US have climates favorable for the spread of insects and pathogens from Mexico, does this imply that the northwestern and northeastern US do not have favorable climates? Perhaps you should include a statement indicating that these latter regions were not really considered as target areas in the analysis. Some high elevation, cold-adapted insects and diseases may actually thrive in the north." (Seybold)

Response to comments—This risk assessment estimated the probability that pests will be introduced and become established anywhere in the United States, regardless of local climatic conditions or host species present. In response to the above comments, a statement was added to the section Comparison of Mexican and United States Forest Ecosystems in Chapter 2 that "due to the great variety of climates in Mexico, from tropical to arctic, it is reasonable to assume that almost any forest in the United States could be favorable for the survival and spread of insects and pathogens from Mexico." Mitigation measures identified by APHIS because of a particular favorable combination of host and climate will be required throughout the United States, regardless of reduced risks due to possible climatic barriers in other regions.

Issue 7: Validity of Current Regulations Allowing Import of Unprocessed Wood from Adjacent Mexican States

Reviewers' comments —Several reviewers questioned the reasoning behind the current regulations allowing import of unprocessed wood from adjacent Mexican states into the United States.

"Just where did this peculiar regulation come from?" (Lattin)

"The biogeographical and ecological barriers/ranges should be the determiners of where any movement of raw logs into the United States is allowed, not the location of artificial boundaries such as the states of Mexico." (Lattin)

"We agree with what we believe is an implication on p. 118 that consideration be given to require logs from the border States of Mexico to be treated in the same manner as those from States farther south. Given that there are isolated, biological islands in those States similar to several in southwestern U.S., it makes great sense." (Cobb/Wood)

"I am also very concerned that the states bordering the U.S. can ship in wood materials with no restrictions. This is a giant loop hole. I would guess many logs will be shipped to these border areas and then shipped to the U.S." (Jacobi)

"…current regulations allow the import of unprocessed wood products from Mexican border states even though many potential quarantine pests occur in these states. This is a very serious issue which I also feel cannot be over emphasized." (Owen)

Response to comments—Historically, there has been regular movement of commodities, including wood articles, between the states adjacent to the Mexican and United States border. The regulation authorized movement from Mexican states adjacent to the United States border without restriction because of the assumption that insects and pathogens in these areas are also indigenous to the United States or may become so through natural migration. This risk assessment has identified numerous pests of concern in the Mexican states adjacent to the United States. It was not one of the objectives of this assessment to determine the appropriateness of the regulation or the quarantine status of these pests, but they should be considered in any review of the policy concerning the border states.

Issue 8: Nematodes Are Not Addressed in the Assessment

Reviewers' comments —Concern was expressed that nematodes, in particular the pine wood nematode, was not directly addressed.

"No nematode pests were addressed and only a brief reference was made concerning the Pinewood Nematode (PWN) in the section on Monochamus. The PWN occurs in Mexico in an area quite far removed from the pine forests of the U.S. and Canada. So, because of isolation on different species of pine growing in a remote area, this PWN is most likely quite different genetically from other NA strains (much like many other pests mentioned in this assessment). It is a well known fact that different isolates of the PWN occur in different regions and therefore potentially could pose a threat to other regions of NA under the right set of ecological circumstances." (Bergdahl)

“This assessment states that the PWN is found in Mexico and it also states the following: “It is the opinion of the Society of Nematology and Dwinell (personal communication with Pest Risk Assessment Team) that the pinewood nematode shouldn’t be considered in this analysis.” My question is WHY? I maintain the PWN should be viewed with concern, especially considering the fact there most likely are strain differences and with those differences there are risks.” (Bergdahl)

“On page 66, it is stated that the pinewood nematode shouldn’t be considered in this analysis, based on opinions of the Society of Nematology and David Dwinell. However, no rationale for the opinion is given. Is there enough evidence (e.g. DNA analysis) to show that the *Bursaphelenchus* in Mexico are no different from the ones in the U.S.?” (Cobb/Wood)

“The North American Plant Protection Organization (NAPPO) has taken the position that the presence of nematodes in wood offers no potential for their establishment and that quarantine action should target their vectors. Thus, discussions regarding mitigation should focus on the vector rather than the nematode itself. This does not preclude the necessity for assessing the potential harm associated with these nematode species and an omission of such discussion could actually misrepresent the actual risk. Therefore, an analysis of the risk associated with plant parasitic nematodes is indeed appropriate and should be included in this document.” (Zadig)

Response to comments—In response to the above comments, an IPRA for pine wood nematodes was developed and is included in this document.

Issue 9: Other Types of Potential Pests Not Directly Associated with Logs (Hitchhikers)

Reviewers’ comments—Several reviewers expressed a concern that certain organisms that may not be identified as potential pests could be transported on logs and become pests upon arrival in the United States.

“You cited some known potential and actual insect and pathogenic pests—there are surely many more we don’t yet know on forest tree species and even some of our agricultural crops.” (Lattin)

“‘. . .the logistics of Mexican carpenter ants relative to the export areas might preclude their transport to the US. . .’ The Mexican species might hitchhike as winged reproductives on the surface or in cracks and crevices on Mexican conifer logs.” (Seybold)

“. . .note both oaks and pine species occur together in adjacent areas. Did the team look at the issues of hitchhiking insects from oak onto pine?” (Johnson and Griesbach)

“Spores or other propagules of all types of potentially injurious microbes can be on untreated logs. Why have you not so indicated? These microbes could be pathogens of almost any plant, not just pines or firs. Why does this assessment exclude such a potential?” (Cobb and Wood)

Response to comments—The issue of hitchhiking (nontimber) organisms on logs, while not a principal component of the pest risk assessment process, was considered by our team. Clearly, it would be impossible for us to address all possible organisms including carpenter ants, pathogen propagules, agricultural or nonconifer hosts, etc. However, we have considered this very important pathway in our deliberations. In fact, we devoted an individual risk assessment for the long-horned grasshopper that feeds on oak and agricultural crops and could be transported by eggs laid in pine bark. The issue of hitchhiking (nontimber) pests on logs coming from Mexico will be considered by APHIS as part of the overall mitigation requirements but was not part of the responsibility of the pest risk assessment team. The movement of nonindigenous organisms that are not considered as potentially damaging to agricultural resources (e.g., most predators and saprophytes) is presently outside of the legal authority of APHIS to regulate.