United States
Department of
Agriculture

**Forest
Service**

Miscellaneous
Publication No. 1517

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Pest Risk Assessment of the Importation of *Pinus radiata*, *Nothofagus dombeyi*, and *Laurelia philippiana* Logs from Chile

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EXECUTIVE SUMMARY

Objective

Several forest industries in the United States propose to import logs of Monterey pine (*Pinus radiata*) from Chile, primarily for processing on the Pacific Coast. Small quantities of two native species, coigüe (*Nothofagus dombeyi)* and tepa (*Laurelia philippiana*), also may be imported as unprocessed logs to produce veneer and lumber. In the absence of specific log import regulations, the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) requested that the USDA Forest Service prepare a risk assessment that identifies potential pests, estimates the probability of their entry on Chilean logs and establishment in the United States, and evaluates the economic, environmental, social, and political consequences. Major emphasis is placed on the risk of Chilean pests to the resources of the western United States because of similarities in climate, high value of these resources, and the fact that most Chilean logs are to enter at western ports. However, the assessment and conclusions are expected to be applicable to the entire United States.

Pest Risk Assessment Team

A six-member team of forest pest specialists provided technical expertise from the disciplines of forestry, entomology, pathology, mycology, and economics. Three of the team members had previously worked in forest entomology programs in Chile. The team also was assisted by representatives from APHIS, the USDA Forest Service, and several Chilean organizations. In November 1992, the team traveled to Chile, accompanied by an APHIS representative. Team members met with Chilean agricultural and forestry officials, entomologists, pathologists, and forest industry representatives to discuss the export of pine and native hardwood logs. The group also toured harvest areas, inspected processing plants and ports, evaluated Chilean industry mitigation procedures, and viewed pest problems in both pine plantations and native forests. In addition, the pest risk assessment document prepared by the team takes into consideration comments by selected persons representing government agencies, universities, and private forest industries in the United States, Canada, and Chile who provided critical reviews of an earlier draft.

Pest Risk Assessment

The team compiled lists of insects and microorganisms known to be associated with Monterey pine, coigüe, and tepa in Chile. From these lists, insects and pathogens having the greatest risk potential as pests on imported logs were identified in accordance with procedures recommended by APHIS. Ten insects (or groups of closely related organisms) associated with Monterey pine logs were chosen as subjects of individual pest risk assessments: introduced pine bark beetles (*Hylurgus ligniperda*, *Hylastes ater*, and *Orthotomicus erosus*), bark weevils of the genus *Rhyephenes*, a pine bark anobiid (*Ernobius mollis*), a siricid (*Urocerus gigas gigas*), wood-boring beetles (*Buprestis novemmaculata*, *Colobura alboplagiata*, and *Callideriphus laetus*), termites (*Cryptotermes brevis*, *Neotermes chilensis*, and *Porotermes quadricollis*), the spiny pine caterpillar (*Ormiscodes cinnamomea*), a bagworm (*Thanatopsyche chilensis*), white grubs (*Hylamorpha* spp., *Brachysternus* sp., and *Sericoides* sp.), and the European pine shoot moth (*Rhyacionia buoliana*). Four types of diseases of Monterey pine were evaluated in detail for pest risk: diplodia shoot blight (*Sphaeropsis sapinea*), needle diseases (*Dothistroma pini*, among others), stain and vascular wilt fungi (*Ophiostoma* spp.), and root/stem rots (*Armillaria* spp., *Phellinus* spp.).

Individual pest risk assessments were prepared on six major insect pests or related groups of pests found on coigüe. These included several genera of wood-boring insects in living trees (*Callisphyris semicaligatus*, *Chilecomadia valdiviana*, *Cheloderus childreni*, and *Sibylla* spp., among others), a cambium-boring lepidopteran (*Notiopostega atrata*), bark-boring beetles common in dead and dying coigüe (*Calydon submetallicum*, *Rhyephenes maillei*, and *Epistomentis* spp.), ambrosia beetles (*Gnathotrupes* spp.), and a dampwood termite (*Porotermes quadricollis*). In addition, two disease problems common to both coigüe and tepa were evaluated: fungi (*Ophiostoma* spp. and *Ceratocystis* spp.) causing wood stains (and possibly vascular wilt) and those causing wood decay (*Ganoderma* spp. and *Phellinus* spp., among others). Finally, limited consideration was given to other harmful pests that conceivably could be associated with logs from Chile. These consisted of various defoliating insects of pine, selected insect pests of trees growing in association with coigüe and tepa, nursery pests, wetwood of coigüe and tepa, mistletoes on native hardwoods, nematodes, weeds, and mollusks. To identify potential risks, pest assessments were conducted without regard to mitigation measures that APHIS may impose on logs from Chile.

Conclusions

The 1.3 million hectares of *Pinus radiata* in Chile are generating an increasing supply of high-quality sawlogs for the export market. Sawtimber stands are intensively managed on 25-year rotations and are monitored closely for pest problems. In sharp contrast to native forests in Chile and other countries, these exotic plantations are relatively free of major insect and disease problems. Exceptions include the recently introduced European pine shoot moth (*Rhyacionia buoliana*), *Hylurgus ligniperda* and two other species of European bark beetles, several needle disease fungi (*Dothistroma pini* and *Lophodermium* spp., among others), diplodia shoot blight (*Sphaeropsis sapinea)*, and two species of blue stain fungi (*Ophiostoma picea* and *O. piliferum*). The wood wasp *Sirex noctilio* (considered to be the most important pest on Monterey pine logs exported from New Zealand) and pine wood nematodes (*Bursaphelenchus* spp.) have yet to be found in Chile.

Among the insect pests of Monterey pine analyzed in detail, only the bark beetle *Hylurgus ligniperda* is considered to have a high pest risk potential. Moderate pest risk potentials are assigned to *Rhyephenes* spp., *Ernobius mollis*, *Urocerus gigas gigas*, *Neotermes chilensis, Porotermes quadricollis*, *Colobura alboplagiata*, and *Buprestis novemmaculata*. Among the pathogens, the stain fungi (*Ophiostoma* spp.) merit a moderate to high pest risk potential, whereas the complex of needle diseases (*Dothistroma pini* and other species) and diplodia shoot blight (*Sphaeropsis sapinea*) are rated as moderate risks. The high rating assigned to

Ophiostoma spp. is based solely on the possible existence in Chile of more virulent strains of these fungi that could cause vascular wilt disease. To date, no tree-killing strains of *Ophiostoma* have been identified in Chile's exotic or native forests. Other pine pathogens are low pest risks for various reasons specified in the document. No harmful mollusks or nematodes and only one weed of concern (*Imperata condensata*, considered a variety of *I. cylindrica* or cogongrass) were identified as potential pests on exported logs.

A comprehensive bibliography of Chilean forest insects and diseases was compiled, but many published articles are limited to taxonomic descriptions or empirical studies. Biological information available on pests of native hardwoods, in particular, is limited. Based on individual assessments of known pests, moderate pest risk potentials were assigned to the following insects: two species of insects that bore deep into the wood of living coigüe trees (the cerambycid *Callisphyris semicaligatus* and the cossid *Chilecomadia valdiviana*), several species of bark-boring beetles of dead and dying coigüe (*Calydon submetallicum, Rhyephenes maillei, Epistomentis* spp.), and various species of ambrosia beetles of coigüe (*Gnathotrupes* spp.). Other known insect pests of coigüe (for example *Notiopostega atrata, Cheloderus childreni, Sybilla* spp., and *Porotermes quadricollis*, among others) would have low pest risk potentials because of host specificity, long life cycles, and other factors that would make their arrival and/or establishment in the United States very unlikely.

Among pathogens of native forests, the complex of stain fungi on tepa and coigüe rank as moderate to high risks; the high rating is based again on the possible existence of a tree-killing strain of *Ophiostoma* or *Ceratocystis* or other unidentified pathogens. The variety of pathogens causing decay of coigüe and tepa are considered to be of moderate pest risk. Tepa logs apparently are free of wood- and bark-boring insects but are more susceptible than those of coigüe to stain fungi (*Ophiostoma* spp. and *Ceratocystis* spp.). In regulating the importation of logs from native forests in Chile, consideration should be given to the paucity of biological information available on most insects and fungi.

Chapter 1. INTRODUCTION

Statement of Purpose

This risk assessment estimates the probability that exotic pests will be introduced and become established in the United States as a direct result of the importation of unprocessed logs from Chile. Pests addressed in this report are chiefly phytophagous insects and fungal pathogens, but limited consideration also is given to harmful weeds, mistletoes, nematodes, and mollusks. Major emphasis is placed on potential pests associated with Monterey (also called radiata) pine (*Pinus radiata* D. Don), the primary tree species destined for export as logs to the United States. An evaluation of pests known to occur on two native tree species--coigüe (*Nothofagus dombeyi* (Mirb.) Oerst.) and tepa (*Laurelia philippiana* Looser)--is included in this risk assessment because small volumes of logs of these native hardwoods are expected to reach United States ports. This assessment also estimates the economic and environmental impact of the more potentially destructive organisms if introduced into the United States, particularly along the Pacific Coast.

The specific objectives of this risk assessment are to

- Identify pest organisms that may be introduced with imported logs from Chile.
- Assess the potential for introduction and establishment of selected Chilean organisms.
- Evaluate the potential impacts these organisms may have on forest resources if they should become established in the United States.

Unlike the pest risk assessment recently conducted on log imports from New Zealand (USDA Forest Service 1992), this risk assessment was 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 Chilean logs. The prescription of mitigation measures, however, is beyond the scope of this document.

Background

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. Also, it is the responsibility of APHIS to detect and, when feasible, eradicate exotic pests should they become introduced.

When a request is made to import a plant commodity, APHIS conducts a risk assessment to identify potential exotic pest problems. This information is used to decide whether to authorize importation of a commodity that may have adverse impacts in the United States. Mitigation procedures may be required to allow safe passage of imported materials.

In July 1992, APHIS requested that the USDA Forest Service prepare a pest risk assessment relative to importation of Monterey pine, coigüe, and tepa logs from Chile. The six-member team of forest pest specialists from the Texas Forest Service and the USDA Forest Service provided technical expertise from the disciplines of forestry, entomology, pathology, mycology, and economics. Three of the team members, Drs. Billings, Cameron, and Eglitis, had previously worked in Chile as Peace Corps volunteers in forest entomology programs. Their knowledge of pest problems in Chile, contacts with Chilean entomologists and pathologists, and fluency in Spanish facilitated this assessment of pest risk. The team also was assisted by representatives from APHIS, the USDA Forest Service, and several Chilean forestry organizations.

In November 1992, the team traveled to Chile, accompanied by APHIS representative David Reeves. Team members met with Chilean entomologists and pathologists; toured harvest areas, processing plants, and ports; evaluated Chilean mitigation procedures for log exports; and viewed pest problems in both pine plantations and native forests. Details of the Chile visit are given in appendix E. The Pest Risk Assessment Team produced this report, which evaluates the significance of potential exotic pests associated with Chilean logs. An early draft of this document was reviewed by selected persons representing government agencies, universities, and private forest industries in the United States, Canada, and Chile. Comments and suggestions of reviewers, summarized in appendix F, were incorporated into the final document to the extent considered feasible by the assessment team.

As of this writing, the United States has no specific timber import regulations and requires no permits for the importation of unprocessed logs from Chile. To date, only small volumes of logs have been imported from Chile. These shipments were inspected at the port-of-entry and, if pests were found (see appendices C-4, C-5, and C-6), mitigating measures were applied before the logs were released. However, U. S. timber companies are now proposing to import larger quantities of Chilean saw and veneer logs. Therefore, it is necessary to identify potential pest risks to determine whether Federal regulations are required and, if so, what the provisions of such regulations should be.

Characteristics of Proposed Importation

Intensive reforestation and investment in forest management in Chile since the 1960's has resulted in the establishment of 1.3 million hectares (3.2 million acres) of fast-growing plantations of Monterey pine. Lesser acreages of eucalyptus (*Eucalyptus globulus* Labilla.), Douglas-fir, and other tree species are being established, but logs from these latter plantations are not destined for export. (Common and scientific names of North American conifers and hardwoods mentioned in this report are listed in appendix D, table D-1.)

The Chilean government and private companies are interested in exporting logs as part of the general trade policy of Chile. Wood and wood products represent a significant share of Chile's export volume of trade. The supply of growing stock in plantation forests is increasing and will continue to increase over the next 20 years. In conjunction, the quantity of forest products exported from Chile has grown from U. S. $353,300,000 in 1981 to

U. S. $913,100,000 in 1991. This trend is expected to continue as a greater number of Monterey pine plantations mature (Instituto Forestal 1992).

The production of high-quality pine timber from exotic plantations in Chile and New Zealand (USDA Forest Service 1992) involves selective pruning and thinning to ensure knot-free, maximum-diameter growth. The pruned butt logs yield clear lumber in long lengths and wide dimensions, while logs above the pruned log are ideal for shop-grade lumber. In contrast to species like Douglas-fir, Monterey pine has only a small difference between the densities of early and late wood rings. Thus, rapidly-grown Monterey pine with its wide rings has many of the same characteristics as slowly-grown wood. The wood of Monterey pine has excellent finishing properties and is easy to stain and paint. Similar properties are noted in ponderosa pine and sugar pine, both grown commercially in the United States. However, recent restrictions in harvesting these pines and other tree species on Federal lands in the western United States have created a market for logs from other countries. Chile is among those countries capable of supplying high-quality sawlogs for this market.

In 1991, Chile harvested 11.4 million cubic meters (m^3) of Monterey pine. Of this, 751,100 m^3 (318 million board feet) were exported as sawlogs, primarily to Korea (62%) and Turkey (34%), and 312,800 m^3 were exported as pulpwood logs to Japan (83%) and Italy (17%) (table 1-1). The remainder was processed in Chile for pulp and paper (3,389,600 m^3), lumber (5,822,500 m^3), veneer (449,700 m^3), chips (504,600 m^3), or other uses (143,700 m^3). As new plantations mature, logs and other forest products available for export will increase dramatically. The Chilean Forest Institute estimates that by the year 2015, 30 million m^3 of Monterey pine will be available for harvest per year, including 20 million m^3 (8,460 million board feet) of sawtimber (Instituto Forestal 1992).

Table 1-1. Volume and value of Monterey pine (*Pinus radiata*) exports from Chile in 1991 (Instituto Forestal 1992)

Product	Volume	Percent change from 1988	Value (U.S. $)
Lumber	954,200 m^3	+11%	$ 128,000,000
Sawlogs	751,100 m^3	−46%	$ 38,500,000
Manufactured products	208,000 m^3	+12%	$ 37,000,000
Pulpwood	312,800 m^3	−67%	$ 13,800,000
Chips	443,800 tons	−29%	$ 21,900,000
Chemical pulp*	664,500 tons	+39%	$ 308,800,000
Paper and cartons	155,100 tons	+18%	$ 97,800,000
Plywood veneer, particle board	113,300 m^3	+129%	$ 33,500,000
Total			$ 679,300,000

* Approximately 95% Monterey pine and 5% other species.

The amount of Monterey pine sawlogs that will be exported annually from Chile to the United States will depend, among other factors, on local consumption and demand from other countries in Asia, Europe and the Middle East. Estimates of the availability of logs for United States markets over the next decade range from 100,000 to 500,000 cubic meters (40 to 200 million board feet) per year.

Logs of coigüe and tepa represent a completely different situation than do those of Monterey pine, both in quantity available for export and in quality. Hardwood logs come from unmanaged native forests and are likely to be available only in small quantities for export. Large-diameter, high-quality logs from mature or overmature trees are in demand within Chile for veneer logs and lumber. Logs from native forests are more likely to contain heart rot or insect borers not common in plantation-grown pine.

Resources at Risk

Discussions with Chilean forestry industry representatives indicated that the pine saw logs will probably enter the United States at ports in the Puget Sound region; at Vancouver, Washington; at Portland and Coos Bay, Oregon; and at the major ports of California for processing into sanded plywood, furniture stock, or moldings. Future shipments of Monterey pine also may be sent to the Gulf Coast or Atlantic Coast.

The forests of the western United States are part of a broad circumpolar band of vegetation that occurs in the mid- to upper latitudes of the Northern Hemisphere. These forests have enormous economic, aesthetic, recreational, ecological, and hydrological value. The coastal ranges and the western slopes of the Cascade Mountains have some of the highest quality stands of large sawtimber in the world. The eastern slopes of the Cascades and the lower slopes and benches of the interior mountains are covered by open forests of pine and juniper. White fir and Douglas-fir associations and mixed conifer (pine, true fir, western redcedar, Douglas-fir, and western larch) forests are found on the interior mountains above the pine zone and on north slopes. Grasslands and desert shrubs extend into the forest in the basins, uplands, and plains areas. Native conifer species found in the western United States include Douglas-fir, western redcedar, western hemlock, Sitka spruce, sugar pine, ponderosa pine, lodgepole pine, western white pine, noble fir, Pacific silver fir, grand fir, white fir, incense-cedar, Port-Orford-cedar, and western larch. Coastal areas of California support extensive native forests of lodgepole pine and redwood, while a variety of other native conifer species have more restricted distributions. The latter include Monterey pine, bishop pine, Torrey pine, and Coulter pine. Also, pure pine forests occur in the Cascade Mountains south of Mt. Shasta and on the eastern slope of the Sierra Nevada range (see appendix D, table D-1, for scientific names of North American tree species mentioned above).

In addition to extensive natural stands of conifers, and to a lesser extent hardwoods, in the Pacific Northwest, there is a very sizable industry devoted to production of ornamentals and Christmas trees. Introduced pests could affect these industries directly by causing damage or indirectly by curtailing commerce through quarantines. Also, as the harvest of natural stands becomes more restricted on Federal lands in the western United States, management on commercial forest lands will intensify. Introduced pests that could frustrate this productive future would be shoot borers, wood borers, ambrosia beetles, defoliators, and reproduction pests. For a more comprehensive discussion of United States' resources at risk, see the pest risk assessment report for Siberian logs (USDA Forest Service 1991).

The Pest Risk Assessment Team for Chilean logs has chosen to concentrate on the forest resources of the western United States for three reasons: (1) this region has a climate similar to that of central and southern Chile, (2) the forest resources of the western United States are of great economic and ecological value, and (3) most log shipments are destined for Pacific Coast ports. However, the team believes that the pest risk potentials developed in this report would remain the same or, because of possible climatic barriers, be significantly lower if logs were imported into other regions of the United States or Canada. It is important to emphasize that the same mitigation measures developed by APHIS from this pest risk assessment will be required regardless of where Chilean logs may eventually enter the United States. Accordingly, climatic dissimilarities would serve as an additional barrier to pest establishment in regions outside the Pacific Coast.

Chapter 2. CLIMATE AND FOREST RESOURCES IN CHILE

Climate

For its area, Chile has the longest continuous span of latitude of any country in the world. Situated on the western coast of South America between the Andes Mountains and the Pacific Ocean, Chile stretches from the southern border of Peru (18° 30' S) to Cape Horn (56° S), a distance of 2,600 miles. This country's great north-south range is associated with a corresponding diversity of climate--a mirror image of what is found on the Pacific Coast of North America from central Mexico to Southeast Alaska.

The northern region of Chile is desert, the central part of the country has a mediterranean climate of winter rain and summer drought, and the southern part is a region of temperate rain forests with high rainfall at all seasons. Two mountain chains, the Andes Mountains and a lower coastal range, lie in a north-south direction, forming a central valley that extends from Santiago (33° 30' S) to Puerto Montt (41° 30' S). Mean temperatures and annual rainfall for selected towns near forested areas of central and southern Chile are given in table 2-1.

Table 2-1. Mean maximum and minimum temperatures and annual rainfall for selected locations in central and southern Chile (Instituto Geográfico Militar 1988)

Region	Locality	Latitude	Mean daily max.(°F)	Mean daily min.(°F)	Annual rainfall (in inches)
V	Valparaíso	33° 00'	63.7	53.2	14.8
RM	Santiago	33° 30'	68.0	49.6	13.6
VII	Talca	35° 00'	71.6	46.8	27.1
VIII	Concepción	37° 00'	64.4	48.2	52.5
X	Valdivia	39° 45'	62.2	45.7	102.1
X	Puerto Montt	41° 30'	60.4	45.0	81.1
XI	Puerto Aisén	45° 30'	56.1	39.2	116.6
XII	Punta Arenas	53° 15'	50.7	34.2	17.7

RM = metropolitan region of Santiago.

Plantation Forests

The forest resources in Chile include over 9.1 million hectares (22.5 million acres) of commercial forest land, consisting primarily of native forests. But Chilean forest industry relies almost exclusively on intensively managed monocultural plantations of fast-growing exotic tree species. Among these, Monterey pine (*Pinus radiata)* is by far the most important. In 1991, Monterey pine accounted for 84% of the total area and 78% of the wood volume in forest plantations in Chile, with eucalyptus, poplar, and Douglas-fir making up most of the remainder (table 2-2). In the 3-year period from 1988 to 1991, pine plantation area increased by 12% and volume of growing stock increased by 25%, reflecting the rapid growth rates and increasing inventory of the exotic pine resource in Chile. The majority of the Monterey pine plantations are located in the central part of Chile between Curicó in region VII and Valdivia in region X, 34° to 40° south latitude (figure 2-1). Over half of the area and growing stock volume (table 2-3) are located in region VIII (Instituto Forestal 1992).

Table 2-2. Forest resources in Chile--1991 (Instituto Forestal 1992)

Forest type	Area (ha)	Volume (million m^3)
Native forest	7,616,500	940.5
Plantations		
Monterey pine	1,305,325	165.6
Other species*	249,930	46.4
Totals	9,171,755	1,152.5

* Principally eucalyptus, tamarugo, Douglas-fir, and poplar.

Table 2-3. Plantations of Monterey pine (*Pinus radiata*) by age class and region in Chile--1991 (Instituto Forestal 1992)

Age class (years)	Area (ha)	Region	Area (ha)	Volume (m^3)
<1	75,416	V	22,903	3,922,000
1-5	322,740	RM†	966	108,000
6-10	365,354	VI	62,286	6,759,000
11-15	302,981	VII	289,082	25,869,000
16-20	165,884	VIII	594,626	89,338,000
21-25	51,798	IX	236,738	29,651,000
23-30	14,106	X	98,724	9,948,000
>30	7,046			
Total	1,305,325*	Total	1,305,325	165,595,000‡

* Increase of 12% since 1988.
† RM = metropolitan region of Santiago.
‡ Increase of 25% since 1988.

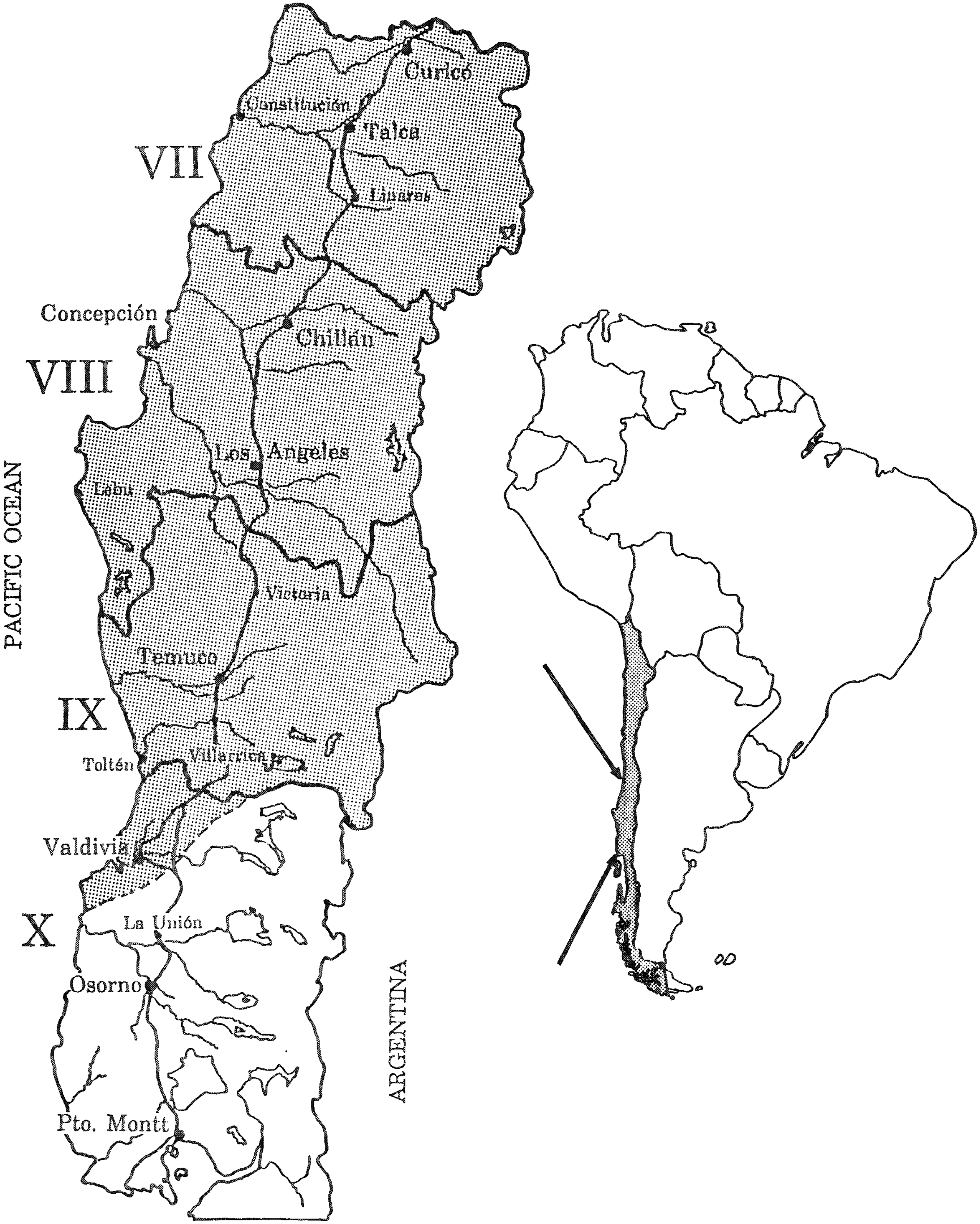

Figure 2-1. Regions of Chile where most plantations of Monterey pine (*Pinus radiata*) are located.

Most Monterey pine plantations in Chile are managed for pulpwood or sawtimber using intensive management practices. These include thinning to reduce stocking as the trees begin to compete for space and periodic pruning of lower branches to produce clear, high-value lumber. The Chilean government has been instrumental in developing a large forest industry based on plantations of exotic species. A forestry incentives program (Decree Law 701) administered by Chile's National Forestry Corporation (Corporación Nacional Forestal or CONAF) subsidizes up to 75% of the costs associated with establishing new plantations, including planting, pruning, and administration. Financial incentives are not provided for second-growth forests. This program was initiated in 1974 and is scheduled to end in 1994.

Much of the Monterey pine products are exported and represent a significant contribution to the Chilean economy. The value of all forest products exported in 1991 was estimated at U. S. $913 million. Monterey pine alone accounted for about 90% (U. S. $822 million) of all forest products exported in 1991. In December 1991, more than 80% of the pine plantations were less than 16 years old (table 2-3). Under the favorable climatic conditions in the pine region of Chile, these plantations grow at an estimated average annual rate of 24 m^3/ha/yr (compared to 7 to 8 m^3/ha/yr for pines in the southern United States). Accordingly, forest products exports from Chile are expected to at least double in the next 15 years (Instituto Forestal 1992).

Native Forests

Chile has some 7.6 million hectares (18.8 million acres) of temperate native forests, consisting primarily of mixed species of evergreen and deciduous hardwoods. The northern boundary of native forests is located near 36° S along the Maule River, some 180 miles south of the capital of Santiago. Here, in the foothills of the Andes, the forests are dominated by native beeches of the genus *Nothofagus*, including roble (*N. obliqua*), coigüe (*N. dombeyi*), and raulí (*N. alpina*). As rainfall increases to the south, additional native species begin to occur, including lenga (*N. pumilio*), ñirre (*N. antarctica*), ulmo (*Eucryphia cordifolia*), tineo (*Weinmannia trichosperma*), laurel (*Laurelia sempervirens*), mañío (*Podocarpus salignus*), olivillo (*Aextoxicon punctatum*), and tepa (*Laurelia philippiana*) (see appendix D, table D-2, for a list of scientific names, authorities, and families of common tree species native to Chile). Yudelevich et al. (1967) described eight different forest types of mixed tree species found in Chile between 37° and 55° S latitude (table 2-4). More recently, the evergreen forest type has been described in more detail by Donoso (1981, 1989).

The native forests that once dominated the central valley south of the city of Chillán (36° S) have given way to agriculture or extensive plantations of exotic tree species, primarily Monterey pine and eucalyptus. Native forests remain at the higher elevations in the coastal range and along the foothills of the Andes mountains. From the Tolten River (39° 15' S) to the south, the evergreen coigüe becomes dominant, extending into the lowlands near Lake Llanquihue, eventually replacing the deciduous roble. A little further south, at Puerto Montt, the central valley ends in the Gulf of Reloncavi. Chile, however, extends another 900 miles

Table 2-4. Predominant tree species that characterize the major types of commercial native forests and their geographical distribution in Chile (Yudelevich et al. 1967)

	Forest type	Predominant tree species*	Distribution of commercial forest: Elevation (m)	Latitude (south)
1.	Araucaria	Araucaria, lenga, coigüe	1000 - 1700	37° 30' - 39° 45'
2.	Coigüe	Coigüe, mañío, tepa	0 - 1200	37° 30' - 48° 00'
3.	Valdiviana	Tepa, ulmo, tineo, olivillo, coigüe	0 - 1000	37° 00' - 45° 00'
4.	Roble-raulí	Roble, raulí, coigüe, lingue	100 - 1200	37° 00' - 41° 30'
5.	Chilote	Canelo, mañío, coigüe	0 - 300	40° 30' - 48' 00'
6.	Lenga	Lenga, ñirre	1000 - 1900	37° 00' - 55° 00'
7.	Alerce	Alerce, ciprés de las Guaitecas	700 - 1200	40° 00' - 42° 30'
8.	Ciprés	Ciprés de las Guaitecas	100 - 1000	40° 00' - 55° 00'

* See appendix D, table D-2, for scientific names and families of common tree species indigenous to Chile.

to Cape Horn. The region between Puerto Montt and the end of the continent, one of the most rugged and inaccessible on earth, contains the bulk of Chile's remaining exploitable virgin timber. It is largely uninhabited except in the areas of development at Puerto Aisén (45° 30' S), Coihaique (45° 31' S), and Punta Arenas (53° S). Recently, a road has been constructed from Puerto Montt to Cochrane, increasing access to this region.

As rainfall increases to 150 to 200 inches per year and average temperatures decline, the forest composition becomes less diverse south of Puerto Montt. Finally, around 48° S., Magallanes coigüe (*Nothofagus betuloides*) becomes the dominate tree species on the labyrinth of islands, fjords, and various channels stretching to the end of Tierra del Fuego (Clarke 1964a and b).

For the most part, the native forests in Chile are represented by unmanaged, natural stands of mixed species. The Chilean Forestry Institute estimates that approximately 940 million cubic meters of merchantable volume are present on 7.6 million hectares (Instituto Forestal 1992). The majority of this merchantable volume (79%) occurs in region X (table 2-5). Unlike the fast-growing plantations of Monterey pine and eucalyptus that currently support most of the forest industry in Chile, the native forests have been heavily high-graded. The remaining trees now being harvested from easily accessible areas tend to be the lower-grade, overmature stems that often contain heart rot and insect borers.

Volumes of sound logs suitable for export are likely to be limited; most available logs are utilized by local forest industries for veneer and lumber. Diseased trees, or those not suitable for local uses, are turned into chips for export, primarily to Japan. Furthermore, Chilean law now protects some of the more valuable timber species in this region from harvest. These include araucaria (*Araucaria araucana*) and alerce (*Fitzroya cupressoides*). Additional restrictions on the wholesale harvesting of native forests is likely in the future as pressure from Chilean environmental groups increases.

Table 2-5. Estimated area and volume of potentially productive native forests in Chile by region (Instituto Forestal 1992)

Region	Area (1000 ha)	Volume (million m^3)
I	4.0	0.1
RM	2.7	0.1
VI	41.2	1.2
VII	196.4	6.4
VIII	401.7	24.1
IX	632.9	82.0
X	3,592.6	744.2
XI	1,686.0	50.6
XII	1,059.0	31.8
Total	7,616.5	940.5

Potentially productive forests are defined as those with merchantable volumes of commercial tree species in excess of 30 m^3/ha, based on 1981 inventories. No consideration is given here to accessibility.

The management of second-growth native forests in Chile is in its infancy. In selected areas, diverse natural stands of mixed hardwood species are being converted gradually by means of selective harvesting of residual trees and/or replanting to less diverse stands of two or three fast-growing commercial species (e.g., raulí, tepa, and coigüe). It will be 40 to 50 years, however, before sufficient volumes of native hardwoods are produced for export from managed stands. Coigüe (*Nothofagus dombeyi)* is one of the native species destined for export to the United States. This species is the most abundant and widely distributed species in the native forests of Chile. Its range extends from region VI (34° S) to region XI (47° S).

Two other native species share the same common name of coigüe. *Nothofagus nitida*, known as coigüe of Chiloé, occurs from region X to region XI, principally on the coastal range. Magallanes coigüe, *N. betuloides*, has a distribution that extends from region X to region XII. The latter is the dominant tree species in extreme southern latitudes of Chile. In the northern part of its range it grows at higher elevations than *N. dombeyi*.

Nothofagus dombeyi grows from 700 to 800 m in elevation on the coastal range. In the Andes, this species grows between elevations of 700 to 1200 m in the northern part of its range, while in the south, it is found from sea level to 500 m (Donoso 1989). It is commonly found growing in mixed stands with roble, raulí, laurel, olivillo, mañío, and/or tepa.

Coigüe (*Nothofagus dombeyi*) is an evergreen, shade-intolerant, pioneering tree species. Individual trees develop relatively straight, clear boles that may attain 2.5 m in diameter. The wood is easy to work and used for all classes of construction because of its strength and considerable resistance to rot. Other uses include veneer, parquet flooring, furniture, and chips for pulp (Rodríguez et al. 1983). The utilization of coigüe in the past has varied by region, depending in large part on what other, more valuable, timber species were growing in association with it. Due to various defects and difficulties in drying coigüe wood, this species has not been as intensively exploited as have other native hardwoods. In past years, only about 1 to 3% of coigüe logs were prime material for export to Europe because of defects (Bonnemann 1967).

The color of the coigüe wood varies greatly, from blond to reddish brown, reducing its utility for exterior veneer panels. The other two species of coigüe (*N. nitida* and *N. betuloides*) share similar wood properties, but the trees seldom grow as large in height or diameter (Rodríguez et al. 1983). Overmature trees of each species characteristically have considerable heart rot, which reduces the volume of merchantable lumber. Logs with severe heart rot are targeted for chips.

Tepa (*Laurelia philippiana*), a native laurel, is distributed less widely than coigüe. It is found in both the coastal and Andes mountain ranges from region XIII (37° S) to region XI (47° S), but is most abundant in regions X and XI. It grows in areas of deep soils and high rainfall, commonly in mixed stands in association with coigüe, ulmo, tineo, canelo, mañío, and/or notro (Donoso 1989).

Tepa is a shade-tolerant evergreen tree with a very straight, clear bole up to 1 m in diameter. The wood is uniformly white in color and easy to work. Major uses are for veneer, interior and exterior construction, furniture, boxes, broom handles, and chips for pulp (Rodríguez et al. 1983). Larger logs may have a typical brown stain of unknown cause ("butterfly" stain) at the center that produces a strong, obnoxious odor unless the lumber is kiln dried.

Similarities between Chile and the United States

Climatic conditions in central and southern Chile are very similar to those along the coast of the Pacific Northwest and lower elevations along the west-side of the Cascade Range. The behavior of pests and pathogens in Chile should therefore provide a guide to their behavior should they become established in the Pacific Northwest. Further inland and south in the western United States, conditions are warmer and drier and it is difficult to predict a pest's behavior under these conditions. In turn, the hot and humid climate of the southern United States is not likely to provide suitable habitats for insects and pathogens found in the cool, temperate climate of southern Chile. Climatic conditions would be more favorable for survival and establishment of insects and pathogens from Chile if they arrived in the northeastern United States or in Canada than along the Gulf Coast or lower Atlantic Coast.

Many North American tree species, particularly those indigenous to the Pacific Northwest, grow as exotics in Chile. Among conifers, examples include Monterey pine, lodgepole pine, ponderosa pine, western white pine, Douglas-fir, cypress, western redcedar, western hemlock, coastal redwood, giant sequoia, bald cypress and various species of true fir, spruce and larch. North American hardwoods grown successfully in Chile include sycamore, American elm, yellow poplar, sweetgum, American basswood, red alder, black locust, catalpa, magnolia and various species of oak, hickory, maple, chestnut, walnut, poplar, and willow (see appendix D, table D-1, for scientific names of these North American tree species). All of these species have adapted well to the conditions in Chile, despite being exposed for many years to the pests and pathogens there.

Chapter 3. THE RISK ASSESSMENT APPROACH

Conceptual Framework and General Considerations

The importation of unprocessed logs from a foreign country into the United States provides an opportunity for the unintentional introduction of insects, nematodes, fungi, and other undesirable organisms. One or more of these introduced species may have the potential to become established in the United States and develop into a serious pest of our forest, agricultural, or ornamental tree resources. To assess the scope and magnitude of the pest risk associated with foreign log imports, an understanding of the probability of pest introduction and establishment is required.

The probability of pest introduction is determined by several related factors: (1) the likelihood of a pest being associated with and surviving in a shipment from the country of origin, (2) the likelihood of the pest colonizing suitable hosts upon entry, and (3) the likelihood of subsequent spread throughout the region or to adjacent regions (Orr and Cohen 1991; USDA Forest Service 1991, 1992). Many insects, pathogens, nematodes, mollusks, and harmful weeds conceivably could be introduced into the United States on logs from Chile. In the case of the Chilean assessment, the assessment team selected possible quarantine pests associated with logs of *Pinus radiata*, *Nothofagus dombeyi*, and *Laurelia philippiana* based on available knowledge of the biology and economic impact of the organism in Chile, the likelihood of at least one stage of the pest being on or in exported logs, and its potential to threaten U. S. resources. Unlike the New Zealand assessment (USDA Forest Service 1992), this pest risk assessment was conducted without consideration for mitigation measures that APHIS may impose on imported logs.

When assessing potential risk for a given insect pest, certain other generalizations are taken into consideration. Based on documented cases of insects and mites introduced into Chile, González (1989) concludes that the colonization of new territories by exotic organisms depends on the capacity of the immigrant to adapt to an environment distinct from that of its native territory. Among factors González and others (van den Bosch 1968, Messinger 1971, Stiling 1993) consider important for predicting whether a given insect will become established in a new territory or country are:

- Host availability. Adequate and suitable host species must be available within dispersal range at the precise time that the immigrant insect arrives or emerges from a resting stage. A species arriving on its host (e.g., inside logs in which it breeds) is more likely to become established than one that is transported together with edible agricultural products (non-host perishable commodities).

- Suitable climate. Climatic conditions similar (on average and in extremes) to those in the place of origin favor insect establishment. Thus, it is easier to establish species within the same hemisphere.

- Reproduction. Species requiring both sexes evidently need various individuals to significantly increase the possibility of success. Some species are capable of oviposition for extended periods after mating, and some initiate oviposition after a long period of time. Species capable of parthenogenesis obviously are more likely to become established. A high initial population density increases the probability that the immigrant insect will encounter conspecific individuals of the opposite sex for mating and reproduction. Absence of important competitors and natural enemies may be essential, at least in the initial stage of establishment.

- Number of generations. The number of generations influences the probability of establishment and dispersal, especially in tropical and subtropical climates. A univoltine species can attain better synchrony with the climate and host than a multivoltine species, especially if it comes from the same hemisphere.

- Migration between hemispheres. The barrier of reversed seasons from the Southern to Northern Hemispheres (or vice versa) may be a formidable obstacle for many potential immigrant insect pests.

A valuable source of information on the probability of pest immigration and establishment consists of analyses of actual interceptions of forest insects infesting wood in international commerce (Milligan 1970, Williams and La Fage 1979). For example, Williams and La Fage summarized 7,363 interceptions of wood-infesting insects by APHIS at United States ports from 1973 to 1976. Although about 170 species were represented, all belonged to one of four orders: Coleoptera (91%), Hymenoptera (7%), Isoptera (2%), and Lepidoptera (0.2%). Nearly all interceptions of Hymenoptera were species of Siricidae (about 96% *Urocerus* spp.). For Isoptera, 83% were drywood species (Kalotermitidae); survival of subterranean and dampwood termites requires more moisture than is normally present in wood, so they are not readily transported by commerce. All Lepidoptera were the goat moth (*Cossus cossus* L.). Interceptions of species belonging to the families Bostrichidae, Cerambycidae, Lyctidae, and Scolytidae accounted for about 85% of all wood-infesting insect interceptions. Of these, most (86%) were found in wood associated with cargo (crates, dunnage, pallets).

Insects infesting wood in commerce may be forest insects, which include pests of healthy and decadent trees and unseasoned logs, or wood product insects infesting seasoned wood. Species of forest insects intercepted by APHIS outnumber wood-product insects (Williams and La Fage 1979), but the latter become established more easily (Wylie and Yule 1977). Among the Coleoptera, buprestid and cerambycid infestations generally consist of a few individuals that have a long larval period, whereas curculionid, platypodid, and scolytid infestations generally contain many individuals with a short larval period. When they enter a port, adults of the latter three families of insects are much more likely to emerge from cargo or logs and seek hosts (Marchant and Borden 1976, Wood 1977).

Clearly, certain insects have a higher probability of entering the United States and becoming established than others, based on relative abundance in association with the imported commodity, their biologies and host ranges, adaptability, ecological plasticity, environmental requirements, and numerous other factors. Although some of the same generalizations apply to fungi, these and other microorganisms are much less hampered than insects by the reversal in seasons and other biological restrictions. Many fungi may remain in a resting stage indefinitely, reproducing and proliferating only when suitable conditions are encountered. The goal of the risk assessment process, then, is to identify those insects, microorganisms, and other pests most likely to immigrate in log shipments from Chile and cause adverse impacts in the United States, based on available biological information.

Risk Analysis

The Pest Risk Assessment Team was responsible for compiling and assessing available data on potential pests associated with Chilean logs. The assessment team followed the methodology required by APHIS (Orr and Cohen 1991) and used in the Siberian larch importation assessment (USDA Forest Service 1991).

Information on the logs to be imported was collected by the Pest Risk Assessment Team during its tour of Chile, conducted from November 8-30, 1992. Pertinent data included tree species, origin, current and future quantity of logs; harvesting, shipping, and mitigation practices; destination; and information on potential pests that may be associated with these logs (see Chile trip report in appendix E for details).

Lists were compiled of insects and microorganisms known to be associated with Monterey pine plantations in Chile, including casual visitors. Names of organisms on these comprehensive lists were obtained from the available literature, from information provided by Chilean entomologists and pathologists during the team's visit to Chile, and from the personal experiences of the three team members (Billings, Cameron, and Eglitis) who had previously worked in forest entomology programs in Chile. Similarly, lists of insects and microorganisms recorded from coigüe (*Nothofagus dombeyi*) and tepa (*Laurelia philippiana*) also were compiled. The latter included only those organisms known to complete their life cycles on these native hosts and excluded the many organisms that may have been collected as adults in "casual" association with these hosts in mixed species forests (see appendix B, table B-2, for a list of common insects that feed on tree species growing in association with coigüe and tepa in Chile).

For each tree species, insects and pathogens were categorized using the characteristics shown in table 3-1. In addition, the names of organisms in categories 1a, 1b, 1c, 2a, 2c, 2d, and 3a were placed on separate lists comprising possible quarantine insects and pathogens associated with imported logs of Monterey pine, coigüe, and tepa from Chile.

Individual pest risk assessments (IPRA) were then prepared for those pests categorized as 1a, 1b, 1c, 2a, or 2c (see table 3-1). Particularly in the case of coigüe and tepa, many potential pests were excluded from the IPRA process simply because insufficient information

Table 3-1. Pest categories and characteristics used to determine quarantine importance and need for individual pest risk assessments for potential pests associated with Chilean logs

Pest category	Characteristics	Place on quarantine list*	Prepare IPRA†
1a	Foreign, not present in U. S.; likely to be imported on logs with no mitigation and considered a potential pest of U. S. resources	yes	yes
1b	Foreign, previously introduced in U. S.; considered a pest capable of further expansion	yes	yes
1c	Foreign, in U. S. and reached probable limits of range, but genetically different enough to warrant concern and/or able to vector a foreign plant pest	yes	yes
1d	Foreign, in U. S. and reached probable limits of range and not exhibiting any of the other characteristics of 1c	no	no
2a	Native to U. S. but known to be genetically different enough to warrant concern and/or able to vector a foreign plant pest and/or capable of further spread	yes	yes
2b	Native to U. S. and not exhibiting any of the characteristics of 2a	no	no
2c	Present in U. S., but not known if organism in Chile is a more virulent strain; associated with export logs and of sufficient pest risk potential to warrant IPRA	yes	yes
2d	Parasitic fungus, present in U. S.; may be different strain in Chile, but doesn't meet other criteria of 2c	yes	no
2e	Saprophytic fungus, present in U. S. and of negligible economic and environmental importance	no	no
3a‡	Considered a potential pest due to habits, abundance and/or wide host range in Chile, but insufficient information available on biology to prepare IPRA	yes	no
3b‡	A potential pest in U. S., but due to habits or geographical distribution, unlikely to be associated with exported logs	no	no
3c‡	Occurs rarely on pine, coigüe, or tepa; known as a pest on other hosts in Chile	no	no
3d‡	Associated with the host, but of little or no economic or environmental importance in Chile and unlikely to be of concern in U. S. (e.g., saprophytic fungus, insect predator)	no	no
3e‡	Associated with host, but biology unknown (includes casual visitors of unknown origin collected on host)	no	no

* Listed in table 4-1, 4-2, 5-1, 5-2, or 5-3 as a possible quarantine pest.
† Individual pest risk assessment.
‡ Native to Chile, not present in the United States.

is available on their biology (category 3a). In other cases, the biology of the organism is totally unknown (category 3e). Organisms in categories 3a and 3e, as well as those organisms known to be of negligible economic or environmental importance (categories 2e and 3d) and those not associated with exported logs (categories 2d and 3b), also were excluded from the quarantine lists.

Obviously, the lack of biological information on a given insect or microorganism should not be equated with low risk. It is quite possible than an insect or disease organism that is of little or no consequence in Chile or one that has not yet been discovered, may cause disastrous impacts once it is introduced into North America. Indeed, some of the most destructive forest pests in the United States are introduced organisms that were not recognized as pests in their native habitats. Examples are the fungi causing chestnut blight, Dutch elm disease, and Port-Orford-cedar root rot (USDA Forest Service 1991).

Recognizing this uncertainty, this pest risk assessment focuses on those species of insects and microbes for which biological information is available. We hope that by developing detailed and sound risk assessments for known pests that inhabit a variety of different locations on imported logs (for example, the bark surface, the inner bark, the sapwood, or the heartwood), effective mitigation measures can subsequently be developed to eliminate these recognized pests. The same series of mitigation measures also should affect unknown organisms that may inhabit the same niches on imported logs.

Individual Pest Risk Assessment Process

The individual pest risk assessment is the most important component of the process used by APHIS in evaluating potential pests and determining the risk associated with commodity importation (Orr and Cohen 1991). The IPRA process is divided into two major components; the "probability of establishment" and the "consequences of establishment." These two major components are further divided into seven basic elements that incorporate available biological information into the assessment (figure 3-1).

The characteristics and explanations of the four elements used to assess probability of pest establishment are as follows:

1. Pest with host at origin. The assessor estimates the probability of the pest being on, with, or in the imported plant commodity at the time of importation. The major characteristic of this element is whether or not the pest shows a convincing temporal and spatial association with the imported commodity. A pest's capability as a hitchhiker on log shipments or in ships coming from the country of origin is given consideration in this element.

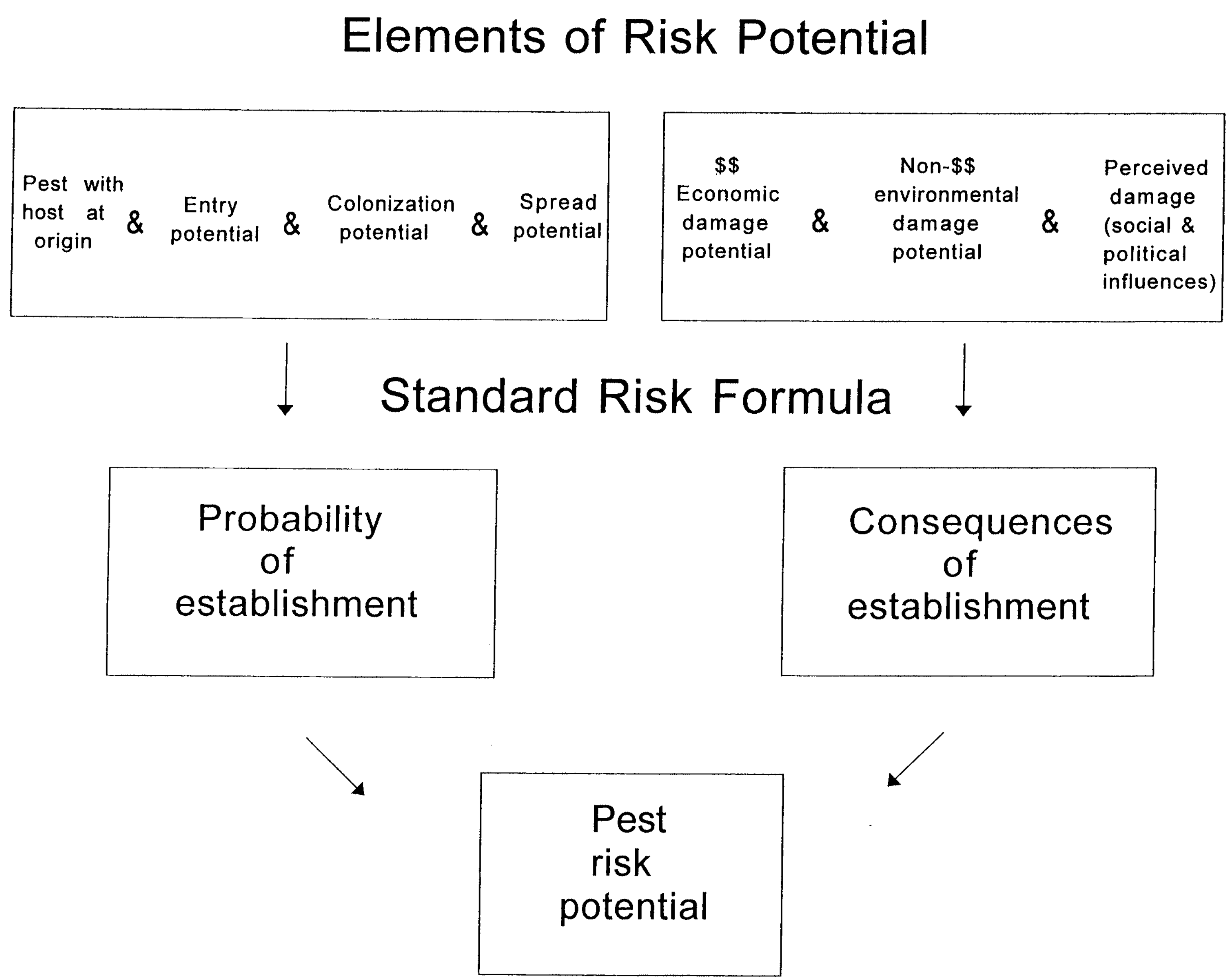

Figure 3-1. Pest risk assessment model (modified from Orr and Cohen 1991).

2. Entry potential. The assessor estimates the probability of the pest surviving in transit from the country of origin to the United States. Some of the characteristics of this element include the pest's hitchhiking ability in commerce, ability to survive during transit, stage of life cycle during transit, and location on or in the exported commodity.

3. Colonization potential. The assessor estimates the probability of the pest colonizing and maintaining a population where introduced. Some of the characteristics of this element include the number of pest individuals expected on the imported commodity and the pest's host specificity. The likelihood that the pest would come in contact with an adequate food resource at the port of entry, encounter appreciable environmental resistance, attract a mate, and reproduce in the new environment also are factors to consider in rating colonization potential.

4. Spread potential. The probability that the pest would spread beyond the colonized area is estimated. Some of the characteristics of this element 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.

Three different elements are considered as a basis for assessing the consequences of establishment, as follows:

5. Economic damage potential. The assessor estimates the economic impact if the pest were to become established. Some of the characteristics of this element include the economic importance of hosts, crop loss, effects on subsidiary industries, costs and efficacy of control.

6. Environmental damage potential. The assessor estimates the environmental impact if the pest were to become established. Considerations include the potential for ecosystem destabilization, reduction in biodiversity, reduction or elimination of keystone species, reduction or elimination of endangered/threatened species, and effects of control measures.

7. Perceived damage potential (social and political influences). The impact from social and/or political influences is estimated, including the potential for aesthetic damage, consumer concerns, and political repercussions.

Each of the seven specific IPRA elements is assigned a risk value (high, moderate, or low) based on the available biological information and the subjective judgement of the assessment team. As emphasized by Orr and Cohen (1991), the high, medium, or low ratings cannot be defined or measured. They have to remain judgmental, because the value of the elements contained under probability of establishment are not independent of the rating of the consequences of establishment. The strength of the risk assessment process is not in each element's rating *per se* but in the detailed biological statements that motivate a low, moderate, or high rating.

In addition, each specific element in the pest risk assessment for individual pests is assigned a certainty code, as defined in table 3-2.

Table 3-2. Description of certainty codes used with specific elements in the individual pest risk assessment process

Certainty code	Symbol	Description
Very certain	VC	As certain as we are going to get
Reasonably certain	RC	Reasonably certain
Moderately certain	MC	More certain than not
Reasonably uncertain	RU	Reasonably uncertain
Very uncertain	VU	A guess

The seven risk values in each IPRA are then combined into a final pest risk potential (PRP) that represents the overall risk of the pest. The following three steps are completed in order to determine the PRP for each pest of major concern (Orr and Cohen 1991).

Step 1. Determine the probability of establishment. The overall risk rating for probability of establishment acquires the same rank as the single element with the lowest risk rating. For example, a pest having ratings of high, low, low, and moderate for the single elements of pest with host at origin, entry potential, colonization potential, and spread potential, respectively, would receive a low rating for probability of establishment.

Step 2. Determine the consequences of establishment. Table 3-3 is used to determine the consequences of establishment, based on the three individual risk elements.

Table 3-3. Method for ascertaining consequences of establishment for a specific pest organism or group of organisms with similar habits, based on individual ratings for economic, environmental, and perceived damage potentials

Economic damage potential	Environmental damage potential	Perceived damage potential	Consequences of establishment
High	Low, moderate, or high	Low, moderate or high	= High
Low, moderate, high	High	Low, moderate, or high	= High
Moderate	Moderate	Low, moderate, or high	= Moderate
Moderate	Low	Low, moderate, or high	= Moderate
Low	Moderate	Low, moderate, or high	= Moderate
Low	Low	Moderate or high	= Moderate
Low	Low	Low	= Low

Step 3. Determine the pest risk potential. The PRP is then ascertained for each pest based on the pest risk associated with probability of establishment and consequences of establishment, using the classification shown in table 3-4.

Table 3-4. Method for ascertaining pest risk potential for a specific pest organism or group of organisms with similar habits, based on ratings for probability of establishment and consequences of establishment

Probability of establishment	Consequences of establishment	Pest risk potential
High	High	= High
Moderate	High	= High
Low	High	= Moderate/low*
High	Moderate	= High
Moderate	Moderate	= Moderate
Low	Moderate	= Moderate/low*
High	Low	= Moderate
Moderate	Low	= Moderate
Low	Low	= Low

* 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.

The classification in table 3-4 is the same as that given by Orr and Cohen (1991), except for the modification defined in the footnote. The Pest Risk Assessment Team specified this modification to avoid assigning a moderate pest risk potential to those pests that could cause significant economic, environmental, or social impacts in the United States, but are very unlikely to be found on imported logs (e.g., *Rhyacionia buoliana*, nursery pests, branch galls, etc.).

In summary, this pest risk assessment strives to identify potential pests likely to be associated with logs imported from Chile, provide a reasonable estimation of the pest risk, and communicate the amount of uncertainty involved and paucity of information on many potential pests. Results of this assessment will be used to formulate mitigation procedures, if deemed necessary by APHIS, to reduce the risk of introduction and establishment of foreign pests associated with logs imported into the United States from Chile.

Chapter 4. INSECTS AND PATHOGENS POSING RISK--MONTEREY PINE

Overview of Pests in Exotic Pine Plantations

Since insect and disease protection became an integral part of Chile's forestry program in the 1970's (Billings et al. 1972, 1973; Gara 1978), all of Chile's plantations are inspected periodically by Chilean forestry personnel for signs of ill health, primarily by ground inspections. The Departamento de Defensa Agrícola of the Servicio Agrícola y Ganadero (SAG) is responsible for the detection and control of exotic forest pests. In turn, survey and management of native forest pests (as well as exotic pests once they are considered established) is the responsibility of Chile's Forestry Corporation (Corporación Nacional Forestal or CONAF). Both SAG and CONAF are supported by professionally trained forest pathologists and entomologists working within these organizations and with Chilean universities in Santiago, Chillán, Concepción, and Valdivia.

An increasing proportion of the 1.3 million hectares of Monterey pine in Chile is now being managed intensively to meet market demands. Occasional mortality in the past has been related to overstocking, poor management activities, and adverse environmental conditions. Despite the fact that Monterey pine is susceptible to a wide variety of insects and diseases in its native habitat of California (Boyce 1961, Ohmart 1981), most plantations established in Chile are healthy. The major insect pest affecting Monterey pine in Chile is the European pine shoot moth (*Rhyacionia buoliana*), introduced into Chile from Argentina around 1981. This pest of young pines has become the target of intensive chemical control programs (Espinoza 1987) and, more recently, biological control programs (Espinoza and Lobos 1988a and b, Aguilar and Beéche 1989, Espinoza et al. 1992). Other insects known to have been introduced into Chile's exotic pine plantations (Francke-Grosman 1963a and b, Billings et al. 1972) are a European bark anobiid (*Ernobius mollis*), an ambrosia beetle (*Xyleborinus saxeseni*), a wooly adelgid (*Pineus börneri*), a European wood borer (*Buprestis novemmaculata*), and a siricid (*Urocerus gigas gigas*). In recent years, three European bark beetles (*Hylurgus ligniperda, Hylastes ater* and *Orthotomicus erosus*) have arrived (Ojeda 1985, Ciesla 1988b). The siricid *Sirex noctilio*, an exotic pest of importance in Australia, New Zealand, Brazil, and Uruguay (USDA Forest Service 1992), has yet to be detected in Chile.

Monterey pine plantations in Chile are relatively free of major disease problems. Boron deficiencies have caused growth problems on severely eroded sites (Billings and Holsten 1969a, Tollenaar 1969); this deficiency can be corrected with borax applications (González 1982). The major disease of concern, dothistroma needle blight (caused by *Dothistroma pini*), is managed through a combination of aerial fungicidal sprays and silvicultural measures. Because there are only a few professionally trained forest pathologists and mycologists in Chile, less research and field observations have been conducted on potential pathogens than on insects in Chile's exotic and native forests.

Without doubt, Chilean foresters consider the European pine shoot moth to be the most serious pest problem of Monterey pine plantations yet encountered. Because of the devastating potential of this pest to Chile's forest economy, research and forest pest management programs since 1985 necessarily have been directed primarily at this one pest. As a result, financial support from the Chilean government and forest industry for entomologists or pathologists to study other potential pests associated with Monterey pine (or native forests) has been scarce. Accordingly, information on the biologies and natural habits of the many indigenous insects (Billings et al. 1972) and fungi (Butin and Peredo 1986) known to occur in Monterey pine plantations remains limited. Furthermore, forest entomology and pathology references pertaining to Chile are written in a variety of languages (Spanish, German, English, French) and are widely scattered among Chilean publications (of limited distribution), foreign journals, and unpublished reports. These constraints made the preparation of detailed pest risk assessments difficult.

Unlike the insects and fungi associated with native forests which are almost exclusively indigenous to Chile, organisms that cause damage to Chile's Monterey pine plantations can be divided into three groups:

- Organisms endemic to Chile, normally living on indigenous hosts but capable of attacking introduced tree species (e.g., *Armillaria* spp., *Ormiscodes cinnamomea, Thanatopsyche chilensis, Callideriphus laetus*).
- Organisms introduced into Chile from locations other than the United States, and which are not present in the United States (e.g., *Hylurgus ligniperda*, *Hylastes ater*, *Orthotomicus erosus*, *Buprestis novemmaculata*).
- Organisms introduced into Chile that occur in the United States on hosts indigenous to the United States (e.g., *Rhyacionia buoliana, Pineus börneri*, *Ernobius mollis*, *Xyleborinus saxeseni*, *Dothistroma pini*, *Sphaeropsis sapinea*).

Organisms in the first two groups are considered most likely to be injurious if introduced into the United States. The possibility that organisms in the third group may be genetically different from those of the same species in the United States has been raised (see USDA Forest Service 1991 and reviewers' comments in appendix F), but very little information is available on the subject. Chilean forest pathologists contend that Chilean populations of species in this group are most likely to be small samples from the much larger and more variable United States populations (Hernán Peredo, personal communication).

Individual Pest Risk Assessments: Insects of Pine

All the insect species recorded from *Pinus radiata* in Chile are listed in table A-1 in appendix A. This list consists of 84 species belonging to 8 orders. Twenty-eight of these species distributed among 6 orders (table 4-1) were identified as possible quarantine pests associated with imported *P. radiata* logs from Chile, based on available information.

In turn, 10 insect pests (or groups of species with similar habits) were selected as subjects for individual pest risk assessments (IPRA), using criteria in table 3-1 (page 18). Comments from reviewers that pertain to a specific pest are summarized at the end of the IPRA for that pest, followed by a response to reviewers' comments by the assessment team.

Table 4-1. Summary of possible quarantine insects associated with imported logs of Monterey pine (*Pinus radiata*) from Chile, including known host range, location on the host, and pest category

ORDER Family *Species*	Other hosts	Location: Seedlings in nursery	Location: Foliage/ other	Location: Bark cambium	Location: Sapwood heartwood	Location: Wood in use	Location: Hitch-hiker*	Pest category†
ORTHOPTERA								
Phasmidae								
Bacunculus phyllopus Gray	N		X				X	3a
ISOPTERA								
Kalotermitidae								
Cryptotermes brevis Walker	P, C, N, E					X		1b
Neotermes (Kalotermes) chilensis (Blanch.)	N, E			X	X	X		1a
Termopsidae								
Porotermes quadricollis (Rambur)	N			X	X	X		1a
COLEOPTERA								
Anobiidae								
Ernobius mollis L.	P, C			X				1b
Buprestidae								
Buprestis novemmaculata L.	P		X	X	X			1a
Cerambycidae								
Callideriphus laetus Blanch.	N		X	X	X			1a
Colobura alboplagiata Blanch. o Sol.	N		X	X	X			1a
Curculionidae								
Rhyephenes humeralis (Guér.)	N			X				1a
Rhyephenes maillei (Gay et Sol.)	N			X				1a

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* Indicates those insects that may be abundant around ports or attracted to lights during some stage of their life cycle, providing opportunity to be imported as "hitchhikers" on the surface of untreated logs or in ships.

† See table 3-1 on page 18 for definitions of pest categories.

Table 4-1. Summary of possible quarantine insects associated with imported logs of Monterey pine (*Pinus radiata*) from Chile, including known host range, location on the host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location: Seedlings in nursery	Location: Foliage/ other	Location: Bark cambium	Location: Sapwood heartwood	Location: Wood in use	Location: Hitch-hiker*	Pest category†
Elateridae								
Crigmus sp.	F	X	X	X				3a
Pyrophorus spp.	F	X	X	X				3a
Scarabaeidae								
Brachysternus prasinus Guér.	N	X	X				X	1a
Hylamorpha elegans (Burm.)	N	X	X				X	1a
Hylamorpha cylindrica Arrow	N	X	X				X	1a
Sericoides germaini Dalla Torre	N	X	X				X	1a
Scolytidae								
Hylastes ater (Paykull)	P, C			X			X	1a
Hylurgus ligniperda (F.)	P			X			X	1a
Orthotomicus erosus Wollaston	P, C			X			X	1a
LEPIDOPTERA								
Lasiocampidae								
Macromphalia dedecora Feisth.	N		X	Xpupa				3a
Macromphalia spadix Draudt	N		X	Xpupa				3a
Olethreutidae (Tortricidae)								
Rhyacionia buoliana (Schiff.)	P	X	X					2c

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* Indicates those insects that may be abundant around ports or attracted to lights during some stage of their life cycle, providing opportunity to be imported as "hitchhikers" on the surface of untreated logs or in ships.

† See table 3-1 on page 18 for definitions of pest categories.

Table 4-1. Summary of possible quarantine insects associated with imported logs of Monterey pine (*Pinus radiata*) from Chile, including known host range, location on the host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location: Seedlings in nursery	Location: Foliage/ other	Location: Bark cambium	Location: Sapwood heartwood	Location: Wood in use	Location: Hitch-hiker*	Pest category†
Psychidae								
Thanatopsyche chilensis Ph.	C, N, E, F		X					1a
Saturniidae								
Catocephala marginata (Phil.)	N, E		X	X (pupa)				3a
Catocephala rufosignata (Blanch.)	N		X	X (pupa)				3a
Ormiscodes cinnamomea Feisth.	C, N	X	X	X (pupa)				1a
Polythysana cinerascens Phil.	N		X	X (pupa)				3a
HYMENOPTERA								
Siricidae								
Urocerus gigas gigas (L.)	P				X			2a

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* Indicates those insects that may be abundant around ports or attracted to lights during some stage of their life cycle, providing opportunity to be imported as "hitchhikers" on the surface of untreated logs or in ships.

† See table 3-1 on page 18 for definitions of pest categories.

Bark Beetles of Pine

Scientific names of pests: *Hylurgus ligniperda* (F.), *Hylastes ater* (Paykull), *Orthotomicus erosus* Wollaston (Coleoptera: Scolytidae).

Scientific names of hosts: *Hylurgus* on *Pinus radiata* (in Chile), *Pinus* spp.; *Hylastes* on *Pinus radiata* (in Chile), *Pinus* spp., *Picea* spp., *Abies* spp., *Pseudotsuga* sp., *Larix* sp.; *Orthotomicus* on *Pinus radiata* (in Chile), *Pinus* spp., *Picea* spp., *Abies* spp., *Cedrus* spp.

Distribution: *Hylurgus* and *Hylastes*--Europe, Great Britain, Western Siberia; introduced into Japan, Australia, New Zealand, South Africa and Chile; *Orthotomicus*--Europe, North Africa; introduced into Chile.

Summary of natural history and basic biology of the pests: These bark beetles were introduced into Chile in the early 1980's (Ojeda 1985; Ciesla 1988a, 1988b). They feed and breed in phloem of logging slash, stumps, stump roots, moribund and dead conifers, and, in the case of *Hylastes ater*, at the root crowns of seedlings. Even more importantly, both *Hylastes* and *Hylurgus* have the potential to be vectors of black stain root disease caused by the fungus *Leptographium wageneri* (see USDA Forest Service 1991 and 1992).

Hylurgus ligniperda. Brood galleries, initiated by females, consist of short entry tunnels that lead to a chamber cut in the phloem; mating occurs in these nuptial chambers. Females then construct long egg galleries parallel to the grain of the wood. Eggs are laid in notches cut in the walls of the egg gallery and are covered with frass. Eggs are laid over 10 to 20 cm of the gallery; the female will then rest before once more extending the egg gallery. Thus, the larvae feeding in the phloem are found in at least two sizes. The insects overwinter in the phloem of their hosts as fourth instar larvae and then pupate in the late spring. Two weeks later they emerge as adults and begin host selection flights (USDA Forest Service 1991). Their host material will include fresh stumps and slash from recently cut trees (Ciesla 1988b). *Hylurgus ligniperda* does not appear to feed on seedlings after emergence from logs and stumps (MacKenzie 1992). In Chile, this insect completes three generations per year (Cogollor 1991) and has become distributed from region VII to region IX (Ciesla 1988b).

Hylastes ater. This scolytid is similar to *Hylurgus ligniperda* in distribution and damage potential. The population breeds primarily in pines; however, sexually immature adults feed in seedlings of pine, spruce, True firs, Douglas-fir, and larch, and also on other green material. Brood galleries consist of short entry tunnels leading to an oblique nuptial chamber where mating takes place. Single egg galleries are dug along the grain by females. About 100 eggs are laid in individual notches that the females cut in the lateral walls of the egg galleries. The larvae initially make feeding tunnels at right angles to the egg galleries, but later these become random in direction and eventually obliterate both the early larval tunnels and those made by the parent adults. The insects overwinter as late instar larvae and emerge in late spring as sexually immature adults (USDA Forest Service 1991). In Chile, this insect appears to have been supplanted by *Hylurgus ligniperda*, which has become more widely established (Cogollor 1991).

Orthotomicus erosus. This scolytid is the least common and the least economically important of the three introduced bark beetles in Chile and has been collected only in regions VII and VIII (Ciesla and Parra 1988). It restricts its attacks to recently felled pines or logging slash. The insect completes two generations per year in Europe, where it is considered an economically important pest. Multiple generations also may occur in Chile. The biology and natural history of this insect is similar to bark beetles of the genus *Ips*. The adults are polygamous; males initiate attacks and attract 1 to 3 females to a nuptial chamber constructed between bark and wood. Each female deposits 10 to 20 eggs and larvae feed in a common gallery. Upon completing development, adults emerge through the bark and fly to new hosts. In Chile, *O. erosus* is the least aggressive of the three bark beetles and has been largely displaced by *Hylurgus ligniperda* (Cogollor 1991).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin: *Hylurgus: High (VC); Hylastes* and *Orthotomicus: Moderate (MC)***

   Of the three introduced bark beetles, *Hylurgus ligniperda* has become the most successfully established and widely distributed on pine logs in Chile. With three generations per year (Cogollor 1991) and adults present throughout the year (Milligan 1978), along with a strong attraction to freshly cut logs, this species' potential for association with unprocessed logs destined for export is very high.

2. **Entry potential: *High (VC)***

   Because most of the life stages of these beetles are protected under the bark, there is a very strong probability that these insects would survive the trip from Chile to the United States in untreated logs with bark attached. Schroeder (1990) reported the interception of larvae and adults of *Hylurgus ligniperda* in 10 of 14 shipments of debarked *Pinus radiata* pulpwood logs from Chile. There is a high probability that any one of the three insect species also may be introduced on dunnage or shipping crates containing bark. Presumably, these insects entered Chile in this manner, since Chile prohibits the import of logs.

3. **Colonization potential: *High (MC)***

   Hylurgus ligniperda, which breeds predominantly in pine, could colonize stumps, fallen branches, and moribund pines in the United States if this host material were present around the port of entry. The transport of infested logs to other areas in the United States with pine could increase the likelihood of subsequent establishment of these insects. *Hylurgus*, more likely to be introduced than *Hylastes* or *Orthotomicus* due to its greater abundance in Chile, has a narrower host range but would probably become established on west-side pines in the Pacific Northwest or California. If *Hylastes* or *Orthotomicus* were introduced, these insects would be highly likely to become established due to the broad host range of conifers available to them in the Pacific Northwest.

4. **Spread potential:** ***High (MC)***
The scolytid members of this ecological group are good fliers and concentrate in response to volatile host odors (terpenes) and/or pheromones (*Orthotomicus*) over long distances. As long as recently cut or broken host material is available, infestations of these species can spread. Although *Hylurgus ligniperda* has spread throughout Chile in a very short time after its introduction in the 1980's, this spread was aided by a fairly continuous concentration of host material. Pine hosts are less abundant than non-host conifer genera west of the Cascade Mountains. But if Chilean logs are hauled to mills located on the east side of the Cascades, emerging *Hylurgus ligniperda* beetles would encounter a pine host type that is much more continuous. *Hylastes ater* and *Orthotomicus erosus* have a broader host range but appear less aggressive in Chile; the introduction of either species into the United States could mean a higher likelihood of establishment in conifer genera other than *Pinus*.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (MC)***
The greatest concern for introduction of these insects would be their potential as vectors of black stain root disease. Two species of *Leptographium* have been isolated from the New Zealand populations of *Hylurgus* and *Hylastes* (MacKenzie 1992). Although symptoms of black-stain have been noted on beetle-infested pines in Chile (Ciesla 1988b, Gara et al. 1988), *Leptographium* has yet to be identified as the causal agent. Both of the New Zealand *Leptographium* species (*L. truncatum* and *L. procerum*) occur in the United States but not extensively in the West (MacKenzie 1992). The association of these fungi with New Zealand *Hylastes* and *Hylurgus* is very high, having been isolated from more than 70% of the beetles examined (MacKenzie 1992).

The USDA Forest Service estimates that black stain root disease (caused by the fungus *Leptographium wageneri*) affects 18,000 acres of pine species and 8,000 acres of Douglas-fir annually in California, Oregon, and Washington. The estimated 24 million cubic feet of volume loss represent a value of $18 million annually or a present value of $311 million (based on a 4% discount rate). Accordingly, the addition of another black stain would increase losses by 10% or a present value of $31 million in the western United States. In the pest risk assessment of importing New Zealand logs (USDA Forest Service 1992), *Leptographium truncatum* was estimated to have present value losses for a 30-year period of $7 to $69 million (4% discount rate). The New Zealand analysis was limited to effects on *Pinus radiata* and is based on the cost of removing and replacing trees. Forest values (such as spotted owl habitat and wilderness) will not be significantly reduced because the loss of a small percentage of trees per acre will not limit its usefulness for these purposes.

6. **Environmental damage potential:** ***Moderate (RC)***
If these insects were introduced and become more efficient vectors of the fungus that causes black-stain root disease, their activity could result in moderate levels of environmental damage. Also, the practice of dipping bare root seedlings in a slurry containing a pesticide to reduce seedling mortality may raise environmental concerns.

7. **Perceived damage potential (social and political influences):** ***Low (RC)***
The damage caused by these insects would not reach the attention of the general public. But if *Hylastes* or *Hylurgus* become established as successful vectors of black stain root disease, their damage potential would readily become evident to private forest industries or government forestry agencies.

Pest risk potential: ***Hylurgus: High*** (probability of establishment = *High*; consequences = *Moderate*); ***Hylastes*** **and** ***Orthotomicus: Moderate*** (probability of establishment = *Moderate*; consequences = *Moderate*)

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Neumann, F. G. 1979. Beetle communities in eucalypt and pine forests in northeastern Victoria. Australian Forestry Research 9: 277-293.

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Reviewers' comments:
"It's unclear why *Orthotomicus erosus* is considered a pest in Europe and not in Chile." (Gara)

"The major bark-beetle pest that could be introduced with logs [of *P. radiata*] is *Hylurgus ligniperda*. This species is especially important because of its association with black stain root disease and its potential to vector other, yet unknown, plant diseases. Unless a procedure can be set in place that will ensure that pest-free...logs can be imported into North America, then perhaps the issue should be reassessed. The other bark beetles mentioned in this document are probably of little importance in this context. Most, or all, are secondary insects that feed mainly in slash, dead or dying trees, or similar non-economic situations...The *Orthotomicus* species has not, to my knowledge, been shown to be of major economic importance." (Bright)

"Since little is known of the pathogens that are probably associated with these bark beetles in Chile...I would be more concerned...with the potential introduction of 'new' strains of black stain." (Holsten)

"*Hylastes ater*--Bevan rates this as a four star pest in the United Kingdom. Where is the documentation that this is not a potentially serious pest?" (Lattin)

"While mitigation measures are not to be considered, I would...emphasize the low efficacy of the debarking method in preventing transport of pest species to new habitats. I inspected debarked *P. radiata* logs from New Zealand. Large areas in the butt logs contained bark and bark beetles" (D. Wood)

"Insect transmission of fungal pathogens should be a major concern. Since some insects (*Hylastes*, *Hylurgus*) already have been detected on treated shipments [from New Zealand], this concern is very real. These very insects likely transport *Leptographium* species." (Shaw)

"My concerns relative to the importation of *Pinus radiata* are minor. All of the species [of Scolytidae] reported from Chile in this host were imported to Chile from Europe. While none occur in North America, all are well-known phloem feeders and could probably be appropriately eliminated by measures applied conscientiously in Chile and the USA." (S. Wood)

"At this point, the native insects that appear to vector *L. wageneri* seem to be insufficient vectors, but we are still witnessing extensive losses. If any of the introductions become more efficient due to their habits, etc., it will be an entirely different game, and the public will surely notice." (Cobb)

"*Hylurgus ligniperda* is ranked at high risk based on its association with fungi that have yet to be identified in Chile. This bark beetle has not caused significant damage to pine plantations in Chile, indicating that the economic damage potential should not be so high." (Campino, translated from Spanish)

"In the case of *Leptographium wageneri*, it is important to emphasize that this fungus has not been reported from Chile." (Beéche, Cerda, Vallejos, translated from Spanish)

Response to comments: We recognize that European bark beetles recently introduced into Chile are likely to present the greatest risk as potential pests associated with logs imported to the United States. This is particularly true for *Hylurgus ligniperda*, the most abundant of the three bark beetle species, due to its potential as a vector of black stain root disease. Accordingly, this insect received the highest pest risk potential of all the pests we evaluated. Although *Leptographium wageneri*, the cause of black-stain root disease, has yet to be identified in Chile, symptoms of the disease have been noted on *P. radiata* by several different observers. If introduced into the United States, *Hylurgus ligniperda* may become a more effective vector of the strain of *L. wageneri* present in the western United States. *Orthotomicus erosus*, although considered an economic pest in certain European countries, has a limited distribution in Chile where it is less abundant and causes less damage compared to *Hylurgus ligniperda*. Also, populations of *Hylurgus ligniperda* in Chile appear to be displacing those of *O. erosus* and *Hylastes ater*. If so, this would effectively reduce the likelihood that the latter two bark beetle species will be associated with exported sawlogs. Pest risk potentials for *O. erosus* and *Hylastes ater* were deemed moderate rather than high as a result of these factors.

Bark Weevils of Pine

Scientific names of pests: *Rhyephenes humeralis* (Guér.), *Rhyephenes maillei* (Gay et Sol.) (Coleoptera: Curculionidae).

Scientific names of hosts: *Pinus radiata*, *Nothofagus alpina*, *N. dombeyi*, *Eucalyptus* (*globulus*), *Maytenus boaria*, *Malus* spp., *Juglans* spp.

Distribution: *R. humeralis*--(regions VII and VIII); *R. maillei*--southern Chile (regions VIII-X), including Chiloé Island (Billings and Holsten 1969a); two other species have been collected in low numbers from *P. radiata* in Chile: *R. literalis* (Guér.) in region VII and *R. gayi* (Guér.) in region IX (Eglitis and Holsten 1972).

Summary of natural history and basic biology of the pests: These weevils have habits similar to secondary bark beetles. The preferred host material includes logs aged for 1 to 3 months or fire-scarred trees and logs (Billings and Holsten 1969a). Adults deposit eggs through the bark and broods develop between the bark and wood surface. The life history of *Rhyephenes* is poorly understood. Both adults and larvae can be found throughout the year (Billings and Holsten 1969a). Females bore small holes in the bark and deposit eggs inside. Larvae develop in galleries beneath the bark. Pupation takes place in chip cocoons beneath the bark and adults emerge by carving exit holes through the bark. Adult weevils have been found on the foliage of pines and other host trees.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin: *High (RC)***
   The incidence of these weevils around harvesting operations is high. Because adult weevils occur throughout most of the year and are widely distributed, the likelihood of eggs being laid on logs destined for shipment is moderate to high, depending on how long the logs remain in the woods or at holding yards in port areas. Logs shipped within a month of harvest should contain few if any *Rhyephenes*, because these weevils prefer host material without flowing resin or the high moisture content characteristic of fresh logs.

2. **Entry potential: *High (VC)***
   Asynchrony with changing seasons between the hemispheres is not considered to be a problem because *Rhyephenes* life stages are found in Chile during most seasons (Billings and Holsten 1969a); these insects appear very adaptable. If bark is intact on logs, the likelihood of survival during shipment is high. However, it is important to note that *Rhyephenes* was intercepted in 9 of 14 Chilean log shipments received in Sweden in spite of the fact that the pine logs were considered to be well debarked (Schroeder 1990). The logs contained callow adults in chip cocoons (Schroeder, personal communication). The presence of callow adult curculionids, cerambycids, and buprestids in these

shipments (see appendix C, table C-1) testifies to the age of host logs (e.g., at least 1 year since harvest).

3. **Colonization potential:** ***High (MC)***
Rhyephenes would colonize logs and stumps of freshly cut host trees. Weevil dispersal capabilities are unknown, but if logs with bark are transported to wooded areas and broods are allowed to develop to adulthood, then establishment could occur. The wide host range of *Rhyephenes* spp. documented in Chile, which includes native hardwoods and exotic conifer species, suggests that their potential for establishment is high in the United States.

4. **Spread potential:** ***Moderate (RU)***
The spread potential would depend on the array of hosts that are found to be suitable for the weevil. If Douglas-fir and pine species other than *Pinus radiata* prove to be suitable, then the weevils could spread throughout the Pacific Northwest and California where the insects would enjoy a climate similar to their native range. Given the available host material, spread would probably occur at the rate of about 1 mile per year. It seems likely that many tree genera in the United States would be suitable hosts for these insects. Their spread would be facilitated in areas where known hosts (e.g., apple, walnut, pine, and eucalyptus) are found. The transport of infested logs also may favor spread of introduced weevil populations.

B. Consequences of establishment

5. **Economic damage potential:** ***Low (RC)***
These weevils have not been observed to be tree killers or pests of seedlings and thus would probably be confined to logging slash, harvested material, stumps, and trees damaged by fire. Damage to wood in the form of staining has not been reported but could result from weevil feeding beneath the bark. *Rhyephenes humeralis* has been reported to infest branches and trunks of apple and walnut trees in Chile (Capdeville 1945), but it causes damage of only minor economic importance (González 1989).

6. **Environmental damage potential:** ***Low (RC)***
Negligible environmental damage is expected because these weevils do not attack live, healthy trees in forest situations. If the weevils become established on weakened or dying ornamental or fruit-tree hosts in urban areas, homeowners may be tempted to treat ailing trees with pesticides.

7. **Perceived damage potential (social and political influences):** ***Low (RC)***
Adults of *Rhyephenes* spp. may cause limited public concern simply due to their large size, abundance, and visibility on host plants. If the *Rhyephenes* weevils became established, perceived damage probably would be higher than economic or environmental damage, particularly if establishment occurred in

urban areas with ornamental and fruit trees. Given the cosmetic nature of insect infestations in urban areas, some control measures would probably be taken by concerned homeowners. Because insects seldom attack living trees, however, perceived damage would be low.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*; consequences = *Low*)

Selected bibliography:

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Reviewers' comments:

"Have you given consideration to the potential of this weevil becoming a vector of *Fusarium subglutanans*, cause of pitch canker? Its biology seems similar to the deodar weevil, which vectors the fungus and/or creates wounds for infection in S. E. United States. We now have the fungus and disease in California on *P. radiata* and other pines. Thus, it should be a consideration." (Cobb)

"The interception of this species by Sweden in spite of mitigation procedures is very telling and yet [it] is rated only of moderate risk." (Lattin)

"In the case of *Rhyephenes*, the knowledge of this insect's biology is insufficient to determine a high colonization potential in the U. S." (Ojeda, Baldini, translated from Spanish)

Response to comments: Given the fact that *Rhyephenes* weevils seldom attack live, standing hosts, these insects are unlikely to vector the pitch canker fungus. The *Rhyephenes* weevils intercepted in Sweden were on shipments of pulpwood logs, not sawlogs. In contrast to sawlogs, which are shipped within a few weeks of harvest, shipments of pulpwood logs are likely to include material that has aged in the woods or in Chilean storage yards for a year or more before shipment, increasing the opportunities for infestation by a variety of insect and disease pests. For these reasons and others detailed in the IPRA, we opted to remain with a moderate pest risk potential for these weevils.

Bark Anobiid of Pine

Scientific name of pest: *Ernobius mollis* L. (Coleoptera: Anobiidae).

Scientific names of hosts: *Pinus radiata* (in Chile), *Pinus* spp., *Picea* spp., *Abies* spp., *Larix* spp., *Pseudotsuga menziesii* (Milligan 1977).

Distribution: Native to Europe; introduced into Chile, New Zealand, Australia, southeastern Canada, eastern and southern United States. In Chile, distributed from region V to region VIII. Recently established in California (Seybold and Tupy 1993).

Summary of natural history and basic biology of the pest: *Ernobius mollis* is associated with fire-scarred trees and logging slash that has aged for at least 1 year (Billings and Holsten 1969a). The beetles undergo a 1-year life cycle. The females deposit eggs under bark scales, and larvae develop in the subcortical layer of the host or in the wood if the bark is thin (Baker 1972). In Chile, the larval stage occurs from March until October (fall through winter) and pupation takes place at the end of spring (November). Adults appear during the summer (December through March) and new eggs are laid at the end of summer (Milligan 1977). This beetle is not expected to be a mortality agent. In Australia, this bark beetle is considered economically unimportant (Neumann 1979). In the southern United States and Canada, this beetle occurs in bark beetle-killed trees (Baker 1972) or as a minor wood products pest in pine or spruce flooring (Craighead 1949).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RC)***
   The distribution of *Ernobius mollis*, an introduced insect first recorded in 1963 (Francke-Grosman 1963a), is more limited in distribution within Chile than is *Rhyephenes*, which occupies a similar ecological niche. However, if well-aged logs are exported with bark intact, there is a moderate possibility that infested material could be included. In Sweden, where 14 shipments of debarked *Pinus radiata* pulpwood logs from Chile were inspected at the port of entry, 7 contained either live larvae or adults of *E. mollis* (Schroeder 1990). The frequency of occurrence of this secondary bark beetle with *P. radiata* sawlogs would be less common than with well-aged pulpwood, particularly if the logs are shipped while still fresh.

2. **Entry potential:** ***High (VC)***
   Larvae and adults are protected beneath the bark during their entire developmental cycle and thus could be effectively transported from the Southern Hemisphere. Their frequent interception in Sweden in shipments from Chile is a testimonial to the high likelihood of entry (Schroeder 1990).

3. **Colonization potential:** ***High (VC)***
These beetles breed in slash and logs, which could be found around the port of entry. If infested logs are transported to areas with slash of host trees, there is the potential for colonization by *Ernobius*. The host range of this beetle includes tree species that grow in northern California and the Pacific Northwest. The beetle has already become established in the eastern and southern United States (Baker 1972) and more recently in California (Seybold and Tupy 1993).

4. **Spread potential:** ***Moderate (MC)***
The spread potential for *Ernobius* in the Pacific Northwest would depend on the array of hosts that are suitable for the beetle and competition from secondary bark beetles indigenous to the western United States. The known host range takes in many conifer genera (Milligan 1977), all of which are found in the Pacific Northwest.

B. Consequences of establishment

5. **Economic damage potential:** ***Low (MC)***
Craighead (1949) refers to *Ernobius mollis* damage to pine and spruce flooring and other woodwork in the eastern United States. If this insect were to become established in the Pacific Northwest, damage would most likely be restricted to logging slash, down material, and some dry wood products. The insect would not be expected to kill trees. It is already established in the southern and eastern United States, so additional damage would be negligible in these areas.

6. **Environmental damage potential:** ***Low (RC)***
Due to the secondary nature of this insect, environmental damage is expected to be minimal.

7. **Perceived damage potential (social and political influences):** ***Low (RC)***
There is a remote possibility that *Ernobius* could become associated with ornamental pines or other trees in urban settings, but it would probably have a minimal effect. Perceived damage would be greater if this insect becomes established in wood products in use.

Pest risk potential: ***Low*** (probability of establishment = *Moderate*; consequences = *Low*)

Selected bibliography:

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Billings, R. F.; Holsten, E. H. 1969a. Progreso realizado en la investigación de insectos forestales de pino insigne (Dic. 1967 hasta Agosto 1969). Santiago: División Forestal, Servicio Agrícola y Ganadero, Universidad de Chile, Cuerpo de Paz. 49 p. (Mimeographed report).

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Milligan, R. H. 1977. *Ernobius mollis* Linnaeus (Coleoptera: Anobiidae), pine bark anobiid. Forest and Timber Insects in New Zealand 17. Rotorua: Forest Research Institute, New Zealand Forest Service. 7 p.

Neumann, F. G. 1979. Beetle communities in eucalypt and pine forests in northeastern Victoria. Australian Forestry Research 9: 277-293.

Schroeder, L. M. 1990. Occurrence of insects in coniferous roundwood imported to Sweden from France and Chile. EPPO (European and Mediterranean Plant Protection Organization) Bulletin 20: 591-596.

Seybold, S. J.; Tupy, J. L. 1993. *Ernobius mollis* (L.) (Coleoptera: Scolytidae) established in California. Pan-Pacific Entomologist (in press).

Reviewers' comments:
"Illustration of how the three low ratings [for consequences of establishment] pull down the average rating." (Lattin)

"Insects such as *Ernobius mollis* that are already established in the U. S. should not be included in the risk assessment. Additional risk of another introduction is nil." (R. Vergara, translated from Spanish)

"*Ernobius mollis* should be considered in category 1d (non-quarantine) rather than 1b, given that it is already established in the U. S. and is not subject to active control." (Beéche, Cerda, Vallejos, translated from Spanish)

Response to comments: The low rating for pest risk potential (rather than moderate) is based on the fact that this insect has already become established in two different regions of the United States and does not appear to cause significant economic or environmental damage.

Siricid Wood Wasp of Pine

Scientific name of pest: *Urocerus gigas gigas* (L.) (Hymenoptera: Siricidae).

Scientific names of hosts: *Urocerus gigas gigas* on *Pinus radiata* (Chile); *Urocerus* spp. on *Larix* spp., *Abies* spp., *Pinus* spp., *Pseudotsuga* spp., *Picea* spp. (Europe and North America).

Distribution: *Urocerus gigas gigas* in Chile; *U. gigas flavicornis* (F.) found in the western United States and Canada; *Sirex noctilio* F. native to Eurasia, northern Africa, introduced into Brazil, Argentina, Uruguay, New Zealand, and Australia (not reported from Chile).

Summary of natural history and basic biology of the pest: Wood-boring Hymenoptera of the family Siricidae are important insects associated with coniferous trees worldwide. In a strictly ecological context, they are beneficial organisms because they help decompose and recycle dead trees, providing mulch and nutrients for forest soils. A symbiotic relationship between various siricids and several basidiomycete fungi hastens the decomposition process. Siricids are considered pests when the fungi they introduce and their larval galleries degrade wood products sawn from infested trees, and, less commonly, when attacks by aggressive species cause the death of living trees (USDA Forest Service 1992). All siricids can infest dead trees, but no North American species are tree killers (Keen 1952, Baker 1972).

Sirex noctilio, considered a secondary pest in Europe, developed into a primary tree killer in plantations of *Pinus radiata* when it was introduced along with its fungi into New Zealand at the turn of the century (Rawlings 1960). Most of the damage occurred in trees stressed by drought or overcrowding. Nevertheless, hundreds of thousands of crop trees were killed in the 1940's and 1950's in New Zealand. By 1952, the insect was introduced into Australia with similar consequences (Ohmart 1980). *Sirex noctilio* is now found in Brazil infesting plantations of *Pinus taeda*. This siricid was identified as potentially the most destructive pest associated with *P. radiata* logs imported to the United States from New Zealand (USDA Forest Service 1992). This species has not been found in Chile to date. If *S. noctilio* were to become established in Chile, the risk of importing this insect into the United States on *Pinus radiata* logs presumably would be similar to that for New Zealand (see USDA Forest Service 1992 for a detailed pest risk assessment and economic evaluation of *S. noctilio*).

The potential threat that *S. noctilio* poses for Chile's pine plantations has long been recognized (Holsten 1970). The possible introduction of this insect pest has become a major concern for Chilean forest entomologists and quarantine officials (Aguilar and Lanfranco 1988). In fact, the Chilean government (SAG) has recently implemented an intensive survey program to facilitate early detection (Marcos Beéche, personal communication). The possible introduction of *U. gigas gigas* into the United States from Chile warrants much less concern than the introduction of *S. noctilio.* Since *U. gigas flavicornis* and other related species occur already throughout the United States as invaders of dead trees and slash, the effects on local resources would probably be minimal. There is no indication that the Chilean *Urocerus* would be more aggressive in competing for this ecological niche.

The following notes summarize the biology, ecology, and life history of the family Siricidae (USDA Forest Service 1992). Typically, the average generation of a siricid wood wasp lasts 2 to 3 years, with adult wasps initiating attacks on wood during the late summer months. Females oviposit deeply into the wood (6 to 20 mm). The number of eggs varies from 1 to 7, averaging 3 to 4 per tunnel. The incubation period is from 3 to 4 weeks. Approximately 21 months are spent in the larval stage. Cutting infested trees for lumber may prolong the length of the larval stage by a year or more. The young larva feeds in the sapwood for 6 to 8 months before moving into the heartwood. The larva usually moves back to the outer sapwood before it pupates. The larval tunnels may vary from 15 to 75 cm in length for various species and are tightly packed with frass.

Wood-destroying fungi are associated with the larval stage of these insects and are introduced into the wood along with the eggs during oviposition (Middlekauff 1960, Stillwell 1960). The larva pupates about 1 to 2 cm from the surface of the wood and remains in the pupal stage from 5 to 6 weeks. Adults emerge in the summer and persist through the fall. Some have been found flying as late as November (in the Northern Hemisphere). These wasps fly mostly in bright sunshine and females usually outnumber the males. Mating takes place in tree tops.

Females usually oviposit in weakened trees, occasionally selecting a healthy tree. Some siricids are attracted to forest fires and it is not unusual to find them ovipositing on smoking logs; others settle on freshly felled trees (Keen 1952) or freshly sawn lumber (Baker 1972). There is little danger of these insects attacking dry, finished lumber products (Keen 1952).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin: *High (VC)***
   Weakened and dead trees (fire-killed, defoliated, windthrown, drought-stressed) and log decks left in the woods can be expected to contain eggs, larvae, and/or pupae of *U. gigas*. Their common occurrence in *Pinus radiata* plantations in Chile means that there is a high probability that some trees being harvested or yarded will contain these siricids. Log decks left in the woods during female flight periods also are susceptible to infestation.

2. **Entry potential: *High (VC)***
   Because eggs, larvae, and pupae are deep in the sapwood of logs, there is a high probability that siricid brood would survive storage and shipment to the United States and emerge after arrival. *Pinus radiata* logs arriving in Sweden from Chile contained siricid life stages (presumably *Urocerus gigas*) in 10 of 14 shipments (Schroeder 1990). The likelihood of introduction of *U. gigas* from Chile into the United States is high; siricids of this genus are commonly intercepted in U.S. ports from various countries (Williams and La Fage 1979).

3. **Colonization potential: *High (VC)***
   The family Siricidae has the capacity to attack most coniferous species and some hardwoods. *Urocerus gigas flavicornis* has a host range in the western

United States that encompasses five conifer genera (Keen 1952). This species breeds in dead and dying conifers. Such hosts are common in the western United States and Canada, particularly following wildfires or prolonged drought.

4. **Spread potential: *High (RC)***
Males and females are strong fliers and are known to fly long distances to recently burned forest sites. Adults also have commonly emerged from finished lumber in homes, pallets, boxes, etc. As such, spread could take place not only directly, but passively as well through transport of infested material unless all lumber is kiln-dried immediately after milling.

B. Consequences of establishment

5. **Economic damage potential: *Low (RC)***
In Chile, *U. gigas gigas* limits its attacks to felled logs or severely weakened trees of *P. radiata*, causing little or no economic damage. *Urocerus gigas flavicornis*, widely distributed in the western United States and Canada, has a similar, nonaggressive habit (Furniss and Carolin 1977). Siricid attacks can result in wood degrade and structural damage. Emergence of siricid adults in new dwellings and furniture is disconcerting and often results in lawsuits by homeowners. However, since *Urocerus* spp. and other siricids are already present in the western United States, the increased damage potential from the introduction of *U. gigas gigas* from Chile would be minimal. If *S. noctilio* (currently not found in Chile) were introduced into the United States, damage would be greater (see USDA Forest Service 1992 for a more comprehensive economic analysis of *S. noctilio*).

6. **Environmental damage potential: *Low (RC)***
It is possible that attacks could occur in severely stressed trees in plantations, causing mortality. Again, this ecological niche in the United States is already occupied by native *Urocerus*, other siricids and bark beetles, such that introduction of the Chilean *Urocerus* would probably not significantly increase this damage potential.

7. **Perceived damage potential (social and political influences): *Low (RC)***
Given the many species of siricid wood wasps native to North America, the addition of one additional invader of weakened trees and logging slash would have negligible social or political impact.

Pest risk potential: *Moderate* (probability of establishment = *High*; consequences = *Low*)

Selected bibliography:

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Reviewers' Comments:
"No basis in fact that *Urocerus* would not be a pest--pure speculation." (Lattin)

"Most if not all siricids including *Urocerus* have a symbiotic relationship with pathogens. As no mention of the pathogens associated with *U. gigas gigas* in Chile was made, I assume it isn't known. If this is the case, I would increase the concern of the potential introduction of this pest into the U. S." (Holsten)

"No information is given to support the <u>belief</u> that the possible introduction of *U. gigas gigas*...warrants much less concern than the introduction of *S. noctilio*. Could *U. gigas gigas* from Chile have a pathogenic fungus that would be devastating to North American forests? I believe that we should assume a worst case scenario here." (D. Wood)

"Several of the fungus symbionts are more than decomposers. There are several pathogenic fungi associated with siricids, e.g., *Stereum*, *Amylostereum*, *Daedalia*... To assume that *Urocerus* will cause minimal problems if introduced into the U. S. is dangerous and unjustified." (Cobb)

<u>Response to comments:</u> Our pest risk assessment of *U. gigas gigas* resulted in a pest risk potential of moderate based on what is known about the biology of *Urocerus* species in the United States (Furniss and Carolin, 1977) and in Chile. Although they probably transport symbiotic fungi, no *Urocerus* species has been found to exhibit the tree-killing capabilities of *Sirex noctilio*. *Urocerus gigas gigas* in Chile appears to have behavior very similar to that of *U. gigas flavicornis* in the United States; the latter is considered a secondary insect involved in the decomposition process. Because *U. gigas gigas* is an insect that attacks dead or moribund hosts, it is not considered a pest in Chile or elsewhere in its present distribution. In light of the high probability of establishment of this insect, we have kept the overall rating as moderate in spite of the low rating for the consequences of establishment.

Wood-Boring Beetles of Pine

Scientific names of pests: *Buprestis novemmaculata* L. (Coleoptera: Buprestidae), *Callideriphus laetus* Blanch., *Colobura alboplagiata* Blanch. o Sol. (Coleoptera: Cerambycidae).

Scientific names of hosts: *Buprestis novemmaculata* on *Pinus radiata* (in Chile), *Pinus* spp.; *Callideriphus laetus* on *Pinus radiata*, *Cryptocaria alba*, *Nothofagus dombeyi*, *Malus sylvestris*, *Eucalyptus* spp. (Barros 1936, Durán 1963); *Colobura alboplagiata* on *Pinus radiata* (Billings and Holsten 1969a), native hardwoods.

Distribution: *Buprestis novemmaculata*--native to Europe; in Chile, distributed from region V to region IX; *Callideriphus laetus*--Chile, from Santiago to region X; *Colobura alboplagiata*--Chile, collected on pine in region VII (Billings and Holsten 1969a).

Summary of natural history and basic biology of the pests: These wood borers are usually associated with dead limbs, stumps, logs that have aged for at least 1 year, and dying or fire-killed pines (Durán 1963, Francke-Grosman 1963a, Billings and Holsten 1969a, Gara et al. 1980). Early larval stages feed in the inner phloem and later larval stages feed in the wood. Larvae of *B. novemmaculata* may penetrate throughout older logs or stumps. *Callideriphus laetus* commonly attacks dead or dying limbs and thin-bark portions of dead trees (Barros 1936, Durán 1963, Billings and Holsten 1969a). Little is known about the life cycle of these insects, other than that more than 1 year is required to complete a generation (Gara et al. 1980). Adults of *Colobura alboplagiata* are found especially in late fall (May), and occasionally in September (Eglitis and Holsten 1972). Pupae of *B. novemmaculata* have been observed in November (Holsten et al. 1970) and adults have been collected from foliage of *P. radiata* from December through April, being particularly abundant in mid-summer (January-February) (Eglitis and Holsten 1972). Winter is passed in the larval stages. *Callideriphus laetus* is presumed to have a similar life cycle, with adults appearing in December (Gara et al. 1980).

Specific information relating to risk elements:
A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RC)***
   Logs of *Pinus radiata* are unlikely to be attacked by wood-boring insects of the genera *Buprestis* or *Colobura* unless they have aged for at least a year (Billings and Holsten 1969a). Small-diameter tree tops and dead branches containing larvae of *Callideriphus laetus* would be removed in the harvest process. If logs remain for extended periods at the harvest site or in log decks near forested areas, then wood borers may colonize the logs prior to export. In 14 shipments of debarked pine pulpwood logs sent from Chile to Sweden, 7 contained larvae and adults of *Buprestis novemmaculata*, 3 contained larvae and adults of *Colobura alboplagiata*, and 3 contained larvae of an unidentified cerambycid (Schroeder 1990). In general, it should be noted that pulpwood

logs tend to be exposed to deterioration for longer periods prior to export from Chile than do sawlogs. The fact that adult wood borers were found in shipments to Sweden provides further evidence that at least some of the pulpwood logs had been in storage for 1 year or more before arrival.

2. **Entry potential:** ***High (RC)***
It is anticipated that larvae or pupae would survive transit within infested logs. Early instar larvae feed in the phloem; in debarked logs, some larvae may survive in inaccessible places, such as in crevices formed around the bases of branches (Schroeder 1990).

3. **Colonization potential:** ***Moderate (MC)***
These wood borers have become adapted to *Pinus radiata* in Chile and may well be able to complete development on other conifer or hardwood species found in the western United States and Canada. *Buprestis novemmaculata* was successfully introduced into Chile from Europe, demonstrating its potential for surviving long-distance travel and for establishment, despite reversal of seasons. Presumably, this insect entered Chile in packing crates or dunnage, because Chile prohibits the import of logs.

4. **Spread potential:** ***High (MC)***
Buprestids and cerambycids are relatively strong fliers. If the species in Chile become established in the western United States, they should encounter ample hosts in the form of older stumps, downed logs, and dead limbs, despite harvest restrictions on Federal lands. *Buprestis novemmaculata* has spread throughout the major *P. radiata* regions of Chile since being introduced around 1940 (Olave 1953). These insects, however, would have to compete for hosts with numerous indigenous wood-boring cerambycids and buprestids common in the western United States.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (RC)***
These wood borers are secondary insects, preferring to attack downed logs, stumps, dead or dying branches and severely-weakened trees. They should pose no risk to healthy, well-managed forests. In situations where forests are under stress from wildfire or prolonged drought, however, these insects may be able to infest living trees but would be competing with the plethora of native bark beetles and wood borers that already occupy this ecological niche. The broad host range and adaptability of Chilean woodborers suggests that these insects may cause increased economic damage to a variety of forest and ornamental tree species under stress if introduced into the United States.

6. **Environmental damage potential:** ***Low (RC)***
Since they confine attacks to dead or dying trees and logging slash, these wood borers would have no detrimental environmental effects. In fact, the tendency of *B. novemmaculata* to infest slash and stumps would aid in decomposition.

7. **Perceived damage potential (social and political influences):** ***Low (RC)***
These wood borers would go largely unnoticed, because they occupy a secondary role, seldom attacking live trees.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*;
consequences = *Moderate*)

Selected bibliography:

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Reviewers' comments:
"Throughout this assessment, the conclusion (re: environmental damage) ignores numerous potential impacts, especially those related to biological diversity and ecological functions. In this case, I am very uncomfortable with the assumption that attacks will be confined to dead or dying trees and logging slash. Forest pathology has many examples of organisms that are almost non-pathogens on native host species or natural habitats but are aggressive pathogens on exotics or even natives only short distances from their natural habitats. If the potential losses were inconsequential, I would not be so concerned, but the losses could be astronomical if we use poor judgement." (Cobb)

"There is no evidence offered that the introduced species would be 'outcompeted' by native species. If that was true, we would have no pests in our native forests west or east." (Lattin).

Response to comments: The assessment team found no evidence that these wood boring insects are capable of infesting healthy trees or even freshly cut logs of *P. radiata*. But, given the wide host range (both hardwood and conifers) demonstrated by the native Chilean wood borers, and in light of reviewer concerns, the assessment team increased the pest risk potential from low to moderate for this group of insects.

<u>Termites of Pine</u>

Scientific names of pests: *Cryptotermes brevis* Walker, *Neotermes* (=*Kalotermes*) *chilensis* (Blanch.) (Isoptera: Kalotermitidae), *Porotermes quadricollis* (Rambur) (Isoptera: Termopsidae).

Scientific names of hosts: *Nothofagus* spp., *Laurelia* spp., *Aextoxicon punctatum*, and other native hardwoods; *Pinus radiata*, *Pseudotsuga menziesii*, *Eucalyptus globulus*, *Populus* spp., *Salix* spp.

Distribution: *Cryptotermes brevis*--introduced into the United States and occurs along the Gulf Coast and as far north as Tennessee. In Chile, *C. brevis* is found exclusively in the arid northern regions (Copiapó to Arica) (Micheli and del Río 1967) and on Easter Island (Peña 1986). *Neotermes chilensis*--common throughout the central and southern regions of Chile (regions IV to VIII), both in dead trees and wood in use. *Porotermes quadricollis*--found in southern Chile throughout regions V to XII (Villán 1972), characteristically under moist conditions (González 1989).

Summary of natural history and basic biology of the pests: *Neotermes chilensis* is commonly associated with native and exotic hardwoods and conifers in central and southern Chile. It is seldom found on living trees, preferring well-aged downed logs or decomposed stumps to make nests. The life cycle and basic biology of *N. chilensis* is similar to other members of the family Kalotermitidae (see Moore 1979). The adults swarm in late summer or autumn and are attracted to lights. The duration of the various life stages is unknown. They are normally found in the heartwood of old trees or under the bark of logs left on the ground for more than 6 months. The galleries are loosely packed with frass. The use of young (25 to 30 years of age) *Pinus radiata* trees for log exports would make this termite an unlikely pest.

The Chilean dampwood termite, *Porotermes quadricollis*, is commonly found in dead trees, old logs and stumps of pine and old standing trees of native hardwoods under damp conditions (Araujo 1979). Wood in use also may become infested with these termites under similar conditions of high humidity (González 1989). In eastern Australia and Tasmania, a related species, *Porotermes adamsoni* Froggatt, is often very destructive to living *P. radiata* and *Eucalyptus*. Attacks are initiated through injured roots or stems and develop slowly, but eventually result in the degrade or destruction of about 50% of the timber in the stand. This termite infests heartwood in preference to sapwood, and characteristically produces a cylindrical pipe in the stem of the host (Browne 1968). There is no evidence that the Chilean species of *Porotermes* is capable of attacking live trees and causing this type of damage. The drywood termite, *Cryptotermes brevis*, only infests wood in use having a low moisture content.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (MC)***
Neotermes chilensis and *Porotermes quadricollis* are seldom found in live plantation-grown Monterey pine, restricting their invasion to dead trees, stumps, or trees severely weakened by fire or other causes. The probability of termites occurring on pine logs for export will depend on how rapidly the logs are removed from the forest and shipped after the trees are felled. Also, *N. chilensis* adults are attracted to lights and may be carried on log shipments as hitchhikers during the swarming season (March-April). *Cryptotermes brevis* does not occur in the damp regions where pine is grown and exported, so should be of no concern as a pest of pine logs.

2. **Entry potential:** ***Moderate (RC)***
Drywood termites (*Neotermes chilensis*) are more likely to survive in unprocessed and untreated logs during transit than dampwood termites (*Porotermes quadricollis*). Unlike drywood termites, dampwood termites require more moisture than is normally in wood, so they are not readily transported over long distances (Williams and La Fage 1979). Termites can usually be observed between the bark and the wood. Schroeder (1990) reported finding adults of *Kalotermes* (*Neotermes*) *chilensis* in 3 of 14 shipments of *Pinus radiata* pulpwood logs imported into Sweden.

3. **Colonization potential:** ***Moderate (RC)***
As with other termites, the establishment of a colony of *Neotermes* or *Porotermes* is a slow process. Colonization of dampwood termites would be favored along the coast of the Pacific Northwest, due to favorable (damp) environmental conditions (Moore 1979), but environmental resistance from competing species of termites may hinder establishment. Also, because adults swarm only once per year, most sawlogs would be processed before winged termites could mature.

4. **Spread potential:** ***Moderate (MC)***
Termites, including drywood termites, spread slowly (50 to 1,000 feet per year) because they are poor flyers and only about 1% of those that fly are likely to establish a new colony. Spread potential is considered moderate, however, because people may physically move infested wood over long distances (USDA Forest Service 1992).

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (RC)***
Neotermes chilensis will attack untreated wood and damage can be serious. Occasionally, *P. quadricollis* also infests wood in use if conditions are damp, with poor ventilation. Termite damage is difficult to detect. If introduced,

however, these termites would have to compete with the other 43 species of termites already found in the contiguous United States. The USDA Forest Service (1992) estimates that an additional drywood termite species in the United States could cause an added $75,000 to $500,000 in damages per year after 10 to 15 years of establishment along the Pacific Coast. In forest situations these termites would attack dead trees and stumps, causing no economic concern.

6. **Environmental damage potential:** ***Low (VC)***
Neither *N. chilensis* or *P. quadricollis* would infest or kill healthy trees but would compete with native insects that degrade and decompose dead or dying host material.

7. **Perceived damage potential (social and political influence):** ***Low (VC)***
These termites would not cause aesthetic damage in the forest. Damage to wood in use could cause public concerns, as do other termite species. Controls for termites are available, but can be expensive.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*; consequences = *Moderate*)

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Micheli, H.; del Río, E. 1967. El ataque de termites a la madera en el norte de Chile y su prevención. Informe Técnico 23. Santiago: Instituto Forestal. 24 p.

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Villán E., L. A. 1972. El género *Porotermes* Hagen en Chile (Isoptera: Termopsidae). Boletín de la Sociedad de Biología de Concepción (Chile) 44: 39-46.

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Reviewers' comments:

"We should conclude that a member of the same genus is destructive to living *P. radiata*. Therefore the 'potential' for a similar biology exists should *P. quadricollis* be introduced into North America." (D. Wood)

"These termites could become serious pests of 'wood-in-service,' especially *N. chilensis*. We cannot assume that a foreign species will be out-competed by native species. We should not forget that the Formosan termite is out-competing the native subterranean termites in the southern U. S. and now in southern California. Damage to wood-in-service is expensive. Some economics should be added on this potential impact." (D. Wood)

"With the termites, *Neotermes chilensis* and *Porotermes quadricollis* will become established with moderate consequences--can we tolerate this? Probably need to treat logs." (Solomon)

"I see no need for much change in this section. Although some points, such as the colonization and spread potential, are debatable, the moderate risk assessment is appropriate (and on the safe side) for infestation of Monterey pine in Chile, entry potential, colonization potential, spread potential, and economic damage potential...I believe that drywood and dampwood termites would likely survive during transit from Chile to the United States...Your statements about the limited areas (Pacific Northwest) that are suitable for establishment and survival of dampwood termites are correct. Therefore, I believe that the drywood termite *Neotermes chilensis* has a greater potential for colonization and spread in the United States than *Porotermes quadricollis*." (Mauldin)

"Do you have any idea why the Chilean *Porotermes* is less aggressive than the Australian one? Unless there is solid evidence to explain the difference, it may not be safe to assume that the Chilean termite cannot do similar damage." (Cobb)

"*Neotermes chilensis* and *Porotermes quadricollis* do not feed on bark of Monterey pine; accordingly, they should be considered as hitchhikers only...*Cryptotermes brevis* should be placed in category 1d (non-quarantine insect), because it is established in the U. S. and is not subject to active control. Being an insect typical of tropical and subtropical areas, it is unlikely to spread farther north in the U. S. than its current distribution." (Beéche, Cerda, Vallejos, translated from Spanish)

"*Cryptotermes brevis*, an introduced insect, is found only in the most arid regions of northern Chile; as a result it would not occur with forest products exported from southern Chile. Thus, a category of 1d would be more appropriate." (Ojeda, Baldini, translated from Spanish)

"We consider that *Porotermes quadricollis* and *Neotermes chilensis* have a low colonization potential. Given the presence of adults as hitchhikers on logs, these would have difficulty becoming established due to the reversal of seasons. Even if termite colonies were present within logs, these too would have little possibility of becoming established; the rapid processing of logs would destroy any colonies that were present." (Beéche, Cerda, Vallejos, translated from Spanish)

Response to comments: Emphasis in the IPRA on termites of pine is placed on those species of termites most likely to be associated with *Pinus radiata* in Chile, specifically the drywood termite *Neotermes chilensis* and the dampwood termite *Porotermes quadricollis*. Neither of these termite species has presented a problem to production of *P. radiata* in Chile; both act solely as decomposers. *Cryptotermes brevis* is only recorded on *P. radiata* wood in use. The moderate pest risk potential given termites on pine appears justified due to the occurrence of *Neotermes chilensis* adults on previous log shipments (to Sweden) and their potential as pests of wood in use. As a measure of potential economic impact, estimates for the New Zealand drywood termite *Kalotermes brouni* (USDA Forest Service 1992) are indicative of potential damage due to *Neotermes chilensis*. Accordingly, these damage estimates were included above in the section on economic damage potential.

Spiny Caterpillar of Pine

Scientific name of pests: *Ormiscodes cinnamomea* Feisth. (= *Dirphia amphimone* F. Berg.) (Lepidoptera: Saturniidae).

Scientific names of hosts: *Nothofagus obliqua, Schinus latifolius, Nothofagus glauca, Populus nigra* var. *italica, Pinus radiata, Pseudotsuga menziesii, Cupressus* spp., *Juglans regia*, various native shrubs.

Distribution: Chile; distributed from region IV to region X, most common to regions VII and VIII where *Pinus radiata* is most abundant (Yudelevich 1953b, Billings and Holsten 1969a).

Summary of natural history and basic biology of the pest: This native insect has long been known in Chile by the common name "cuncuna del álamo y del nogal" (poplar and walnut caterpillar) (Silva 1917b), testifying to its association with these exotic hardwood hosts. This insect also has presented problems as a defoliator in native hardwood nurseries (Gara 1992). With the introduction of *Pinus radiata* into Chile and its extensive use as an exotic, *Ormiscodes cinnamomea* expanded its host range to conifers, particularly Monterey pine, earning the common name of pine caterpillar ("cuncuna de los pinos") as early as 1944 (Durán 1944, Yudelevich 1953b). This insect also has been observed defoliating Douglas-fir (Billings and Holsten 1969a, Naray 1979) and cypress (Billings and Holsten 1969a).

Ormiscodes cinnamomea produces a single generation annually throughout most of its range. A single reference (Villa and Ojeda 1981) has suggested that two generations may be completed per year in the northern extremes of its ranges (region IV). Larval populations occur on host trees from the middle of July until the end of December (Billings and Holsten 1969a, Parra et al. 1985a), but are most abundant between September and November (spring) (Yudelevich 1953b, 1954). Early instar larvae typically feed gregariously, beginning near the top of the tree and proceeding downward, completely defoliating smaller pines (Villa and Ojeda 1981). Late instar larvae become more widely dispersed on host trees and understory vegetation. The larva has a black head capsule and a black body, the latter covered with reddish-brown branching urticating spines. Upon completing its development, the mature larva crawls down the host tree in search of a protected place to pupate. Pupation takes place from the end of October until the middle of March (with some geographical variation). Pupae may be found in the duff at the base of host trees, under fallen trees or logs, and occasionally in bark niches on the lower trunk of infested trees (R.F. Billings, personal observation).

Adult moths emerge during the fall (February through May), being most abundant in March or April (depending on the latitude). Adults rest during the day on the foliage or trunks of pines or other hosts, flying only at night. Both males and females respond to light. The female oviposits 200 to 300 eggs in rings around small limbs or needles of host trees in protected places. The insect overwinters in the egg stage; eggs can be observed from the end of February until the first of September (Parra et al. 1985a).

Localized outbreaks of *O. cinnamomea* are rather common in plantations of Monterey pine in Chile, with individual trees being completely defoliated in scattered epicenters (Yudelevich 1953a, 1953b; Billings and Holsten 1969a). In 1977 and 1978, scattered pockets of severe defoliation occurred over several hundred hectares in young *Pinus radiata* plantations in region VIII (Gara 1978). In 1979, this insect was observed to cause over 50% defoliation in a 25-ha pine stand near Quintay (region V) (Gara 1992). Most defoliation has been noted in young plantations, due to the preponderance of young age classes of *P. radiata* in Chile. The insect, however, is capable of defoliating pines of all ages, often causing measurable growth losses (Yudelevich 1953b).

This insect has a variety of native parasites, predators, and diseases which help to maintain natural populations under control in most cases. These include chalcid egg parasites (*Dirphiphagus* sp., *Paridris* sp.), braconid larval parasites (*Apanteles* spp.) (Silva 1917a, 1917b; Durán 1944; Yudelevich 1953b) and a fungal pathogen (*Entomophthora* spp.) (Olalquiaga 1963-4). Larvae also may be killed by an unidentified microbial agent that causes symptoms characteristic of a nuclear polyhydrosis virus (R. F. Billings, R. S. Cameron, personal observations). Most outbreaks seldom last more than 1 year due, presumably, to these natural control factors. Similar dynamics appear typical for many indigenous defoliating insects that have adapted to exotic plantations of *P. radiata* in other countries (Ohmart 1980).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Low (RC)***
   This insect is distributed throughout the *Pinus radiata* zone and is the most commonly encountered defoliating insect in pine plantations. It is conceivable that eggs, larvae, or pupae of this pest could be transported to the United States on unbarked logs. Adult moths are attracted to lights. However, outbreaks are usually localized, and life stages generally do not occur in direct contact with logs but would remain at the harvest site on foliage or branches (eggs, larvae) or in the duff (pupae).

2. **Entry potential:** ***High (RC)***
   It is anticipated that eggs on foliage or pupae on the bark of logs would survive transit to the United States.

3. **Colonization potential:** ***Moderate (MC)***
   Colonization potential is expected to be moderate for adults and low for eggs that arrive with log shipments. This pest has become adapted to exotic conifers and shows a preference for foliage of Douglas-fir and poplar. Most ports along the Pacific Coast have suitable conifer or hardwood hosts nearby. The overwintering stage (eggs) may encounter favorable seasonal conditions when brought to the western United States from March to July due to the reversal of seasons, but first instar larvae may have difficulty successfully dispersing from logs to fresh foliage. Unlike gypsy moth, first instar larvae

do not spread by ballooning on silk threads, but would be forced to crawl from logs in search of food; mortality would be high. Adults emerging from pupae could fly to suitable hosts near ports of entry, but would need to attract mates to successfully reproduce. Late-season arrivals also may have insufficient time to complete their life cycle prior to winter even if they encounter a source of food.

4. **Spread potential:** ***Moderate (MC)***
If this insect becomes established without its native natural enemies, spread potential would be moderate. Due to this pest's univoltine life cycle, spread would be slower than for multivoltine insects. The wide host range and ability to adapt to new hosts would tend to increase spread potential, however.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (MC)***
Growth loss of host trees would result from severe defoliation, but tree mortality is unlikely unless hosts are completely defoliated for 2 or more years in succession. Defoliation of young trees may be sufficient to reduce growth for the year in which the defoliation occurs. Growth loss in young trees has the effect of lengthening the rotation an amount equal to the interval of defoliation. If these insects were to become established in the United States without the myriad of biological control agents that keep populations in check in Chile, outbreaks may be more prolonged and the adverse impact on host trees considerably more severe. In turn, the existence of natural control agents in Chile suggests that biological control in the United States would be possible.

6. **Environmental damage potential:** ***Low (RC)***
In Chile, defoliated trees seldom die, so environmental damage potential is considered to be low. If tree mortality were to result from prolonged outbreaks or successive defoliations in the United States, then the environmental impact would increase to levels similar to that associated with indigenous defoliating insects.

7. **Perceived damage potential (social and political influences):** ***Moderate (RC)***
Defoliated trees could cause public concern, particularly in urban situations. In addition, the presence of large, conspicuous larvae with urticating spines would create a public nuisance and social concern, perhaps exceeding the economic damage due to sporadic defoliation.

Pest risk potential: *Moderate* (probability of establishment = *Low*; consequences = *Moderate*)

Selected bibliography:

Artigas, J. N. 1972. Ritmos poblacionales en lepidópteros de interés agrícola para Chile. Boletín de la Sociedad de Biología de Concepción (Chile) 45: 5-94.

Billings, R. F.; Holsten, E. H. 1969a. Progreso realizado en la investigación de insectos forestales de pino insigne (Dic. 1967 hasta Agosto 1969). Santiago: División Forestal, Servicio Agrícola y Ganadero, Universidad de Chile, Cuerpo de Paz. 49 p. (Mimeographed report).

Durán M., L. 1944. Las cuncunas de los pinos--un problema de entomología forestal. Agricultura Técnica (Santiago) 4(1): 17-25.

Gara, R. I. 1978. Forest protection in Chile: a national plan. Santiago: Corporación Nacional Forestal, United Nations Food and Agriculture Organization CHI-76/003. 140 p. (Mimeographed report).

Gara, R. I. 1992. Introduction of insect pests from Chile. In: Log imports and introduced forest pests into the Pacific Northwest. Symposium Proceedings, Oregon State University, Corvallis; 21-23 April, 1992. 6 p.

Naray O., J. 1979. Algunos saturnidos (Lep.: Saturniidae): defoliadores de especies forestales. Informe de Convenio 17. Valdivia: Facultad de Ingeniería Forestal, Universidad Austral de Chile. 20 p.

Ohmart, C. P. 1980. Insect pests of *Pinus radiata* plantations--present and possible future problems. Australian Forestry 43(4): 226-232.

Olalquiaga F., G. 1963-4. *Ormiscodes cinnamomea* Feisth. Saturniidae. Agricultura Técnica (Chile) 23-24: 82.

Parra, L. E.; Angulo, A. O.; Jana-Saenz, C. 1985a. Biología y estados inmaduros de dos mariposas saturnidas chilenas (Lepidoptera: Saturniidae): carateres diagnósticos diferenciales específicos. Boletín de la Sociedad de Biología de Concepción (Chile) 56: 131-139.

Silva F., C. 1917a. La *Dirphia amphimone* (F.) Berg. y sus parásitos. Boletín del Museo Nacional de Historia Natural (Santiago) 10: 105-114.

Silva F., C. 1917b. Los parásitos de la cuncuna del álamo y del nogal. Boletín del Museo Nacional de Historia Natural (Santiago) 10: 115-128.

Villa S., A.; Ojeda G., P. 1981. La cuncuna espinuda, un insecto nativo, defoliador de pino insigne (*Ormiscodes* sp., Lepidoptera: Saturnidae). Folleto de Divulgación Año 2, No. 5. Santiago: Corporación Nacional Forestal. 4 p.

Yudelevich, M. 1953a. Las plagas que atacan al *Pinus radiata* en las provincias de Linares a Malleco. In: Mensura de las Plantaciones de Linares a Malleco--1953-1954. Santiago: Sección de Estudios Industriales, Corporación de Fomento de la Producción 1(4): 48-50 y Anexo C: 66-75.

Yudelevich, M. 1953b. Cuncunas de los pinos. Santiago: Instituto Forestal. 20 p. (Mimeographed report).

Yudelevich, M. 1954. La cuncuna de los pinos. El Maderero (Santiago) 4(7): 1-4.

Reviewer's comments:
"The pupae of *O. cinnamomea* are in the litter and duff. I would think that litter with pupae could easily become attached to logs. I would, accordingly, increase the entry potential of this defoliator...If a defoliator such as *O. cinnamomea* were to be established in intensively managed Douglas-fir stands [in the PNW], rotations would lengthen, and the commercial feasibility of carrying capital investments through a 40 to 50 year rotation may become even more marginal than they seem currently. I would raise the damage potential to high. Especially, in light of the tremendous ecological plasticity that this defoliator apparently has...Might *O. cinnamomea* become established in ornamental trees? If so, social costs might also warrant a higher risk rating." (Gara)

"We have many poplar plantations in the Northwest that would be at risk [to *O. cinnamomea*]...A very serious potential problem for Douglas-fir, yet considered only of low risk." (Lattin)

"The assessment that the risk of introduction and establishment of *Ormiscodes* is low appears reasonable. However, it should be presented in the context that even a low risk is still a risk and that with increasing importations a low risk associated with a small number of shipments can become a high risk that cannot be accepted." (Cobb)

"A basic condition stated at the beginning of this report was that <u>no</u> mitigation procedures would be considered. You have assigned a low entry potential to this insect based on excluding all foliage and bark, with all mitigation procedures. Is this appropriate?" (Cobb)

Response to comments: In response to concern by reviewers, the entry potential for *Ormiscodes cinnamomea* was increased to high and economic damage potential was increased to moderate, resulting in an overall pest risk potential of moderate (rather than the low ranking assigned in the draft). Due to biological constraints that would reduce the likelihood of this pest becoming a major defoliator in the United States, the team does not anticipate that the economic damage or overall pest risk would be high.

Bagworm of Pine

Scientific name of pest: *Thanatopsyche chilensis* Phil. (Lepidoptera: Psychidae)

Scientific names of hosts: Hardwood hosts include *Aristotelia chilensis*, *Schinus* spp., *Populus* spp., apricot and various other fruit trees (Olalquiaga 1953); conifer hosts include *Pinus* spp., *Cupressus* spp., *Sequoia sempervirens*, *Taxodium distichum*, *Abies* spp., and *Thuja* spp. (Capdeville 1945, Billings and Holsten 1969a).

Distribution: Chile (Reed 1871)--found from the metropolitan region of Santiago to region IX (Billings and Holsten 1969a).

Summary of natural history and basic biology of the pest: As with other bagworms, *Thanatopsyche chilensis* feeds on foliage of a wide variety of host plants from within a tough, silk-lined bag constructed of leaf fragments. The female is wingless and remains in the bag throughout her life cycle, attracting a winged male at time of mating. The female deposits her eggs inside the bag, which she fastens to twigs for overwintering. In late spring, the eggs hatch and young larvae may disperse to new hosts by ballooning on silken threads. Upon arrival on a suitable host, the larva encloses itself in a protective bag and feeds until mid-summer, when it pupates. Adults appear in late summer or fall. This bagworm has one generation per year in Chile. It feeds on a wide variety of hardwood and conifer trees, particularly conifers of the genera *Cupressus* and *Pinus* (Olalquiaga 1953, Herrera and Carraseo 1964, Gara et al. 1980). Adaptations of bagworms that aid survival and increase their importance as potential quarantine pests are the ability to go without food for long periods, acceptance of many different plants for food, use of any support for the necessary attachment of the bag for pupation, and production of many eggs by a single female (Davis 1964, Wollerman 1965). *Thanatopsyche chilensis* is not considered a serious pest of *P. radiata* in Chile because populations seldom reach levels that cause defoliation of economic importance (Billings and Holsten 1969a).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Low (RC)***
   It is conceivable that bagworms could become attached to bark of *Pinus radiata* logs or young larvae could blow onto decked logs awaiting export. The probability of occurrence with pine logs is considered low because the insects are relatively uncommon and most are attached to small branches with foliage, which are not transported out of the harvest site.

2. **Entry potential:** ***Moderate (MC)***
   Larvae or pupae inside bags attached to logs are more likely to survive in transit than young, exposed larvae that may disperse to logs by ballooning. Larvae can survive for long periods without feeding.

3. **Colonization potential:** ***Low (RC)***
This bagworm has been collected in Chile on a variety of conifers native to the United States, including Monterey Pine, true fir, redwood, hemlock, cedar and poplar, as well as fruit trees. Thus, suitable hosts would be readily available near ports along the Pacific and Atlantic Coasts of the United States. Nevertheless, because the females are wingless, it would be difficult for them to travel from logs to suitable food sources upon arrival at ports of entry.

4. **Spread potential:** ***Low (MC)***
Females are wingless; first instar larvae are capable of limited dispersal by ballooning on silken threads.

B. **Consequences of establishment**

5. **Economic damage potential:** ***Low (MC)***
Bagworms are solitary feeders with limited dispersal potential. If they became established in the United States, they would likely become of greater importance on ornamental trees than in native forests. Arborvitae and juniper may die following complete defoliation by bagworms and less severe attacks retard growth (Wollerman 1965).

6. **Environment damage potential:** ***Low (RC)***
The environmental impact of this insect is expected to be low in forest situations, because the bagworms seldom cause noticeable defoliation, except occasionally on young trees.

7. **Perceived damage potential (social and political influence):** ***Low (RC)***
The bag resembles plant material and usually escapes notice by the untrained observer. Heavy defoliation of ornamental trees and shrubs may cause public concern.

Pest risk potential: ***Low*** (probability of establishment = *Low*; consequences = *Low*)

Selected bibliography:

Billings, R. F.; Holsten, E. H. 1969a. Progreso realizado en la investigación de insectos forestales de pino insigne (Dic. 1967 hasta Agosto 1969). Santiago: División Forestal, Servicio Agrícola y Ganadero, Universidad de Chile, Cuerpo de Paz. 49 p. (Mimeographed report).

Capdeville C., C. 1945. Plagas de la agricultura en Chile. Quillota, Chile: Academia Chilena de Ciencias Naturales. 337 p.

Davis, D. R. 1964. Bagworm moths of the western hemisphere. Smithsonian Bulletin 244. Washington, DC: Smithsonian Institution. 1-233.

Gara, R. I.; Cerda M., L. A.; Donoso M., M. A. 1980. Manual de entomología forestal. Valdivia: Departamento de Silvicultura, Universidad Austral de Chile. 61 p.

Herrera, J.; Carraseo, J. 1964. Biología de *Thanatopsyche chilensis* Ph. Publicación del Centro de Estudios Entomológicos 6. Santiago: Facultad de Filosofía y Educación, Universidad de Chile: 33-66.

Olalquiaga F., G. 1953. Insectos que atacan los árboles forestales y sus productos en Chile. Santiago: Departamento de Investigaciones Agrícolas, Ministerio de Agricultura. 37 p. (Mimeographed report).

Reed, E. C. 1871. La *Psyche chilensis*. Anuales de la Universidad de Chile 38(1): 197-198.

Wollerman, E. H. 1965. Bagworm. Forest Pest Leaflet 97. Washington, DC: U.S. Department of Agriculture, Forest Service. 7 p.

Reviewers' comments:
"Wingless females have not stopped the introduction and establishment of the winter moth." (Lattin)

"*Thanatopsyche chilensis* does not feed in the bark or cambium of Monterey pine. Its presence on logs would be as a hitchhiker." (Beéche, Cerda, Vallejos, translated from Spanish)

Response to comments: We agree that the bagworm would only occur on logs as a hitchhiker, as shown on table 7-1. Accordingly, we revised table 4-1, showing the bagworm only as a pest of foliage. No changes in the pest risk ratings were deemed justified.

White Grubs of Pine

Scientific names of pests: *Hylamorpha elegans* (Burm.), *H. cylindrica* Arrow, *Brachysternus prasinus* Guér., *Sericoides germaini* Dalla Torre (Coleoptera: Scarabaeidae).

Scientific names of hosts: *Nothofagus obliqua, N. dombeyi, Myrceugenella apiculata, Pinus* spp., *Fraxinus* spp., *Betula* spp.

Distribution: *Hylamorpha* spp.--central and southern Chile from region VIII to region X including Chiloe Island; *Brachysternus prasinus* and *Sericoides germaini*--southern Chile from region VII to region XI.

Summary of natural history and basic biology of the pests: *Hylamorpha elegans*--Adults of these scarab beetles fly during the summer (mid-November to the end of February) and feed on foliage of pines (Billings and Holsten 1969b) and/or *Nothofagus* spp. In some cases, large trees are completely defoliated by feeding adults (Durán 1952). Eggs are laid in the ground in pastures or nurseries and larvae are found in the soil from January through November where they feed on plant roots. During the spring when soil moisture is high, the larvae are found at the depth of plant roots, but as the soil dries during the summer, they move deeper into the ground. Pupation occurs in the soil and adults emerge in the early summer, completing one generation per year. In Chile, white grubs have been pests in *Pinus radiata* nurseries (Peredo et al. 1981) where these nurseries were established in old pastures. Larvae of these white grubs have also been found within decaying logs, where their feeding habits appear to be similar to the family Lucanidae, serving as agents of decomposition. Adults fly at night and are attracted to lights. White grubs of the genera *Brachysternus* and *Sericoides* have life cycles similar to *Hylamorpha* (Durán 1963, 1964).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Low (VC)***
   Given the adult habit of feeding on tree foliage and the larval habit of feeding on roots or decomposing wood, the likelihood of association of these insects, in any stage, with pine logs is considered to be extremely low. However, if logs were loaded at night during the summer, there would be a good possibility that these beetles would be attracted to lights and could be brought in as hitchhikers.

2. **Entry potential:** ***Low (RC)***
   Due to the reversal of seasons between the hemispheres, if adult beetles were able to survive transit to the United States on log shipments, they would arrive in the winter and as a result, probably would not be able to find suitable conditions for oviposition in the Pacific Northwest. Those insects arriving alive on log shipments in the warmer climates of southern California during winter months would be more likely to successfully reproduce. Nevertheless, probabilities of adult scarabs surviving the 2-week voyage would be low.

3. **Colonization potential:** ***Moderate (RC)***
Pinus, *Fraxinus*, and *Betula* would serve as host genera in the United States for these Chilean scarabs. Ornamental beeches could also be potential hosts because these insects feed on *Nothofagus* in their native country. Assuming that adult stages successfully entered the United States, larvae would be able to survive on various grass or perennial roots. The possibility of establishment in urban settings with suitable hosts is more likely for these polyphagous insects than for monophagous species.

4. **Spread potential:** ***Moderate (RC)***
If these polyphagous insects become established on hardwoods or conifers in the United States, their spread would occur at moderate rates. Larvae feed on roots of herbaceous and perennial plants and should have no problem encountering suitable host plants along the Pacific Coast of North America.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (MC)***
Damage would probably be most likely on ornamental trees, given the known host range and high defoliating capability of adult beetles. The extent of the new host range would be a key factor in the resultant economic damage. According to J. D. Solomon (personal communication), larval feeding on roots of hardwood and conifer seedlings can cause serious losses on occasion. This fact supports a moderate rating for economic damage potential.

6. **Environmental damage potential:** ***Low (MC)***
Occurrence of these insects in the urban setting on ornamental trees could lead to increased use of insecticides, with some negative consequences associated with their misuse.

7. **Perceived damage potential (social and political influences):** ***Low (MC)***
Feeding by voracious insects such as these scarabs in their adult stage can contribute to perceived problems far in excess of their real effect. It is not known that defoliation by these scarab beetles causes tree mortality, but the perception would lead to requests for suppression action. This perceived damage would be greater in urban settings than in the forest.

Pest risk potential: ***Low*** (probability of establishment = *Low*; consequences = *Moderate*)

Selected bibliography:

Billings, R. F.; Holsten, E. H. 1969b. Prospección sanitaria de los bosques de pino insigne en Chile. Santiago: División Forestal, Servicio Agrícola y Ganadero, Universidad de Chile, Cuerpo de Paz. 24 p. (Mimeographed report).

Durán M., L. 1952. Aspectos ecológicos de la biología del San Juan verde (*Hylamorpha elegans* Burm.) y mención de las demás especies de escarabeidos perjudiciales en Cautín. Agricultura Técnica (Santiago) 12(1): 24-36.

Durán M., L. 1963. Insectos de importancia económica para la zona austral. Valdivia, Chile: Ministerio de Agricultura, Dirección de Agricultura y Pesca. 73 p.

Durán M., L. 1964. La biología de un escarabeido austral de importancia agrícola y forestal, el *Sericoides germaini* D. T. (Coleoptera: Scarabaeidae). Simiente (Santiago) 34 (1-4): 31-37.

Gara, R. I. 1978. Forest protection in Chile: a national plan. Santiago: Corporación Nacional Forestal, United Nations Food and Agriculture Organization CHI-76/003. 140 p. (Mimeographed report).

Havrylenko, D.; Winterhalter, J. H. 1949. Insectos del Parque Nacional Nahuel Huapi. Buenos Aires: Ministerio de Obras Públicas, Administracion General de Parques Nacionales y Turismo. 57 p.

Peredo, L.; Cerda, L. A.; Rodriguez, C. 1981. Prospección entomológica en viveros de *Pinus radiata* de la decima región. Prospección Nacional de Sanitaria Forestal CONAF-UACH. Informe de Convenio 39. Valdivia: Facultad de Ingeniería Forestal, Universidad Austral de Chile. 31 p.

Reviewers' comments:
"In spite of the many possible host plants, the overall rating is low, that does not make sense." (Lattin)

"White grubs--feeding by the adult scarabs probably least damaging. Larval feeding on the roots of both conifer and hardwood seedlings sometimes destroy stands over wide areas--yet, rated low. I would upgrade this rating to moderate." (Solomon)

"The biology of *Oryctomorphus bimaculatus* is completely different from that of *Hylamorpha* spp. Larvae of the former feed on decomposing wood, similar to larvae of Lucanidae. As for *Brachysternus* and *Sericoides*, we know nothing of the larval feeding habits." (Beéche, Cerda, Vallejos, translated from Spanish)

"Adult scarabs would have little problems finding food near California and southern U. S. ports." (D. Wood)

Response to comments: Based on information provided in the review process by Chilean entomologists on the biology of *Oryctomorphus bimaculatus*, this species of scarab was removed from the list of quarantine pests (table 4-1). In consideration of suggestions from North American reviewers, the economic damage potential of white grubs (*Hylamorpha*, *Brachysternus*, *Sericoides*) was increased from low to moderate. The overall pest risk potential, however, remains low due to minimum association with logs of *P. radiata*, coupled with a low entry potential.

European Pine Shoot Moth

Scientific name of pest: *Rhyacionia buoliana* Den. et Schiff. (Lepidoptera: Olethreutidae).

Scientific names of hosts: Prefers the three-needle pines and has been reported from 30 or more pine species. The most common hosts are *Pinus contorta*, *P. halapensis*, *P. muricata*, *P. nigra*, *P. pinaster*, *P. pinea*, *P. ponderosa*, *P. resinosa*, *P. radiata*, *P. sylvestris*, and *P. taeda*. In Chile, it has been found infesting *P. radiata* and *P. contorta*. There is one report of attacks on Douglas-fir (*Pseudotsuga menziesii*) in Chile (Espinoza et al. 1986), but this appears to be a very uncommon occurrence (Cameron 1990).

Distribution: The European pine shoot moth (EPSM) is widely distributed around the world. It is native to Europe, Asia, and northern Africa and has been introduced into North America (United States and Canada) and South America (Argentina, Uruguay, and Chile). The EPSM was introduced into the United States in the early part of this century and spread across the northern United States and southern Canada despite early attempts with chemical, biological, and quarantine controls (Miller 1967). Distribution to the north in Canada appears to be limited by extreme cold which causes larval mortality. Distribution to the south in the United States ends abruptly at 40° north latitude, apparently due to unsuitable climatic conditions (perhaps high humidity and temperatures).

The EPSM was introduced into Argentina at Buenos Aires in 1939 and now is distributed in scattered locations in the Argentine provinces of Buenos Aires, Cordoba, Santa Fe, and Entre Ríos, as well as in Uruguay. In Chile, the EPSM was first discovered in 1985 (Cerda et al. 1985), although its arrival was anticipated much earlier (Billings 1969, Eglitis and Gara 1974). The pest was presumably introduced from Argentina on two separate occasions; once near Ensenada about 1977 and again near Pucón about 1982 (Aguilar and Beéche 1989). The spread of the EPSM in Chile has been documented by Servicio Agrícola y Ganadero (SAG) using visual surveys to detect larval infestations and pheromone traps to detect the presence of adult moths (Espinoza et al. 1986, 1991; Espinoza and Lobos 1987, 1988b; Espinoza and Cerda 1989). Since 1985, the EPSM has steadily spread northward at a rate of about 40 km per year and is now encroaching into the major pine growing areas in region VIII (Espinoza et al. 1992).

Summary of natural history and basic biology of the pest: Two varieties of EPSM have been recognized in Europe. *Rhyacionia buoliana* var. *buoliana* is distributed to the north, while *R. buoliana* var. *thurificana* is found in the Mediterranean Region (Bodenheimer 1927, Miller 1967). Other species or varieties occur eastward from Europe to Japan. The northern European variety has one generation per year, as does the EPSM in the United States, but *R. buoliana* var. *thurificana* has two generations per year in the Mediterranean area. It has been suggested that the EPSM in Argentina may have more than one generation per year (Eglitis 1974, Eglitis and Gara 1974), but this remains to be confirmed. Considerable confusion exists concerning *R. buoliana* varieties and generations per year, and it is uncertain at this time which variety exists in Chile. However, in regions IX and X of Chile, the EPSM completes only one generation per year (Cerda et al. 1986, Cisternas and Villagra 1991).

The life cycle of the EPSM in Chile is similar to that in northern Europe and North America (Cerda et al. 1986, Aguilar and Beéche 1989). Recently-emerged adults mate and females lay eggs and disperse from late spring (mid-November in Chile) through mid-summer (early February). Eggs are laid at the bases of needles and on buds. The larvae hatch and mine in needles before tunneling inside buds. Larval feeding causes mortality of infested buds during mid-summer. The third-stage larvae then cease feeding and remain quiescent inside their feeding tunnels from late summer through the winter. They resume activity in early spring (September) when they feed in new buds and elongating shoots.

Larval feeding often causes the shoots to form a crook, eventually affecting the form of the main stem. The fully grown larvae pupate inside the feeding tunnels during the spring (October-November) and adults emerge and lay eggs during late spring and early summer. The EPSM is considered the most destructive forest pest of *Pinus radiata* plantations yet to occur in Chile (Alvarez de Araya and Ramírez 1989, Lanfranco et al. 1991), affecting height growth and form of pines primarily in the first 6 to 10 years. The insect is of particular concern as an obstacle to production of high-quality straight-grained sawlogs (Gara 1987). The insect has two important means of spread: (1) via dispersal flights of the adult moths, and (2) with the aid of humans that transport infested nursery stock and cut host material. The latter means undoubtedly has been especially significant in Chile because small pine trees and branches commonly are cut for Christmas decorations in December, at the same time that EPSM adults are emerging from host material. The EPSM also has been detected in pine nurseries in Chile.

The EPSM already is widely distributed in the United States and Canada. The rationale for considering this insect as a potential pest in this report is that the populations in Chile and the United States may have different origins and vary genetically; they may in fact represent separate varieties. The EPSM apparently has yet to reach its limits of geographical spread in Chile. Thus, it remains to be seen whether the Chilean variety is capable of greater ecological plasticity than its counterpart in the United States, (e.g., possibility of multiple generations per year, broader host spectrum, and greater tolerance of environmental extremes), as Gara (1992) has speculated.

Specific information relating to risk elements:

A. Probability of pest establishment

1. Pest with host at origin: ***Low (RC)***

The EPSM has very successfully infested *Pinus radiata* and *P. contorta* in Chile. However, the larval and pupal stages are confined to leaders and branches, adults are fragile and short lived, and eggs are laid at the bases of needles and on buds. Therefore, it is very improbable that any of this insect's developmental stages would be associated with logs for export.

2. **Entry potential:** ***Low (RC)***
In the event that buds, shoots, or small branches infested with EPSM were included with shipments of *P. radiata* logs, the probability that the insects would survive in transit would be very low. Immature larvae would not complete their development in cut host material and mature larvae and/or pupae would only be present in material cut during a narrow window from October through December. Adults are unlikely to be present on host material in shipment and those emerging in transit would be short lived.

3. **Colonization potential:** ***High (RC)***
Although EPSM adults are not particularly strong flyers, they are very capable of locating host material near their point of entry into the United States. Since this insect is capable of breeding in many species of pine, the likelihood of adults finding suitable host material nearby is high. For example, mugho pine (*Pinus mugo*) is a widely planted ornamental tree and is a common host of the EPSM in port cities on the Pacific Coast of the United States.

4. **Spread potential:** ***High (RC)***
Following the initial introduction of EPSM into the United States and Canada, this insect spread largely unabated by control procedures and was aided by the transport of nursery stock. It is likely that any new introduction would follow the same pattern.

B. **Consequences of establishment**

5. **Economic damage potential:** ***Moderate (MC)***
The EPSM is a major pest of *Pinus radiata* in Chile and a moderate problem in some areas in the United States, especially on ornamental pines. If re-introduced, this pest may significantly affect the growth rate and form of pines in plantations, as well as in Christmas tree plantations and ornamental plantings in some areas. Damage may be severe, particularly if the variety of EPSM in Chile is more aggressive than the one already here. However, it probably would not do well on the east side of the Cascade Mountains because of low winter temperatures and low relative humidities during critical egg laying periods in the summer (Daterman and Carolin 1973). The extent of damage and expansion into new areas is unknown and would depend on its ecological adaptability, as discussed above.

6. **Environmental damage potential:** ***Low (RC)***
The EPSM does not kill its hosts and would not significantly alter the stand structure in forest situations.

7. **Perceived damage potential (social & political influences):** ***Moderate (RC)***
There will be little social and political influence from shoot moth infestations in forest situations, but the general public may be significantly impacted by insect-caused damage to ornamental plantings of pine.

Pest risk potential: *Low* (probability of establishment = *Low*; consequences = *Moderate*)

Selected bibliography:

Aguilar, A. M.; Beéche, M. A. 1989. Current situation of the European pine shoot moth *Rhyacionia buoliana* (Schiff.) (Lepidoptera: Tortricidae) in Chile. In: Alfaro, R. I.; Glover, S. G., eds. Insects affecting reforestation: biology and damage. Proceedings, IUFRO Working Group (S2.07-03), XVIII International Congress of Entomology; Vancouver, BC; July 1988: 155-160.

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Reviewers' comments:
"The European pine shoot moth, *Rhyacionia buoliana,* is already well established in the United States. This pest should be excluded from the pest risk assessment." (Campino, M. Ramírez, translated from Spanish)

"The shoot moth is not associated with logs and, as a result, poses absolutely no risk of introduction on log shipments." (Vergara, translated from Spanish)

"Some serious potential problem with the European pine shoot moth. Solid information is needed, but seems unavailable." (Lattin)

"I too would reiterate that there is a real possibility that reintroducing a pest such as the European pine shoot moth, *Rhyacionia buoliana*, into the U. S. should be considered potentially more injurious than the original introductions to North America. The reasons for this notion are as follows: (a) *R. buoliana* introductions into Chile probably were from a different race; (b) apparently the EPSM that entered Chile first moved across Argentina's radiata pine plantations from lowland, hot-dry plantations, and eventually into higher elevation plantations with cool-moist, and cool-dry climates; and (3) there have been reports in Chile that the genetic plasticity of the EPSM race that entered Chile may include other conifers, e.g., Douglas-fir. The worry in the Pacific Northwest would be that the Chilean EPSM strain has been selected to better withstand the harsh conditions of commercial ponderosa pine stands. Also keep in mind that natural ponderosa pine stands do occur in western Washington in the Ft. Lewis-Tacoma area. And the Port of Tacoma would be a major point of entry of Chilean logs." (Gara)

Response to comments: *Rhyacionia buoliana* is without doubt the most significant pest of *Pinus radiata* plantations in Chile. The assessment team deliberated the same issues later raised by reviewers and decided at the onset of the project to prepare an individual pest risk assessment for this insect. The EPSM is well established in North America and apparently has reached its limits in distribution and damage. However, there is some indication in the literature that considerable genetic variation exists among populations of EPSM in Europe. Thus, the EPSM population in Chile may have greater genetic adaptability than the population currently in North America, allowing for a wider distribution and more damage if it enters the United States. Although one report indicated that the EPSM may use Douglas-fir as an alternate host in Chile, team members have inspected Douglas-fir trees surrounded Monterey pine plantations heavily infested by the EPSM, and no infested tips were found on Douglas-fir. In the IPRA, consequences of establishment were estimated to be moderate risk, but the rankings for pest with host at origin and entry potential were both considered to be very low. Thus, the probability of establishment and the overall pest risk potential are estimated to be low.

Individual Pest Risk Assessments: Pathogens of Pine

A comprehensive list of fungi associated with *Pinus radiata* in Chile, taken principally from Butin and Peredo (1986), is presented in appendix A (table A-2). Using the criteria in table 3-1 (page 18), this list was reduced to 14 species considered of quarantine importance as potential pathogens associated with logs exported from Chile (table 4-2). Individual pest risk assessments (IPRA) were then prepared on those groups of microorganisms classified in categories 1a, 1b, 1c, 2a, and 2c. Reviewers' comments are summarized at the end of each IPRA, followed by a response from the assessment team.

Table 4-2. Summary of possible quarantine fungi associated with imported logs of Monterey pine (*Pinus radiata*) from Chile, including host range, location on the host, and pest category

Species	Other hosts	Location: Seedlings in nursery	Location: Foliage/ other	Location: Bark cambium	Location: Sapwood	Location: Heartwood	Pest category*
Armillaria spp.	P, C, N, E			X	X	X	1a
Cercoseptoria pini-densiflorae Hori & Nambu	P		X	X			2c
Colletotrichum acutatum Simmds. f. sp. *pinea* Ding. et Gilm.	P	X		X	X		2d
Cyclaneusma minus (Butin) DiC., Per. & Min.	P		X				2c
Cyclaneusma niveum (Pers.:Fr.) DiC., Per. & Min.†			X				2c
Dothistroma pini Hulbary‡	P		X	X			2c
Lophodermium conigenum (Brun.) Hilitz.	P		X	X			2c
Lophodermium pinastri (Schrad. ex Hook.) Chev.	P		X	X			2c
Lophodermium seditiosum Minter, Staley & Millar	P		X	X			2c
Mycosphaerella dearnesii Barr (=*Scirrhia acicola*)	P		X	X			2c
Ophiostoma (=*Ceratocystis*) *piceae* (Munch) Syd. & P. Syd.	P, C, N			X	X	X	2c
Ophiostoma (=*Ceratocystis*) *piliferum* (Fr.:Fr) Syd. & P. Syd.	P, C, N			X	X	X	2c
Phellinus spp.	P, C, N				X	X	2c
Sphaeropsis sapinea (Fr.) Dyko & Sutton (= *Diplodia pinea*)	P	X	X	X	X		2c

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and other agricultural crops.

* See table 3-1 on page 18 for definitions of categories; all fungi in category 2 are found in United States.

† Found only on *Pinus pinaster* to date in Chile.

‡ = *Dothistroma septospora* (Dorguine) Morelet, *Scirrhia pini* Funk & Parker, and, most recently, *Mycosphaerella pini* Rostr. in Munk.

Diplodia Shoot Blight of Pine

Scientific name of pest: *Sphaeropsis sapinea* (Fr.) Dyko & Sutton (= *Diplodia pinea* (Desm.) Kickx).

Scientific names of hosts: *Pinus radiata* in Chile; *Abies* spp., *Larix* spp., *Picea* spp., *Pinus* spp., *Pseudotsuga menziesii*, *Chamaecyparis lawsoniana* in other countries.

Distribution: North America, Central America, South America, Europe, Africa, Asia, Australia, and New Zealand. In Chile, distributed from region V to region X.

Summary of natural history and basic biology of the pest: *Sphaeropsis sapinea* is a cosmopolitan, opportunistic pathogen of 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, canker, 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 New Zealand, this fungus may infect *P. radiata* seedlings in nurseries (Chou 1982).

In Chile, *Sphaeropsis sapinea* has been isolated from *Pinus radiata* logs and lumber (Aguilar 1985). The pathogen also causes whorl cankers on stems associated with pruning wounds. The fungus has seriously damaged extensive exotic plantations of *P. radiata* in Australia, New Zealand, and South Africa (Peterson 1982b). Infection intensity appears to vary with environmental and host conditions. Dieback tends to decrease with increasing tree size (Chou 1976a and b; Gibson 1979). In New Zealand, fast-growing trees on productive sites may be more severely infected than stressed trees on inferior sites (Chou 1982). In contrast, damage by this fungus on second-rotation Monterey pine plantations in Chile has been most commonly observed on poor sites in nutrient-depleted soils (Gara 1978, Butin and Peredo 1986). 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 (Butin and Peredo 1986). Infection occurs directly in unwounded, succulent shoots as they are expanding in the spring. Stems become infected through wounds.

Recent studies suggest that *S. sapinea* is a highly variable species. Chou (1976b) examined 18 New Zealand isolates and did not find differences in pathogenicity or virulence. Others have found differences among isolates in cultural characteristics, conidial size and morphology, and pathogenicity (Wang et al. 1985, Palmer et al. 1987, Swart et al. 1988). Two distinct types of *S. sapinea*, denoted types A and B, were identified from the North Central United States (Palmer et. al 1987). The general pattern of isozymic diversity reflected relatively high levels of genetic variation within local populations but a lack of sharp dissimilarity between geographic populations (Swart et al. 1992). The fungus may be a highly variable species that represents a continuum without definite 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 North America. 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 (M. Palmer, personal communication) and that differences also exist between an isolate from New Zealand and one from the United States (G. Stanosz, personal communication).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RC)***
   Sphaeropsis sapinea is common throughout the region where *Pinus radiata* is grown commercially in Chile, affecting pine plantations under stress or planted off-site. It is most common in regions VI to VIII, where conditions are best for growth of the host. Because limbs and branches will be removed at harvest, only stem infections will remain on the logs. In logs pruned at an early age, such cankers will be buried in the interior of the log. It should be noted, however, that most pines with stem infections will not reach rotation age or be harvested for sawlog exports; infected pines are removed in periodic thinnings or are eliminated by intraspecific competition (M. Beéche, L. Cerda, R. Vallejos, personal communication).

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. Considering these factors, entry potential is high.

3. **Colonization potential:** ***Moderate (VC)***
   Pine hosts and Douglas-fir--both native stands and ornamental plantings--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 (Butin and Peredo 1986) 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 establishment

5. **Economic damage potential:** ***Low/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 et al. 1987). However, because the strain of *S. sapinea* in Chile may be different, and possibly more virulent, than the one in the United States, there is potential for increased economic damage. Until studies can be conducted to confirm that the strains are the same, a low/moderate rating is warranted.

6. **Environmental damage potential:** ***Low/Moderate (RC)***
   In North America and in Chile, *Sphaeropsis sapinea* is known to cause 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 et al. 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 et al. 1992). Such differences may also be expressed in pathogenicity or virulence that 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 the Chilean strain is more virulent, the potential for environmental damage would increase from low to moderate.

7. **Perceived damage potential (social and political influences):** ***Low/Moderate (RC)***
   From data regarding pathogenicity and virulence of the known strains of *S. sapinea*, little major impact on the forest ecosystem will result from further introduction of the species. 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.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*;
consequences = *Low/Moderate*)

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Sinclair, W. A.; Lyon, H. H.; Johnson, W. T. 1987. Diseases of trees and shrubs. Ithaca, NY: Cornell University Press. 574 p.

Swart, W. J.; Wingfield, M. J. 1991. Biology and control of *Sphaeropsis sapinea* on *Pinus* species in South Africa. Plant Disease 75: 761-766.

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Swart, W. J.; Grant, W. S.; Wingfield, M. J. 1992. Allozyme variation among geographic isolates of *Sphaeropsis sapinea*. Proceedings, 1992 joint APS/MSA meeting, Portland, OR (abstract).

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Reviewers' comments:
"In Chile, pines affected by *Sphaeropsis sapinea* are unlikely to be found in sawtimber stands at harvest, because infected trees are routinely eliminated in thinnings or by intraspecific competition. As a result, occurrence of this pathogen in exported sawlogs is very low." (Beéche, Cerda, Vallejos, translated from Spanish).

"*Sphaeropsis sapinea* is already present in the United States. Any additional introductions would not increase the risk." (Vergara, translated from Spanish)

"Since there are always some trees or tree branches that are wounded and/or stressed, and the inoculum potential is likely to be high, I again would rate spread potential high!" (Cobb)

"Unless you have solid evidence that the Chilean *Sphaeropsis* is the same strain present on the West Coast of the U. S., there is no way that we can consider the damage potential low." (Cobb)

"Given the high inoculum potential that may be present, I strongly believe that the colonization potential must be considered high." (Cobb)

"As pointed out in Gara (1978), second-rotation radiata pine plantations, growing in nutrient-depleted (particularly the micronutrient boron) sites near Los Angeles and Chillán were severely damaged by *Sphaeropsis sapinea*. I would suspect that this syndrome between harsh and depleted sites would continue to have an association with this disease." (Gara)

Response to comments: The individual pest risk assessment for diplodia shoot blight discusses the variability of *Sphaeropsis sapinea*, the existence of different strains in North America, and the lack of knowledge of what strain(s) are present in Chile. This species already occurs in North America and causes damage only in local situations. If the strain of *S. sapinea* that exists in Chile is the same as that in the United States, the risk associated with imported logs is nil. If a more virulent strain of this pathogen were introduced into North America, economic, environmental, and perceived damage would increase in natural stands and ornamental plantings. For these reasons, the ratings for these components were changed from low to low/moderate. Finally, other comments from reviewers regarding specific risk ratings were considered and initial ratings were changed in certain cases. For example, the rating for pest with host at origin was reduced from high to moderate, based on the infrequent incidence of the disease in *P. radiata* sawlogs destined for export. In contrast, the spread potential was increased from low to moderate, because stressed conifer stands and potential infection courts are relatively common in the western United States. As a result of these modifications, the pest risk potential was increased from low to moderate for this fungus.

Needle Diseases of Pine

Scientific names of pests: *Dothistroma pini* Hulbary (= *Scirrhia pini* Funk & Parker, *Dothistroma septospora* (Dorguine) Morelet, *Mycosphaerella pini* Rostr. in Munk), *Mycosphaerella dearnesii* Barr (= *Scirrhia acicola* (Dearn.) Siggers), *Cyclaneusma minus* (Butin) Dicosmo, Peredo & Minter, *Lophodermium* spp.

Scientific names of hosts: Many *Pinus* species worldwide, *Pseudotsuga menziesii*, *Larix decidua*.

Distribution: Worldwide.

Summary of natural history and basic biology of the pests: Several genera of fungi causing needle diseases of *Pinus radiata* occur in Chile (Butin and Peredo 1986). *Dothistroma pini*, a pathogen that invades and kills foliage, is most significant. The fungus causes a needle blight of more than 30 pine species worldwide (Sinclair et al. 1987) and *P. radiata* is highly susceptible (Cobb and Libby 1968). The disease is considered the most devastating disease encountered in *P. radiata* plantations in the Southern Hemisphere, particularly in East Africa, New Zealand and Chile (Gibson 1972). Outbreaks of similar scale have not been recorded in pine plantations in the Northern Hemisphere (Gibson 1972). In Chile, infected material was first collected in 1962 (Oehrens 1962) and the disease was first reported in plantations of *P. radiata* in 1965 (Dubin 1965, Dubin and Staley 1966). 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 et al. 1987). On *P. radiata* in Chile, the fungus is susceptible to drying conditions, with infections occurring only after 15 days of high humidity (García 1967). Although *D. pini* is not considered a serious problem on *P. radiata* throughout Chile, there are some areas in Chile where control is considered necessary. These include humid zones along the coast and locations around Arauco in region VIII and further south in region X (Hosking and Dick 1992). Copper fungicides effectively prevent infection by *D. pini* (Peterson 1982a). In Chile, infection levels above about 30% result in growth loss and are justification for fungicide application (Forestal Arauco, personal communication).

Species of *Cyclaneusma* also cause needle cast of many pine species in plantations and nurseries throughout the world (Sinclair et al. 1987). *Cyclaneusma minus* occurs on *P. radiata* in Chile (Butin and Peredo 1986), but has caused only occasional damage. Symptoms include yellowing and casting of second year foliage. Needles of all ages are susceptible. A second species in Chile, *C. niveum* (Pers.:Fr.) Dicosmo, Peredo, Minter is restricted to *P. pinaster* and is considered saprophytic. Several species of *Lophodermium*, another genus of fungi causing needle disease, have been reported on pines in Chile (Butin and Peredo 1986). The species include *L. conigenum, L. pinastri*, and *L. seditiosum*. Only

L. seditiosum, which attacks and kills the current season's foliage, is considered a major pathogen in some locations in the United States (Sinclair et al. 1987). This species of *Lophodermium* was identified in Chile fairly recently (Rack 1981).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RC)***
   These fungi are restricted to needles and do not occur in shoots 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 et al. 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 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.

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 species of needle disease fungi reported on *P. radiata* in Chile apparently already occur in the United States, their spread potential also would be the same.

B. Consequences of establishment

5. **Economic damage potential:** ***Low/Moderate (RC)***
   These fungi seldom cause economic loss 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 negligible. If a more virulent strain or species were introduced, the economic damage potential would be increased (moderate), particularly in the case of ornamentals or Christmas tree plantations.

6. **Environmental damage potential:** ***Low/Moderate (RC)***
   Because these fungi seldom cause significant damage in the United States, any impact on associated ecosystems from further introductions would be minimal

or non-existent. This low rating would increase to moderate if more virulent strains of these fungi, or some unknown but potentially damaging disease of needles, were to be introduced.

7. **Perceived damage potential (social and political influences):** ***Low/Moderate (RC)*** Further introduction of the 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.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*; consequences = *Low/Moderate*)

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Dubin, H. J.; Staley, J. M. 1966. *Dothistroma pini* on *Pinus radiata* in Chile. Plant Disease Reporter 50: 280.

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Reviewers' comments:

"*Dothistroma*, *Cyclaneusma*, and *Lophodermium* are agents associated only with shoots and foliage and are not transmitted on shipments of logs or chips. As a result, they pose no risk." (Vergara, translated from Spanish)

" The fungi that cause needle diseases (*Dothistroma*, *Cyclaneusma*, and *Lophodermium)* are already present in the United States, so the risk from re-introducing the organisms from Chile is nil; they should not be included in the list of quarantine pests." (M. Ramírez, translated from Spanish)

"The fungus (*D. pini*) produces abundant conidia that are rain splashed primarily but are also disseminated by wind. They can adhere to any kind of substrate, and the New Zealanders apparently still believe that the fungus was introduced there on the boots of a forest pathologist (not mine). Hence, there is no reason to believe that the spores cannot be carried on the surfaces of logs, potentially in great numbers. Therefore, the entry potential should be considered at least moderate." (Cobb)

"As you have indicated, *D. pini* is not a needle cast fungus. It causes a blight and has the following distinctions that increase its potentials substantially: (a) spores are produced during much or all of the year; (b) the fungus can infect needles of all ages; (c) symptoms and damage are not delayed for 1 or more years but can occur within weeks; and (d) the life cycle is substantially shorter and the potential rate of increase [R] of disease is quite high." (Cobb)

"We simply do not know what the fungus...in Chile will do to our native Monterey pine or any other North American species for that matter. I cannot accept a casual approach to the potential of this pathogen." (Cobb)

"I do not see a basis for assuming that any species of needle cast fungi introduced would not be new or more virulent. Without that assumption, the economic damage potential must be at least moderate. Sublethal damage is highly significant in the Christmas tree industry and may be an important factor in forest tree declines. An associated environmental consequence might be the increased use of pesticides to reduce damage from introduced foliar pathogens. As with any group of potential pathogens, the unknown or unexpected will likely be the most important. For this reason alone I believe the economic and environmental damage potential should be increased to moderate." (Kanaskie)

Response to comments: In response to reviewer suggestions, the entry potential for needle fungi was increased from low to moderate. In turn, given the abundance of susceptible hosts of high value in the western United States (e.g., Christmas trees and ornamental conifers), the economic, environmental, and perceived damage potentials were increased from low to low/moderate. The moderate rating reflects the possibility of more virulent strains of needle disease fungi in Chile. Despite the beliefs of our Chilean colleagues that the strains of these fungi are the same as those already present in the United States, this conclusion remains to be verified. With these modifications, the overall pest risk potential for needle disease fungi on logs becomes moderate (rather than low) if logs are imported without being debarked.

Stain and Vascular Wilt Fungi of Pine

Scientific names of pests: *Ophiostoma piceae* (Munch) Syd. & P. Syd. (= *Ceratocystis piceae* (Munch) Bakshi), *Ophiostoma piliferum* (Fr.:Fr.) Syd. & P. Syd. (= *Ceratocystis pilifera* (Fries) C. Moreau).

Scientific names of hosts: In Chile, *Ophiostoma piceae* common on *Laurelia* spp., *Nothofagus* spp., *Pinus* radiata; in other countries on many coniferous hosts. *Ophiostoma piliferum* on *P. radiata* and *N. pumilio* in Chile and on many conifers throughout the world.

Distribution: Worldwide.

Summary of natural history and basic biology of the pest: 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 specific blue stain fungi addressed in this section include *Ophiostoma piceae* and *O. piliferum*, both of which occur on *Pinus radiata* and certain native hardwoods in Chile (Osorio 1985, Butin and Peredo 1986). These fungi have been previously discussed as potential pests on imported logs from New Zealand (USDA Forest Service 1992), and have been identified on native trees in the United States and Canada (Hepting 1971, Farr et al. 1989).

Ophiostoma araucariae has been reported in Chile, but only on *Araucaria araucana* (Butin 1968). While some species of *Ophiostoma* cause blue stain, other species in the genus, or its anomorphs, *Leptographium* and *Graphium*, can cause disease in standing trees (Boyce 1961, Upadhyay 1981). Some 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.

A few *Ophiostoma* spp. with *Leptographium* anomorphs are root pathogens (Alexander et al. 1988, Wingfield et al. 1988). One pathogen, *Leptographium wageneri*, causes 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 tree-killing *Ophiostoma* species has not been reported on *P. radiata* in Chile. However, Ciesla (1988b) reported secondary attacks of the bark beetle *Hylurgus ligniperda* in the root zone of *P. radiata* infected with an unidentified root pathogen in Chile. Gara, Holsten, and Burwell (1988) observed black-stain symptoms on 6- to 7-year-old *P. radiata* in Chile. While two North American species of *Hylastes* have been implicated as vectors of black stain root disease (Goheen and Cobb 1978, Witcosky et al. 1986), this relationship has not been demonstrated for the bark beetles present in Chile (Cielsa 1988b). During the tour of Chile's pine plantations in November 1992, team pathologists observed two cases in which 3-year-old trees were dying from an unknown agent. The affected trees possessed a blackened, rotted root system, but cultures taken from these roots to identify a causal agent were not successful. The plantings were in low, poorly-drained areas, suggesting that the trees were predisposed from growing off site.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***High (VC)***
   Ophiostoma piceae and *O. piliferum* have been identified from *Pinus radiata* in Chile. Although vectors have not been identified, 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 *P. radiata* logs.

2. **Entry potential:** ***High (VC)***
   These fungi survive well for some time in logs (more than a year with favorable temperatures and moisture regimes). They would be favored by the conditions that could be expected to prevail during transport of the logs (many logs packed close together in an enclosed, moist environment). Bark removal would not prevent survival in transit, as 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 extremely 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 North American host is high because of the presence of the appropriate vectors near these ports. The proximity of *P. radiata* and other probable 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 most 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 Chile and the western United States, especially the Pacific Northwest, 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. 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 distances traveled by their insect associates are the critical factors. Bark beetles and cerambycids are capable of flying distances of several miles 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 establishment

5. Economic damage potential: ***Low/Moderate (MC)***
The *Ophiostoma* species known to attack Monterey pine in Chile are already present in North America. Economic damage from the introduction of a new blue stain fungus would be minimal, meriting a low risk. However, increased damage to North American conifer forests could result from the introduction of a pathogenic strain of one of the above mentioned *Ophiostoma* species, a *Leptographium* anomorph, or an as yet undescribed species. On this basis, a moderate rating is justified. But, to date, no tree-killing *Ophiostoma* species have been reported or observed on exotic conifers in Chile.

6. Environmental damage potential: ***Low/Moderate (MC)***
If the strains of *Ophiostoma* on Monterey pine in Chile are the same as those already in North America, the introduction of these fungi on Chilean logs poses no additional threat. Clearly, however, the introduction of a new tree-killing strain or species of *Ceratocystis*, *Ophiostoma*, or *Leptographium* has the potential of causing significant environmental damage. Loss of trees in ornamental plantings and in areas of non-commercial conifers, such as in wilderness or spotted owl areas, would cause considerable impact. However, there is no evidence or documentation of tree-killing strains of *Ceratocystis* or *Ophiostoma* in Chile, and only two species causing blue stain have been identified from Monterey pine to date. Indeed, most conifers and hardwood species indigenous to the western United States are growing as exotics in Chile without major disease problems.

7. Perceived damage potential (social and political influences): ***Low/Moderate (MC)***
An accidental introduction of another blue stain fungus in 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* and an insect vector would be noticeable, justifying an increase in the rating for perceived damage from low to moderate.

Pest risk potential: ***Moderate/High*** (probability of establishment = *High*; consequences = *Low/Moderate*)

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Reviewers' comments:
"The phrase 'stain fungi' carries an air of unimportance. We are not nearly as concerned about introducing 'stain' as we are introducing vascular wilt disease. Perhaps the heading could be altered to reflect this." (Kanaskie)

"I agree with the ratings given...for the probability of establishment. Given the high probability and certainty of establishment for stain fungi, and the potential for rapid long-distance spread of these fungi, the consequences of establishment have been underrated. Even though North American tree species have been grown in Chile without major disease problems, the situations may be different in North America. Far more potential hosts occur in North America (particularly the Pacific Northwest) than have been planted in Chile (street trees, ornamentals, nurseries, Christmas trees, etc.). The economic and environmental consequences of establishment of a pathogenic strain or undescribed species [of] this group of fungi would be severe." (Kanaskie)

"I believe that we should not dismiss the hypothesis of Clive Brasier that *O. ulmi*, cause of DED [Dutch elm disease], may have very recently evolved out of *O. piceae*. *O. piceae* appears to be a very diverse species with 'strains' that infect both conifers and hardwoods. It deserves a very careful analysis and much more research." (Cobb)

"Importation of potential tree-killers in the genus *Ophiostoma* (which includes the causal agents of oak wilt and Dutch elm disease) is of major concern. The two species of *Ophiostoma* analyzed are known to attack a wide range of hardwood trees in addition to conifers. Because these pathogens are moved both by insects and human activity, eventual introduction and establishment are a virtual certainty if Chilean log shipments are allowed. Should this happen, we could only hope that these isolates would prove to be benign." (Hilburn, Griesbach, Johnson, Wright)

"*Ophiostoma* spp. causing blue stains are already present in the United States; these fungi should be removed from the quarantine list." (Vergara, translated from Spanish)

"We believe that the blue stain fungi associated with Monterey pine in Chile are cosmopolitan, and have distinctly different biologies than *Ceratocystis ulmi.*" "There is no evidence to suggest that Chilean populations of *Ophiostoma* are genetically different from the strains in the United States of other regions of the world. We consider *Ophiostoma* to be a problem of product quality, not a problem of quarantine." (Beéche, Cerda, Vallejos, translated from Spanish)

Response to comments: The lack of documented effective mitigation measures suggests that some of these fungi would eventually enter the United States. Subsequent colonization is probable. Because the knowledge of *Ophiostoma* species in Chile is incomplete and it is not known whether the strains of *O. piceae* and *O. piliferum* in Chile are more virulent than those in the United States, an estimated risk of moderate/high appears warranted. The pest risk potential would be high only if a more virulent, tree-killing strain of *Ophiostoma* were introduced. If the strains are the same as those already in the United States, as Chilean specialists believe, then the possibility of further introductions would pose no quarantine problem. Nevertheless, to emphasize the possible occurrence in Chile of tree-killing strains, the title for this group of fungi was modified in this report to include vascular wilts, despite the fact that none of the *Ophiostoma* species in Chile are known to cause disease problems other than stain of logs and green lumber.

<u>Root/Stem Rots of Pine</u>

Scientific names of pests: *Armillaria* spp.; *Phellinus* spp.

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

Distribution: Central and southern Chile; 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. From all available evidence, the species of *Armillaria* and *Phellinus* that occur in Chile are different from any of those occurring in the United States. The literature indicates the existence of at least a half dozen species of *Armillaria* occurring in Chile (Garrido 1985a). Several species of *Phellinus* may be found in Chile, although only one is reported with certainty (Larsen and Cobb 1990). None of these species is known to occur in North America. They cause a characteristic root- or heart rot in living trees. As soil-borne fungi, *Armillaria* and *Phellinus* species exist to one 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 of the species of *Armillaria* depend almost entirely on rhizomorphs as their principal means of dispersal (Smith et al. 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 await a situation when the tree is in a stressed condition. At this point 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" which increase in size over 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: ***Low (RC)***

Because *Armillaria* and *Phellinus* species 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 very difficult to detect, would likely go unnoticed in an inspection, and would be transported with uninfected logs. However, indications are that these species are not common in Chile. They are infrequently encountered in collecting seasons (Gastón González, personal communication), and signs of their presence are otherwise uncommon, particularly in fast-growing Monterey pine sawtimber stands. Thus, the likelihood of their being with the host at origin is considered to be low.

2. **Entry potential:** ***High (VC)***
Although advanced decay would be visible at cut ends of logs, incipient decay would not. These root-rot species can exist as rhizomorphs, 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 be easily able to survive during harvest and transport to North America. 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 the logs to appropriate substrates at the port of entry in the United States is low. Inoculum 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. Nothing is known of the spread potential of the Chilean species. We do know that some North American species do not require spores for spread, at least on the local level (Wargo and Shaw 1985, Smith et al. 1992). If the Chilean species spread in the same manner as North American species, the spread also will be slow and restricted to "infection centers."

B. Consequences of establishment

5. **Economic damage potential:** ***Low (RC)***
The species of root-rot fungi in Chile appear to be about the same as those in New Zealand. Plantations of Douglas-fir and Monterey pine thrive in both countries in spite of the presence of these species. 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 that spread at only several feet per year, 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 Chilean logs is low because of their ability to spread at only slow rates (Smith et al. 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 (social and political influences):** ***Low (MC)***
Increased mortality in native Monterey pine stands in California could have significant social and political impacts at the local level because of the large population centers associated with these areas and the high environmental regard for these native stands due to their limited distribution. However, as mentioned above, Monterey pine and other conifers thrive in Chile in the presence of those root-rot fungi that would be imported with the logs.

Pest risk potential: ***Low*** (probability of establishment = *Low*; consequences = *Low*)

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Reviewers' comments:
"Although there might be support for a low 'with host at origin' potential, it is still high enough to be of substantial concern when the damage potential that some of us envision is considered." (Cobb)

"One oversight under Root/Stem Rots of Pine...is that ample colonization potential will exist. Hosts are abundant in and around Oregon ports and many mills are far inland. Nearly all highways in the state transect public and private commercial forest land. The logs will be conveyed directly through forests on their way to processing mills. Tree growth right at the roadside and ample Northwest rainfall and humidity will provide excellent conditions for introduction of fungi from frass, dunnage, loose bark, etc., directly to forests. This direct avenue of infection should be reflected in a higher colonization potential and would indicate a higher overall risk." (Hilburn, Griesbach, Johnson, Wright)

"We are not sure that some of these fungi, especially species of *Phellinus*, are not vectored by insects at least on some occasions. Insect vectoring would substantially raise the potential for colonization and spread." (Cobb)

"Because mitigation measures have not been included in the risk assessment, the colonization potential stated for armillaria root disease is too low. Mill waste, chips or bark can harbor the fungus. If these products are distributed and used as mulches, the fungus could be disseminated widely. This is particularly hazardous considering the very broad host range of *Armillaria* species and their ability for saprophytic survival in relatively small pieces of wood. Ornamental and food crops would be at risk." (Kanaskie)

"Spread of these root pathogens occurs primarily via mycelial growth in and along roots. Roots may be dead or alive. Infection and development of disease are not dependent on trees entering a stressed condition for either *Armillaria* or *Phellinus*. Stress certainly predisposes some trees to armillaria root disease, but it is not prerequisite." (Kanaskie)

Response to comments: There appears to be considerable disagreement among forest pathologists concerning the colonization and spread potential of stem/root rot fungi as introduced pests. As we have indicated, conidiospores and other easily dispersed propagules are rare in fungi causing root- and stem rots of forest trees. *Heterobasidion annosum* (= *Fomes annosus*) is an exception, but *H. annosum* is not known to occur in Chile. Considering this lack of dissemination capability without forming a basidiome, the likelihood that the fungi could reach the potential hosts is considered low. Extensive discussion among team members and reviewers' comments did not change this conclusion. A major concern with regard to dispersal is the possibility that logs may be transported long distances from the port of entry. Movement of untreated logs from the port area or subsequent use of untreated mill byproducts (e.g., sawdust, bark, and firewood) from these logs will greatly increase the colonization potential and spread potential of any of the pests addressed here.

Chapter 5. INSECTS AND PATHOGENS POSING RISK--COIGÜE AND TEPA

Overview of Pests in Native Forests

The risk analysis of organisms associated with coigüe (*Nothofagus dombeyi*) and tepa (*Laurelia philippiana*) logs is different in several important ways from that for Monterey pine logs in Chile. Monterey pine is an introduced species with pest/host relationships that are mostly new, consisting of either endemic organisms that have adapted to pine or organisms that have been introduced from outside Chile. All the literature on insects on pine is relatively recent and many of the investigations were directed specifically toward detecting all insects found on pine (Billings and Holsten 1969a and b; Holsten et al. 1970; Eglitis and Holsten 1972).

The native forests in southern Chile are isolated from the rest of the world by mountains to be east, ocean to the west, desert to the north, and the Antarctic to the south and have unique floral and faunal associations. The native forests cross the lower elevation Andes Mountains from Chile into Argentina in the southern latitudes; however, these unique forests are still isolated from other parts of the world to the east by expansive dry Patagonia and the Atlantic Ocean in southern Argentina. Most of the commercial coigüe and tepa timber is located in the Valdivian rain forest in region X. This forest type is thought to be an ancient relic of the Tertiary period and is characterized by a wet and cool climate and a mixture of deciduous and evergreen hardwoods (Schmithüsen 1966).

The flora and fauna in this region have been of considerable interest to scientists throughout the world for a long time. The literature on the organisms associated with *N. dombeyi* and *L. philippiana* are in diverse publications and reports in a variety of languages (primarily Spanish, English, German, and French) spanning a period well over 100 years. However, comprehensive studies on the insects or fungi associated with specific native hardwood species have not been conducted. Most of the studies on the organisms in the native forests in Chile have been restricted to work on certain taxonomic groups with little emphasis given to specific life histories of individual organisms.

Unique and close associations have evolved between particular insect groups and the various forest types in Chile (Peña 1966, 1986; Davis 1986). There are several compilations of the insects associated with trees in parks in Chile and Argentina (Havrylenko and Winterhalter 1949, Bosq 1953a, Saiz et al. 1989). Special attention has been focused on the beetles, especially those species that bore in living, apparently vigorous trees (Cameron and Real 1974, Gara et al. 1978, Cameron and Peña 1982, Giganti 1986).

Wood-boring beetles of the families Cerambycidae and Buprestidae are common candidates for importation with unprocessed logs (Allen 1973, Ohmart 1980). Accordingly, generalizations on this group of potential pests are worthy of mention. Broadly speaking, climatic factors and availability of suitable food plants are the main factors governing the distribution of Cerambycidae in the world today (Linsley 1959). Most cerambycid larvae feed upon the solid tissues of living, dead, or dying plants or, less commonly, in rotten wood. For each species, the host requirements are usually very exacting for normal development. Yet, several cerambycids have host ranges that cross several genera. Polyphagous species are usually associated with wood that has been dead for some time or is actually decomposing. In contrast, those species of cerambycids that develop in living trees are more narrowly host specific, some being restricted to a single genus. In the tropics, a greater proportion of species are live-stem borers, perhaps because of the intense competition for dead wood provided by termites.

A number of more detailed studies on the biologies of specific organisms associated with the Valdivian rain forest have been conducted by forest entomologists and pathologists and their students at the Universidad Austral de Chile in Valdivia (Butin 1967, Carey 1975, Puentes 1979, Kruuse 1981, Cruz 1981, among others). However, since the discovery of the European pine shoot moth (*Rhyacionia buoliana*) in Chile in 1985, nearly all research efforts concerning forest insects have been directed toward this one pest (Aguilar and Beéche 1989, Alvarez de Araya et al. 1991, Lanfranco et al. 1991, among others).

Gathering information on the potential quarantine organisms on coigüe and tepa logs was a difficult task due to the dispersed and sketchy nature of the information available in the literature. The Pest Risk Assessment Team has attempted to gather as much of the pertinent literature as possible (see chapter 8). Forest pathologists and entomologists in Chile provided invaluable assistance in this effort. Most helpful were Hernán Peredo, Moises Osorio, Dolly Lanfranco, and Angélica Aguilar, Universidad Austral in Valdivia; Gastón González, Universidad de Concepción in Chillán; Marcos Beéche and Luís Cerda, Servicio Agrícola y Ganadero; and Patricio Santa Cruz, Forestal Bío Bío.

The most comprehensive list of insects and pathogens associated with coigüe and tepa is contained in the unpublished database entitled "Hongos e Insectos Asociados a la Flora Arborea de Chile," generated by the special project "Red Latinoamericana de Botánica, Universidad Austral de Chile" (Aguilar et al. 1991). This database contains lists of the scientific names of forest insects and fungi in Chile together with the taxonomic grouping (order/family), accepted host tree species, and the types of damage for each insect or fungus. A copy of the database was given to the team during the visit to the Universidad Austral in November 1992. Angélica Aguilar and Dolly Lanfranco also provided a listing of forest insects and pertinent references grouped by damage type that they use in their forest entomology classes at the University Austral. Gastón González provided a list of pathogens associated with coigüe and tepa.

Tepa appears to be nearly free of insect pests. The assessment team is unaware of any literature that documents insects on tepa trees or logs. *Ormiscodes nigrosignata* is the only insect species associated with tepa on the "Redlatin" list (Aguilar et al. 1991). Details of this association with tepa are not known, and possibly, this observation was of transient visitors of little significance. A "sooty mold," often associated with sucking insects, has been observed on the leaves of *Laurelia* spp. in region X in Chile (R. S. Cameron, personal observation), but no sucking insects have been recorded to date from *Laurelia* in Chile.

One drywood termite, *Cryptotermes brevis*, infests tepa wood in use in northern Chile (Micheli and del Río 1967), but this insect is not found in southern Chile. It is unknown whether the Chilean dampwood termite (*Porotermes quadricollis*) that infests coigüe in native forests also attacks tepa trees or logs. *Umbellularia californica*, a similar species in the Lauraceae family in the United States, also "has no serious insect enemies," presumably due to chemicals in the wood, leaves and fruit, including menthol and the ketone umbellulone (Fowels 1965). Tepa undoubtedly contains the same or similar compounds.

All insects known to utilize coigüe (*N. dombeyi*) as a host are listed in appendix B, table B-1. Insects commonly found on other native tree species growing in association with coigüe and/or tepa and their locations on the host are summarized in appendix B, table B-2. Fungi associated with *Nothofagus* spp. and *Laurelia* spp. in Chile are listed in appendix B, table B-3. Insects noted in the literature as casual or transient visitors on coigüe are not included in appendix B, table B-1. Characteristics of potential pests, outlined in table 3-1 on page 18, were used to develop the list of possible quarantine insects associated with imported coigüe logs from Chile (table 5-1).

Individual Pest Risk Assessments: Insects of Coigüe and Tepa

Individual pest risk assessments (IPRA) were prepared for those insects that might be imported on logs with no mitigation, are considered potential pests of resources in the United States, and for which sufficient biological information is available to prepare an IPRA. Where feasible, organisms with similar characteristics and life histories were combined and evaluated together. In several of these IPRA's, one species, usually that for which the most is known, was emphasized as representative of the group. Comments from reviewers pertaining to a specific pest are summarized at the end of the IPRA for that pest, together with a response from the assessment team.

Table 5-1. Summary of possible quarantine insects associated with imported logs of coigüe (*Nothofagus dombeyi*) from Chile, including host range, location on the host, and pest category

ORDER Family *Species*	Other hosts	Location: Seedlings in nursery	Location: Foliage/ other	Location: Bark cambium	Location: Sapwood heartwood	Location: Wood in use	Hitch-hiker*	Pest category†
ISOPTERA								
Kalotermitidae								
Cryptotermes brevis Walker	P, C, N					X		1b
Neotermes (Kalotermes) chilensis (Blanch.)	P, C, N			X	X	X	X	1a
Termopsidae								
Porotermes quadricollis (Rambur)	P, C, N			X	X	X		1a
HOMOPTERA								
Coccidae								
Aspidiotiphagus citrinus	C		X					3a
Pseudoparlatoria chilina Lindgr.	C		X					3a
COLEOPTERA								
Anobiidae								
Hadrobregmus incisicoli Pic.	C				X			3a
Buprestidae								
Conognatha viridiventris Sol.				X	X			3a
Epistomentis pictus Gory				X	X			1a
Epistomentis vittata Phil.				X	X			1a
Cerambycidae								
Callideriphus laetus Blanch.	P, N, E			X	X			1a
Callisphyris semicaligatus F. & G.	N, E			X	X			1a
Calydon submetallicum Blanch.	N, E			X	X			1a
Cheloderus childreni Gray	N			X	X			1a
Chenoderus testaceus Blanch.	N, E			X	X			3a
Grammicosum flavofasciatum Blanch.	N, E			X	X			3a
Lautarus concinnus Phil.	N			X	X			3a

P = *Pinus* spp., C = other conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* Indicates those insects that may be abundant around ports or attracted to lights during some stage of their life cycle, providing opportunity to be imported as "hitchhikers" on the surface of untreated logs or in ships.

† See table 3-1 on page 18 for definitions of pest categories.

Table 5-1. Summary of possible quarantine insects associated with imported logs of coigüe (*Nothofagus dombeyi*) from Chile, including host range, location on the host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location: Seedlings in nursery	Location: Foliage/ other	Location: Bark cambium	Location: Sapwood heartwood	Location: Wood in use	Hitch-hiker*	Pest Category†
Planopus laniniensis Bosq				X	X			3a
Planopus octaviobarrosi Cerda				X	X			3a
Sibylla coemeterii Thomson	N			X	X			3a
Sibylla flavosignata F. & G.				X	X			3a
Sibylla integra F. & G.				X	X			3a
Sibylla livida Germ.				X	X			3a
Curculionidae								
Nothofagobius brevirostris Kuschel			X	X				3a
Nothofaginus lineaticollis Kuschel	N			X				3a
Aegorhinus fascicularis Kuschel				X				3a
Aegorhinus nodipennis Hope	N			X				3a
Aegorhinus oculatus Kuschel				X				3a
Aegorhinus silvicola Kushel				X				3a
Aegorhinus vitulus bulbifer Kuschel				X				3a
Aegorhinus vitulus vitulus Fab.	N			X				3a
Rhyephenes maillei (Gay & Sol.)	P, N, E			X			X	1a
Scarabaeidae								
Hylamorpha elegans (Burm.)	P, N, E	X	X				X	1a
Sericoides germaini Dalla Torre	P, N, E	X	X				X	3a
Scolytidae								
Gnathotrupes fimbriatus (Schedl)	N				X			1a
Gnathotrupes longipennis (Blanch.)	N				X			1a
Gnathotrupes spp.					X			3a
LEPIDOPTERA								
Cossidae								
Chilecomadia valdiviana (Phil.)	N, E, F				X			1a
Opostegidae								
Notiopostega atrata Davis				X				1a

P = *Pinus* spp., C = other conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* Indicates those insects that may be abundant around ports or attracted to lights during some stage of their life cycle, providing opportunity to be imported as "hitchhikers" on the surface of untreated logs or in ships.

† See table 3-1 on page 18 for definitions of pest categories.

Callisphyris and *Chilecomadia* Wood Borers of Living Coigüe

Scientific name of pest: *Callisphyris semicaligatus* Fairm. et Germain (Coleoptera: Cerambycidae) and *Chilecomadia valdiviana* (Philippi) (Lepidoptera: Cossidae).

Scientific names of hosts: *Callisphyris semicaligatus* on *Nothofagus antarctica, N. dombeyi, N. pumilio, Castanea* sp., and other unidentified species; *Chilecomadia valdiviana* on *N. antarctica, N. dombeyi, N. pumilio, Weinmannnia trichosperma* and various fruit trees.

Distribution: *Callisphyris semicaligatus*--southeastern Argentina and southern Chile, principally in regions VIII to X; *Chilecomadia valdiviana*--central and southern Chile, principally in regions V-X (González 1989).

Summary of natural history and basic biology of the pests: Twelve species of *Callisphyris* are described; two species are recognized as agricultural pests and one (*C. semicaligatus*) as a forest pest. The adults of these cerambycid beetles look strikingly like wasps. The larvae generally bore in smaller diameter stems and branches, eventually cutting off the portion in which they are feeding, and complete their development in the severed portions. Larvae bore deep within the host material, along the length of the branch or stem. Lateral galleries are occasionally constructed to expel frass to the exterior of the host. Galleries are partially packed with granular frass. Adults apparently emerge in the spring and females oviposit on the surface of branches and stems. It has been estimated that *C. semicaligatus* has a 4-year life cycle (Havrylenko and Winterhalter 1949).

Callisphyris semicaligatus generally attacks branches and small diameter stems of apparently healthy *Nothofagus* and other native and exotic trees (Monrós 1943, Havrylenko and Winterhalter 1949, Cameron and Peña 1982). Young trees can be mutilated and sometimes killed, while older trees are weakened (Havrylenko and Winterhalter 1949). Cameron and Peña (1982) extracted a single *C. semicaligatus* adult from a pupal chamber in a fast-growing raulí (*N. alpina*) tree (40 years old, 23 cm in diameter), thus indicating that larvae do not develop exclusively in small branches. However, it seems fairly unlikely that this insect would be found in coigüe logs suitable for export, because *Callisphyris* spp. as a group are not known to inhabit the main boles of large diameter trees.

The carpenter worm, *Chilecomadia valdiviana*, is best known for its association with lenga (*Nothofagus pumilio*) in southern Chile (Peterson 1988) and as a pest of fruit trees in central Chile (González 1989). The density of attacks is high in some lenga trees, resulting in serious damage to the wood. However, the association of this insect with *N. dombeyi* is not well documented and may be infrequent. Cossid larvae generally breed in living trees, often associated with damage from other agents. Heavy-bodied female moths deposit their eggs in bark crevices, and young larvae bore directly into the host and feed on the wood. Larvae require two or more years to complete their development in southern Chile; however, a univoltine life cycle is common in central Chile (González 1989). Galleries are generally kept clear of frass and wood chips; pupal cases extrude from exit holes and are conspicuous on the boles of heavily attacked trees.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RU)***
   Callisphyris semicaligatus has been commonly collected in Chile (Bosq 1953a, Peña 1986) and is considered a serious pest of coigüe in Argentina (Monrós 1943). *Chilecomadia valdiviana* has been reported to cause substantial damage to *N. pumilio* in southern Chile and fruit trees in central Chile. However, neither of these two wood borers is known to cause extensive damage to *Nothofagus dombeyi* in Chile. Therefore the probability of either of these insects being associated with large coigüe logs destined for export from Chile is believed to be low. However, until this conclusion can be confirmed, a moderate rating should prevail.

2. **Entry potential:** ***High (RC)***
   All life stages of *Callisphyris semicaligatus* and *Chilecomadia valdiviana* may be present on coigüe logs exported from Chile. Late stage larvae, pupae, and adults deep in the wood are very likely to survive the journey from Chile to the United States.

3. **Colonization potential:** ***Moderate (RU)***
   Many of the immature larvae of these insects would not survive in the logs imported from Chile because they apparently require living host material for more than 1 year before pupating. However, late instar larvae, pupae, and adults in galleries are likely to survive and eventually emerge from unprocessed logs. Because of the long life cycle of these insects, the reverse of seasons from the Southern to the Northern Hemisphere would have little effect on its survival and synchronization with climate and potential hosts. Climatic conditions in the Pacific Northwest would be very similar to those experienced where these insects are native in southern Chile. These wood borers primarily attack *Nothofagus* spp., but they apparently also infest other hardwood genera, including various fruit trees (González 1989). Although unlikely, both of these insects might be capable of colonizing a variety of hardwoods indigenous to North America such as maple, alder, beech and/or oak. Adults probably use pheromones to locate the opposite sex, which would facilitate mating and location of potential hosts. The fact that the leopard moth, *Zeuzera pyrina*, from Europe was successfully established in the United States (Anderson 1966) may indicate a somewhat higher risk for the cossid *Chilecomadia valdiviana* to be introduced than the cerambycid *Callisphyris semicaligatus*.

4. **Spread potential:** ***Moderate (MC)***
Adults of both of these insects are fairly strong fliers and capable of flying over considerable distances. However, once established, spread rates would be moderate due to the patchy distribution of potential hosts.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (RU)***
If these insects were to exhibit the same habits on new host species as they do on hosts in Chile and Argentina, they could cause considerable economic damage, especially on ornamental trees.

6. **Environmental damage potential:** ***Moderate (MC)***
These insects are fairly unusual: they attack and debilitate apparently healthy trees. They could occupy previously unoccupied niches which could alter plant and animal communities significantly.

7. **Perceived damage potential (social and political influences):** ***Low (MC)***
The greatest concern about the damage caused by these insects would probably be raised by homeowners with ornamental trees. This concern could result in the increased use of pesticides and/or requests to conduct research on management and control measures.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*; consequences = *Moderate*)

Selected bibliography:

Anderson, R. F. 1966. Forest and shade tree entomology. New York: John Wiley & Sons. 428 p.

Bosq, J. M. 1953a. Longicórnios del Parque Nacional Lanín, zona de San Martín de los Andes y cercanía. Anuales del Museo Nahuel Huapi (Argentina) 3: 69-88.

Cameron, R. S.; Peña, L. E. 1982. Cerambycidae associated with the host genus *Nothofagus* in Chile and Argentina. Turrialba (Costa Rica) 32(4): 481-487.

González, R. H. 1989. Insectos y ácaros de importancia agrícola y cuarentenaria en Chile. Santiago: Universidad de Chile, BASF Chile S.A. 210 p.

Havrylenko, D.; Winterhalter, J. H. 1949. Insectos del Parque Nacional Nahuel Huapi. Buenos Aires: Ministerio de Obras Públicas, Administración General de Parques Nacionales y Turismo. 57 p.

Monrós, F. 1943. Algunos coleópteros de interés forestal observados en la Isla Victoria (Gobernación del Neuquén). Revista de la Facultad de Agronomía y Veternaría, Universidad de Buenos Aires 10(3): 536-543.

Peña, L. E. 1986. Introducción a los insectos de Chile. Santiago: Editorial Universitaria, S. A. 253 p.

Peterson, J. 1988. *Chilecomadia valdiviana* (Philippi) (Lepidoptera: Cossidae), asociado a *Nothofagus pumilio* (Peopp. et Endl.) Krasser (lenga) en la región de Magallanes. Anuales del Instituto de Patagonia, Punta Arenas (Chile) 18: 51-55.

Ureta, E. 1957a. Revisión de la familia Cossidae (Lep. Het.) en Chile. Aportes Lepidopterológicos. Boletín del Museo Nacional de Historia Natural (Santiago) 27(2): 129-153.

Reviewers' comments:
"The cossids, even though live-tree borers, often have very wide host ranges, i.e., *Prionoxystus robiniae* and *Zeuzera pyrina*." (Solomon)

"I cannot understand how this report can state that little is known about the abundance of *Callisphyris*, that it has been collected commonly in Chile, and that it is considered a serious pest of coigüe in Argentina and then state that the 'with host at origin' potential is low." (Lattin)

"It is worth mentioning that *Callisphyris semicaligatus* has not been observed to attack trees of the genera *Acer, Alnus, Fagus,* or *Quercus* growing in Chile." (Beéche, Cerda, Vallejos, translated from Spanish)

"I do not see enough evidence here to downgrade the colonization potential to low. With the entry potential high and the spread potential moderate, it appears to me that the colonization potential should be at least moderate." (Cobb)

"The patchy distribution of potential hosts that you state here is very much dependent upon the extent of the host range. You list *Acer, Alnus, Fagus,* and *Quercus*, all of which occur along the Pacific Coast, and together they are not all that discontinuous. Considering the strong flying character of the insect, the rating may be more than the moderate that you indicate. Hence, I believe that the risk potential should be raised to moderate (from low)." (Cobb)

Response to comments: *Chilecomadia valdiviana* was included with "Other Wood-boring Beetles of Living Coigüe" in the review draft of this report. However, following consideration of the review comments and team discussion, we decided to combine *Callisphyris* and *Chilecomadia* in one pest risk assessment because they have similar habits and pose similar risks.

The observation that *Callisphyris semicaligatus* adults have been collected "commonly" in Chile does not necessarily indicate that they are very abundant. This insect may have been encountered more often by collectors than other cerambycid beetles because of its unique appearance and its diurnal habits. Several hosts have been recorded for *C. semicaligatus* in

Chile; thus coigüe probably was the host of only a portion of the specimens collected. Also, the damage reported by Monrós (1943) to coigüe trees in Argentina has not been reported in Chile. Finally, and most importantly, *Callisphyris* spp. tend to inhabit branches and small diameter stems and are not likely to be associated with large diameter, export quality coigüe logs. Also, *Chilecomadia valdiviana* apparently prefers *Nothofagus pumilio* and may seldom be associated with *N. dombeyi*. However, given the uncertainty on the abundance and host preferences of these two insects, the team decided to increase the risk rating for pest with host at origin from low to moderate.

Because adults of *C. semicaligatus* and *C. valdiviana* are strong fliers and the larvae feed on several hosts, and in response to comments from reviewers, we have raised the colonization potential from low to moderate. In turn, the certainty code was changed from moderately certain to reasonably uncertain. This change in colonization potential results in the elevation of this species from an overall pest risk potential of low to moderate. However, we still believe that the probability of *C. semicaligatus* finding an acceptable host is still relatively remote, especially since Chilean entomologists noted that this insect has not been observed attacking possible North American host species growing in Chile. *Chilecomadia valdiviana* may be more likely to find suitable host material in the United States because its host range in Chile includes a variety of fruit trees that are common to North America.

Other Wood Borers of Living Coigüe

Scientific names of pests: *Cheloderus childreni* Gray (Coleoptera: Cerambycidae); other wood-boring cerambycid beetles with similar habits include *Holopterus chilensis* Blanch., *Lautarus concinnus* Philippi, *Planopus laniniensis* Bosq, *P. octaviobarrosi* Cerda, *Sibylla coemeterii* Thomson, *S. flavosignata* Fairm. & Germain, *S. integra* Fairm. & Germain, and *S. livida* Germain.

Scientific names of hosts: *Cheloderus childreni* on *Nothofagus dombeyi* and *N obliqua*; *Lautarus concinnus*, *Sibylla coemeterii*, and *S. flavosignata* on *N. antarctica* and *N. dombeyi*; *S. integra* and *S. livida* on *N. dombeyi* only.

Distribution: *Cheloderus childreni*--southwestern Argentina, from the mountains near Neuquén to the Nahuel Huapi National Park; southern Chile, from the mountains near Curicó to Puerto Aisén. Distributions of the other wood-boring beetles are similar to that of *C. childreni*.

Summary of natural history and basic biology of the pests: The larvae of *Cheloderus childreni* and the other cerambycid beetle species listed above bore deep into the wood of living coigüe trees. All have been reported to feed exclusively on one or two species of *Nothofagus* (Cameron and Peña 1982). Detailed information on the biology and habits is available only for *C. childreni* (Cameron and Real 1974); therefore the following information refers to this species, unless otherwise noted. The adults of *C. childreni* are brightly colored. This is arguably the most beautiful insect species in Chile and is highly valued by collectors. Adults emerge over an extended 6-month period, with peak emergence occurring from mid- to late summer; they are diurnal, and males are attracted to females by a sex pheromone (Cameron and Real 1974, Gara et al. 1978). Single eggs are glued in bark crevices of coigüe.

Larvae of *C. childreni* construct a single gallery, in the form of a "J." The gallery penetrates about 12 cm into the wood of the trunk and has a total length of about 36 cm. The larva enters and the adult exits through the same hole, which is enlarged as the larva grows. The larva tends to keep the gallery clean by expelling frass and wood shavings through the entrance hole. Pupation occurs at the deepest extension of the gallery, behind a tightly packed plug of wood shavings. Attacks by *C. childreni* can be recognized by the wood shavings extruded from the entrance/exit holes and by the characteristic bumps on the stems of attacked trees which develop when callous tissue grows over the entrance hole. Most of the galleries are located at the bases of trees, from the soil level to about 3 meters. The development of *C. childreni* larvae occurs extremely slowly; the entire life cycle from egg to adult requires about 6 years. Attacks on host trees are usually scattered and populations are relatively low.

Little is known about the galleries of the other cerambycid beetles listed above, but some are much longer, more complex, and may be packed with frass. Some are located high in the trees and may be restricted to branches or smaller diameter stems (Cameron, personal observations). None of these wood borers is known to kill trees. However, one or more of the wood-boring beetles may introduce, or at least facilitate the entrance of, wood-rotting fungi. Wood-rotting fungi have been observed associated with wood-borer galleries in coigüe on several occasions (Cameron and Peña 1982).

Holopterus chilensis is a major wood-boring pest of live *Nothofagus obliqua*, but it rarely breeds in *N. dombeyi*, at least in the Valdivia area (Cameron and Peña 1982). Thus, *H. chilensis* is deemed unlikely to be associated with coigüe logs shipped to the United States. Little is known about the host preferences or abundance of *Lautarus* sp., *Planopus* spp., and *Sibylla* spp. Some of these deep-wood borers may breed primarily in limbs or small diameter stems; if so, they would be uncommon in coigüe logs destined for export.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RC)***
   Cheloderus childreni is widely distributed and often associated with large-diameter trees, but generally it is not encountered in large numbers in any tree or group of trees.

2. **Entry potential:** ***High (RC)***
   Most of the immature larvae of these insects would not survive to maturity in the logs imported from Chile because they apparently require living host material and several years to complete their development. However, late-stage larvae, pupae, and adults in galleries may survive the transit from Chile to the United States and emerge from unprocessed logs.

3. **Colonization potential:** ***Low (MC)***
   Colonization in the United States by *C. childreni* and the other cerambycid species listed above would be highly unlikely. Numbers of any of these insects arriving and emerging from logs at any one time would be low. All the wood borers in this group are nearly monophagous, feeding on one or two species of *Nothofagus*. The closest genus to *Nothofagus* in the United States is *Fagus* and it would be highly improbable that any of these insects would locate and survive on a species from a different host genus.

4. **Spread potential:** ***Low (MC)***
   Although *C. childreni* males are strong fliers, females appear to fly very little, at least when heavily laden with eggs upon emergence. The majority of eggs probably are deposited on the tree from which the female emerges and nearby trees within walking distance. Thus, the potential for rapid spread of *C. childreni* is low.

B. Consequences of establishment

5. Economic damage potential: *Low (MC)*

It would be nearly impossible for *C. childreni* and other wood-boring cerambycids of living coigüe to become established in the United States because of their host specificity and other biological limitations discussed above. However, if they did, damage is not expected to be extensive. These insects do not kill trees. At most, they would cause some degrade in lumber sawn from infested trees. If any of the deep-wood boring beetles included in this analysis were to actively vector a pathogenic fungus, the potential for economic damage might be elevated to moderate. However, such an association has not been confirmed for any of these insects.

6. Environmental damage potential: *Low (RC)*

Although the wood borers discussed in this assessment are unique to Chile and do not have a parallel in the United States, the low population levels anticipated (assuming they were to become established) would cause negligible environmental damage.

7. Perceived damage potential (social and political influences): *Low (RC)*

Because this group of wood-boring insects does not kill trees, little or no perceived damage would result from their establishment in living trees in the United States. Some public concern may be generated if any of these wood-boring insects were to become very numerous in ornamental or fruit trees.

Pest risk potential: ***Low*** (probability of establishment = *Low*; consequences = *Low*)

Selected bibliography:

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Cambium Miner of Living Coigüe

Scientific name of pest: *Notiopostega atrata* Davis (Lepidoptera: Opostegidae).

Scientific name of host: *Nothofagus dombeyi.*

Distribution: *Notiopostega atrata* has been collected only in the Valdivia area in southern Chile (region IX). However, the damage caused by *N. atrata* is very common in *Nothofagus dombeyi* and, presumably, this insect is distributed throughout the range of its host.

Summary of natural history and basic biology of the pest: *Notiopostega atrata* is a recently described species in a monotypic genus (Davis 1989). This unique family of leaf- and cambium-mining caterpillars is dispersed throughout most of the world, but only 106 species have been described and little is known about the life histories of most species. One of the first references to the damage caused by *N. atrata* was by Bonnemann and Knigge (1969), who mistook this insect for an agromyzid fly.

The life history of *N. atrata* in association with coigüe in the coastal mountains near Valdivia has been thoroughly investigated by Carey (1975) and Carey et al. (1978). This univoltine insect overwinters in the pupal stage inside silken cocoons in the leaf litter under host trees. Adults emerge early in the spring (September) and eggs are deposited on the undersides of leaves in the upper crown of coigüe, its only known host. Upon hatching, larvae mine through the leaf, down the petiole, and into the cambium of young branches. Larvae continue descending in the cambium of branches and the main stem in a characteristic "zig-zag" pattern for about 2 months. They then mine back up the stem, eventually forming an aestivation chamber where they remain for about 2 months. In the fall (April), larvae leave the aestivation chamber and descend about 35 cm, feeding on the callous tissue in the original gallery. At this point they emerge through the thin bark and descend to the forest floor, where they spin cocoons and overwinter.

The width of larval mines varies from 0.2 to 2.0 mm, and the overall length is about 7 meters. In young trees, galleries are encountered from the top to the base of the tree. However, in large trees, galleries are restricted to larger diameter branches. Larval galleries are quickly covered over by callus tissue, leaving characteristic reddish-colored inclusions and grain-texture defects in the wood. In cross and radial sections, these inclusions are represented by "pith flecks" or "medullary spots" in the wood. However, in tangential cuts or veneers, these inclusions appear as reddish zig-zag lines, or lines of different textured grain. Pith flecks are very common in the wood of coigüe, and in the past, have greatly limited its acceptance for veneers, especially in the European market (Bonnemann 1967).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RC)***
   Eggs would not be included in log shipments, because they are located on leaves, which would not be shipped with the logs. The larva is the only stage likely to be associated with coigüe logs from Chile. Larvae are mostly associated with branches and smaller diameter stems. Thus, most of the large-diameter logs selected for export would not contain *N. atrata* larvae.

2. **Entry potential:** ***Low (RC)***
   Larvae mine just beneath the bark in living trees. They may survive a short time in felled trees, but they would be especially vulnerable to the extreme climatic conditions encountered in the tropics in transit from Chile to the United States.

3. **Colonization potential:** ***Low (RC)***
   It is highly unlikely that this insect would survive and locate a new host in the United States. Even if larvae could survive in transit, they would have to emerge from the stems, find a suitable site for pupation, emerge, be synchronized with a new climate and reversed seasons, have sufficient numbers of adults to mate, and then locate a suitable host. This insect is highly host specific, limited only to *N. dombeyi* in Chile and probably in Argentina, and it is doubtful that any of the hardwood species in the United States would be a suitable host.

4. **Spread potential:** ***Moderate (RU)***
   Adult dispersal would be the primary means of spread for this insect. Adults are fragile moths, probably incapable of strong and distant flight. Some larvae may be transported in host material, but relatively few individuals would be involved and most would not survive the transport or be capable of finding a mate or locate suitable hosts.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (RU)***
   This insect does not kill trees. The larval gallery and resulting callus tissue cause a pith fleck, or medulary spot in wood, which may cause some degrade in high-value hardwood peeler logs and furniture lumber.

6. **Environmental damage potential:** ***Low (RC)***
   Few insects utilize the niche occupied by this cambium miner. It does not kill trees and does not occur in such large numbers as to cause significant adverse environmental effects.

7. **Perceived damage (social and political influences):** ***Low (RC)***
The damage and the various life stages of *N. atrata* are inconspicuous to all but a trained specialist. The general public would not be bothered by the damage or the insects, even if populations were very high.

Potential pest risk: ***Low*** (probability of establishment = *Low*; consequences = *Moderate*)

Selected bibliography:

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Carey, P. 1975. Biología del minador del cambium de *Nothofagus dombeyi* (Mirb.) Oerst. Tesis, Ingeniería Forestal, Universidad Austral de Chile, Valdivia. 59 p.

Carey, P.; Cameron, R. S.; Cerda, L.; Gara, R. 1978. Ciclo estacional de un minador subcortical de coigüe (*Nothofagus dombeyi*). Turrialba (Costa Rica) 28(2): 151-153.

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Reviewers' comments:

"[The] statement that defects have limited export of *Nothofagus dombeyi* to Europe further indicates the danger of importing this species into North America. The presence of defects is often an indicator of the presence of insects or disease agents." (Cobb)

"Contrary to your statement that larval *Notiopostega atrata* 'would be especially vulnerable to the extreme climatic conditions encountered in the tropics in transit...', we believe *N. atrata* would be well-protected under the bark. Either bark provides excellent insulation or insect-threatening extreme climatic conditions are not encountered in ships in the tropics, because we have found larval *Hylurgus* alive and well under bark remaining on logs shipped from New Zealand." (Hilburn, Griesbach, Johnson, Wright)

"Perhaps more should be made of the cambium miners and resulting pith flecks. You mention the objection to pith flecks in the wood of coigüe. I have had a number of calls and inquiries in this country about pith flecks in ash originating in Louisiana and elsewhere and imported to Europe. Callers object to the defects and try to buy logs free of pith fleck." (Solomon)

Response to comments: The first and second comments reflect concern that *Notiopostega atrata* may be more likely to enter the United States in coigüe logs than we have indicated in our pest risk assessment. First, the presence of defects does not necessarily indicate that the insects causing these defects are in logs destined for export. The primary defect limiting export of coigüe to Europe apparently is the pith fleck in wood. Pith flecks are the remnants of *N. atrata* larval mines in the cambium layer, primarily in thin-barked, smaller diameter branches and stems, of living coigüe trees. Thus, although pith flecks are common in certain portions of coigüe logs, we believe that the larvae of this insect would be relatively rare under the bark in large diameter coigüe logs destined for export. Furthermore, unlike larvae of scolytids in pine which attack dying, dead, or cut host material, the larvae of *N. atrata* mine in the succulent cambium in living coigüe trees; the latter insects would be very susceptible to the major changes in moisture and temperature encountered in logs during harvesting, storage, and transport to the United States.

We believe it is very unlikely that *N. atrata* would enter the United States and find a suitable host. However, if it were to infest a valuable North American hardwood species used for veneers and furniture lumber, especially one exported to Europe, the pith fleck defect caused by this insect may result in considerable economic damage. Thus, in response to the third reviewer's comments, we have increased the economic damage potential from low to moderate. This does not change the overall pest risk potential because two of the single elements that determine the probability of establishment are low.

Bark-Boring Beetles of Dead and Dying Coigüe

Scientific names of pests: *Calydon submetallicum* (Blanchard) (Coleoptera: Cerambycidae); other species with similar distributions, life cycles and habits include *Rhyephenes maillei* (Gay & Sol.), (Coleoptera: Curculionidae), *Epistomentis pictus* Gory, and *E. vittata* Phil. (Coleoptera: Buprestidae).

Scientific names of hosts: *Calydon submetallicum* on various *Nothofagus* species, including *N. antartica*, *N. betuloides*, *N. dombeyi*, *N. glauca*, *N. obliqua*, and *N. pumilio* (Havrylenko and Winterhalter 1949, Aguilar et al. 1991, Fairmaire and Germain 1859), also *Drimys winteri*, *Persea lingue*, and *Quillaja saponaria* (Porter 1938); *Rhyephenes maillei* on all types of weakened trees, native and exotic, including *Pinus radiata, Nothofagus dombeyi, Maytenus boaria, Lomatia hirsuta* (Billings et al. 1972, Aguilar et al. 1991); *Epistomentis pictus* and *E. vittata* on *Nothofagus alpina, N. dombeyi,* and *N. pumilio* (Aguilar et al. 1991).

Distribution: *Calydon submetallicum*--distributed in southwestern Argentina and in Chile from Santiago to Magallanes, coinciding closely with the distribution of *N. dombeyi* and *N. obliqua* forests (Bruch 1912, Duffy 1960, Peña 1976). This is one of the most widely distributed and abundant cerambycid species in Chile and Argentina (Bosq 1953a, Peña 1976). *Rhyephenes maillei* and *Epistomentis* spp.--found throughout the range of *N. dombeyi* in Chile and Argentina.

Summary of natural history and basic biology of the pests: Most of the references to *Calydon submetallicum* in the literature concern taxonomy and distribution. Little information on its biology is available. This cerambycid has a 2-year life cycle (Havrylenko and Winterhalter 1949). Adult emergence and oviposition occur during the late spring to early summer (November and December). Monrós (1943) indicated that this insect attacks live or dead trees. However, recently cut or fallen limbs or tree trunks are actually preferred (Havrylenko and Winterhalter 1949; Peña 1976; R. S. Cameron, personal observation). Larvae feed on the inner bark, leaving a characteristic frass-packed, winding gallery. The larvae score the surface of the wood during their early stages of development and bore into the sapwood to prepare pupal chambers up to 1.5 cm deep along the grain of the wood. If the bark is 1.5 to 2 cm thick, pupal chambers may be constructed in the bark (Havrylenko and Winterhalter 1949). Biological controls include woodpeckers, ichneumonid parasitoids, and various coleopteran predators that attack the larvae (Havrylenko and Winterhalter 1949). *Rhyephenes maillei* and *Epistomentis* spp. also inhabit the inner bark region of dead and dying coigüe logs and have similar life cycles.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***High (RC)***
   Logs left in the forest for any length of time are likely to be attacked by *C. submetallicum* or some other bark-infesting insects, such as *R. maillei* or *Epistomentis* spp. However, infestations of these insects can be eliminated by

scheduling harvests and transportation of logs prior to adult emergence, or by timely debarking (Havrylenko and Winterhalter 1949). But, given the remoteness and adverse weather conditions associated with most of the native hardwood resources in Chile, it would be difficult to totally avoid infestation.

2. **Entry potential:** ***High (RC)***
In their protected environment beneath the bark, and especially in the wood, these wood borers are likely to survive the trip from Chile to the United States. Their apparent extended two-year life cycle with overlapping generations would increase the probability that life stages would be present in the logs that could survive the rigors of transport and reversal of seasons.

3. **Colonization potential:** ***Moderate (MC)***
Calydon submetallicum and *Epistomentis* spp. attack many *Nothofagus* species and the former species may develop in native hardwoods of other genera as well. *Rhyephenes maillei* attacks a wide variety of hosts, including many native and exotic hardwoods and conifers. All of these insects prefer recently cut logs. Thus, one or more of these bark-boring beetles may be capable of successfully developing in freshly cut hardwood logs of the genera *Acer, Alnus, Fagus, Fraxinus*, or *Quercus* in the United States. Such hosts are likely to be present near the ports along the Pacific, Atlantic, and Gulf Coasts of the United States.

4. **Spread potential:** ***Moderate (MC)***
Assuming that any of these insect species is capable of developing on a variety of host species in the United States, the potential for spread is moderate. Hardwood species are present in most of the forested areas in the United States. However, the rates of expansion and levels of populations of these insects are likely to be limited by natural barriers, such as breaks in host availability and competition from native insect species which already occupy this niche.

B. Consequences of establishment

5. **Economic damage potential:** ***Low (MC)***
Given the superficial character of the larval galleries of these insects, and the fact that these insects prefer dead or dying host material, they are unlikely to cause significant economic damage. Even if high populations were to develop, removal of cut logs from the forest before adults emerge and/or debarking would eliminate any potential degradation by these insects (Havrylenko and Winterhalter 1949).

6. **Environmental damage potential:** ***Low (MC)***
Many insects native to the United States bore under the bark of dead and dying trees but have little or no detrimental environmental impact. Thus, even if one of these insects were to be introduced and become very abundant in the United

States, it would be among a group of species that are generally considered beneficial as contributors to the decomposition process.

7. **Perceived damage potential (social and political influences):** ***Low (RC)*** All life stages and damage of *C. submetallicum* and *Epistomentis* spp. are unlikely to be noticed by, or be of any concern to, the general public. If the relatively large *Rhyephenes* weevils were to become very numerous on dead and dying ornamental trees, their presence and the unusual appearance of the adults might cause some alarm and generate numerous inquiries from the general public.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*; consequences = *Low*)

Selected bibliography:

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Monrós, F. 1943. Algunos coleópteros de interés forestal observados en la Isla Victoria (Gobernación del Neuquén). Revista de la Facultad de Agronomía y Veternaría, Universidad de Buenos Aires 10(3): 536-543.

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Porter, C. 1938. Introducción al estudio de los cerambícidos chilenos. Revista Chilena de Historia Natural 42: 221-231.

Reviewers' comments:
"It is necessary to specify the hosts for each of these insects. For example, *Calydon submetallicum* and *Epistomentis* spp. are host specific, developing exclusively under the bark of *Nothofagus*. These wood borers have not been observed to infest exotic hardwoods growing in Chile (e.g., *Acer, Alnus, Fagus, Fraxinus,* or *Quercus*) as hypothesized in this document." (Beéche, Cerda, Vallejos, translated from Spanish)

Response to comments: As recommended by our Chilean colleagues, the known hosts for each wood borer species have been specified in the "scientific names of hosts" section of this IPRA. The reviewers' observation that *Calydon submetallicum* and *Epistomentis* spp. have not been found infesting exotic hardwoods growing in Chile is important to note. However, we are unaware of any systematic surveys conducted on exotic trees in Chile to determine if they do have any native or exotic pests. Such a study would be a valuable contribution for any future pest risk assessments. *Rhyephenes maillei* is known to inhabit numerous native and exotic tree species in Chile and would likely adapt readily to one or more North American species. Thus, we have left the colonization potential as moderate for this group of potential pests.

Ambrosia Beetles of Coigüe

Scientific names of pests: *Gnathotrupes* spp. (Coleoptera: Scolytidae), including *G. caliculus* (Schedl), *G. cirratus* Schedl, *G. fimbriatus* (Schedl) *G. impressus* (Schedl), *G. longipennis* (Blanchard), *G. longiusculus* (Schedl), *G. nanulus* (Schedl), *G. naumanni* (Schedl), *G. nothofagi* (Schedl), *G. pauciconcavus* Schedl, *G. pustulatus* Schedl, *G. similis* Schedl, *G. solidus* Schedl, *G. vafer* (Schedl), and *G. velatus* Schedl (Wood and Bright 1992).

Scientific name of host: *Nothofagus dombeyi*.

Distribution: Southern Argentina and southern Chile.

Summary of natural history and basic biology of the pests: Scolytids of the genus *Gnathotrupes* are ambrosia beetles similar in structure and habits to the North American *Gnathotrichus*. In their world catalog of Scolytidae and Platypodidae, Wood and Bright (1992) list 30 species of *Gnathotrupes* from Central and South America, of which 21 species occur in Chile and/or Argentina. Among the latter, hosts are recorded for only 14 species. For each of these 14 species, the one and only host recorded in the world catalog is *Nothofagus dombeyi* (coigüe). Although this information suggests that these insects exhibit a high level of host specificity, a more plausible explanation is that collection efforts were limited only to this one tree species. According to Chilean forest entomologists (D. Lanfranco and A. Aguilar, personal communication), only two species of ambrosia beetle, *Gnathotrupes fimbriatus* and *G. longipennis*, are found infesting lumber sawn from native hardwoods in Chile. No further information is available on their biologies, specific hosts, or economic impacts. (Wood and Bright do not list a known host for *G. fimbriatus*).

According to S. Wood (personal communication), South America is now the poorest known area of the world for Scolytidae and Platypodidae and probably less than 50% of the neotropical species are named. For those known to science, fewer than 20% have a recorded host. Less than 5% have been investigated biologically in even the most limited sense. No scolytids or platypodids are cited in the world catalog in association with *Laurelia* spp. (Wood and Bright 1992).

The following information on biology of these insects pertains to the genus *Gnathotrichus* in North America. Presumably, the biologies of *Gnathotrupes* spp. in Chile are similar. *Gnathotrichus* spp. attack dying, standing trees or, more commonly, fallen trees or recently cut logs. The male of these monogamous insects constructs a radial entrance hole and primary tunnel that extends through the bark and into the sapwood. The male inoculates the tunnel wall with symbiotic fungal spores and is joined by a female. One or more secondary tunnels branch horizontally, following growth rings in the wood. Eggs are deposited individually in large egg niches. The larva enlarges its egg niche into a gallery as it grows. Pupation occurs in the larval gallery and the young adults emerge through the parental tunnels. The larval food consists primarily of the ambrosial fungus (Furniss and Carolin 1977, Wood 1982).

In the coastal forests of British Columbia, where damage by ambrosia beetles has been most serious, *Gnathotrichus retusus* (LeC.) and *G. sulcatus* (LeC.) together are a distant second in importance to *Trypodendron lineatum* (Olivier). Ambrosia beetles are important enemies of forest products because of their ability to riddle unseasoned wood with small round pin holes or shot holes. These holes often become surrounded with a dark brown or black stain, which causes additional degrade (Furniss and Carolin 1977).

Ambrosia fungi are of several genera, including *Ambrosiella* and *Raffaellea*. The fungi are stored in specialized structures, usually in the female, and are introduced into the galleries during the burrowing process. Each fungus is associated with just one or a few species of beetle (Batra 1967). The requirements of these insects are very exacting. If moisture conditions are not suitable, the fungi fail to develop and the beetles starve; or if the fungi grow too abundantly, the beetles are unable to cope with them and are smothered in their own food. For this reason only moist, unseasoned wood is suitable for attack, and dried seasoned lumber is immune. Ambrosia beetles are common in coniferous forests throughout the West, but in the drier areas they are not reported to cause significant damage (Furniss and Carolin 1977).

Ambrosia beetles, in general, are not host specific and can adapt to a broad spectrum of conifers or hardwood hosts, but not both (Wood 1982, 1986, Furniss and Carolin 1977). According to S. Wood (personal communication), *Gnathotrichus materiarius* (Fitch) was exported from the United States to Europe, apparently during World War II. In the absence of disease, parasites, and predators, it became a much more serious pest of conifers there than it is in its native range.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin: *High (RU)***
   Although numerous species of *Gnathotrupes* have been recorded on *Nothofagus dombeyi*, almost nothing is known about the relative abundance of these species or the location on the host. However, with such a large species diversity, it is highly likely that at least one species colonizes the sapwood of large-diameter trees. Given the remoteness of many coigüe harvest sites and the prolonged extraction periods (compared to Monterey pine), we must assume that the opportunities for invasion of coigüe sawlogs by *Gnathotrupes* spp. will be great.

2. **Entry potential: *High (RC)***
   Eggs, larvae, and pupae of ambrosia beetles inhabiting sawlogs are likely to be protected from adverse environmental extremes deep inside their sealed tunnels. Conceivably, however, the increased temperatures incurred in tropical regions during shipment of logs to the United States could favor growth of the symbiotic fungi in the ambrosia beetle galleries, resulting in high mortality of developing beetles. Until such a hypothesis is documented, however, entry potential is rated as high.

3. **Colonization potential:** ***Moderate (VU)***
In the world catalog (Wood and Bright 1992), the species of *Gnathotrupes* in Chile have been recorded exclusively from *Nothofagus dombeyi* and not from other hardwood tree species even within the same genus. This suggests a high level of host specificity, in which case the probability of establishment in the United States would be nil, due to the absence of *Nothofagus*. Again, however, very little is known about the biologies and actual host ranges of the multitude of *Gnathotrupes* species in Chile. Thus, a colonization potential of at least moderate appears justified until major faunal and economic surveys can be conducted in Chile's native forests. Indeed, most North American species of the closely related *Gnathotrichus* have a broad range of host genera (Furniss and Carolin 1977).

4. **Spread potential:** ***Moderate (MC)***
Assuming that species of *Gnathotrupes* become adapted to one or more North American hardwood hosts (beech, alder, oak and/or ash, among others), spread potential would depend on the relative abundance and distribution of the host species in vicinity of the entry location. Scolytids are relatively strong fliers and should be capable of moderate to rapid spread if suitable hosts are available.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (MC)***
Pinholes and staining caused by ambrosia beetles may seriously degrade high-quality logs, thus causing significant financial losses. Damage is greatest in conifers harvested from coastal forests, because temperature and moisture conditions are most favorable to ambrosia beetle development. Economic damage to native hardwood logs due to *Gnathotrupes* spp. introduced into the United States may vary from negligible to severe, depending on the host involved and its use for commercial purposes. Accordingly, an economic damage potential of moderate seems warranted until more comprehensive information becomes available.

6. **Environmental damage potential:** ***Low (MC)***
Ambrosia beetles of the genera *Gnathotrupes* and *Gnathotrichus* are not known to attack healthy, living trees. They most commonly restrict their attacks to recently cut logs or dead branches. Thus, a species newly introduced into the United States would cause little environmental damage.

7. **Perceived damage potential (social and political influences):** ***Low (RC)***
All life stages and damage by ambrosia beetles are restricted to the interior of logs or to trees dying from other causes and would not be noticed by, or be of concern to, the general public in forest situations.

Pest risk potential: ***Moderate*** (probability of establishment = *Moderate*; consequences = *Moderate*)

Selected bibliography:

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Reviewers' comments:

"There are 18 species of South American scolytids recorded from *Nothofagus* (*N. dombeyi*, *N. obliqua*, *N. pumilio*), almost all named since 1960. This says we know virtually nothing of the species of Scolytidae in *Nothofagus* and absolutely nothing of their economic impact in Chile or in alternate hosts on which they might survive if imported into the USA. Major faunal and economic surveys should precede any proposal to export timber [of native hardwoods]. Failure to do so could result in the biological chaos that now exists in Japan. The economic return is not worth the risk to our environment." (S. Wood)

"If Stephen Wood has identified [18] species of ambrosia beetles from *Nothofagus* in Chile, I expect we (U.S.) will have some or all of them if we don't treat the logs. I would raise the risk potential from <u>low</u> to <u>moderate</u>." (Solomon)

"The bark beetles associated with the *Nothofagus* . . . would be unlikely to cause concern to North American forests, unless they brought with them some unknown plant pathogen." (Bright)

Response to comments: Given the great number of *Gnathotrupes* recorded by Wood and Bright (1992) on *Nothofagus* and the potential risk posed by these wood-inhabiting insects for U. S. resources, the team decided to prepare a separate pest risk assessment for these ambrosia beetles, rather than include them together with the bark-inhabiting insects of coigüe, as was done in the review draft. In turn, the category for the two species of *Gnathotrupes* (*G. fimbriatus* and *G. longipennis*) known to attack coigüe logs and lumber in Chile was changed from 3a to 1a, according to definitions given in table 3-1. The other 13 species of *Gnathotrupes* listed in the world catalog on *N. dombeyi* were assigned to category 3a because no other information is available on their biology or locations on this host.

Termites of Coigüe and Tepa

Scientific names of pests: *Porotermes quadricollis* (Rambur) (Isoptera: Termopsidae), *Cryptotermes brevis* Walker, *Neotermes* (= *Kalotermes*) *chilensis* (Blanchard), *Kalotermes* (= *Neotermes*) *gracilignathus* Blanch. (Isoptera: Kalotermitidae).

Scientific names of hosts: *Nothofagus* spp., *Laurelia* spp., *Aextoxicon punctatum*, and other native species; *Pinus* spp., *Pseudotsuga menziesii*, *Eucalyptus* spp., *Populus* spp., *Salix* spp.

Distribution: The dampwood termite, *Porotermes quadricollis,* is found in southern Chile throughout regions V to XII (Villán 1972), characteristically under moist conditions (González 1989). In Chile, the drywood termite *Cryptotermes brevis* is found exclusively in the arid northern regions (Copiopó to Arica) (Instituto Forestal 1965, Micheli and del Río 1967) and on Easter Island (Peña 1986). This drywood termite has already been introduced into the United States and occurs along the Gulf Coast and as far north as Tennessee. Another drywood termite, *Neotermes chilensis,* is distributed from region IV to region VIII, both in old dead trees and wood in use. The third drywood termite, *Kalotermes gracilignathus*, apparently occurs only on Juan Fernández Island off the coast of Chile (Peña 1986), infesting wood in use (Aguilar et al. 1991).

Summary of natural history and basic biology of the pests: *Cryptotermes brevis* and *Neotermes chilensis* are common pests of coigüe and tepa wood in use (Micheli and del Río 1967). Although *N. chilensis* may attack dead trees and stumps of pine and native hardwood trees, its distribution does not extend into the southern regions where coigüe or tepa will be harvested. The Chilean dampwood termite, *Porotermes quadricollis*, is commonly found in dead trees, old logs and stumps of pine, and old standing trees in native hardwood forests under damp, humid conditions (González 1989). It is the termite most likely to be associated with coigüe logs destined for export. The frequency with which *P. quadricollis* infests standing coigüe trees or logs remains to be documented; without doubt, it would vary with the condition of the stands being harvested and the duration of the extraction process, respectively.

Tepa trees are well known to be free of insect pests, although *Cryptotermes brevis* infests tepa wood in use (Instituto Forestal 1965, Micheli and del Río 1967). Recently, a species of exotic subterranean termite (*Reticulitermes* sp.) has been discovered in a few houses in Santiago (Prado 1991). This is the first report of subterranean termites in Chile and, presumably, the distribution of this newly introduced species is limited to Santiago.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate (RU)***
   Porotermes quadricollis, the only termite of concern in native forests of southern Chile, restricts its invasion to dead trees, stumps, and trees severely

weakened by disease, fire, or other causes (Araujo 1979). The probability of dampwood termites occurring on coigüe logs destined for export is uncertain; no doubt it will depend on the frequency that termites occur in standing trees and how rapidly the logs are removed from the harvest site. Presumably, termites are more likely to be encountered in logs of native trees cut from overmature natural stands than in Monterey pine logs from fast-growing 20 to 25-year-old plantations. The three species of drywood termites associated with coigüe and tepa are of concern only as pests of wood in use; their known distributions preclude their occurrence on coigüe or tepa logs.

2. **Entry potential: *Low (RC)***
The dampwood termite (*Porotermes quadricollis*) is less likely to survive in unprocessed and untreated logs during transit than the drywood termites. Dampwood termites require more moisture than is normally in wood, so they are not readily transported by commerce (Williams and La Fage 1979).

3. **Colonization potential: *Low (MC)***
As with other termites, the establishment of a colony of *Porotermes* would be a slow process. Colonization of dampwood termites would be favored along the coast of the Pacific Northwest, due to favorable (damp) environmental conditions (Moore 1979), but environmental resistance from competing species of termites may hinder establishment. Also, because adults swarm only once a year, logs may be processed before winged termites could mature.

4. **Spread potential: *Low (MC)***
Termites, including dampwood termites, spread slowly (50 to 1,000 feet per year) because they are poor fliers and only about 1% of those that fly are likely to establish a new colony (USDA Forest Service 1992).

B. Consequences of establishment

5. **Economic damage potential: *Low (MC)***
Unlike *Porotermes adamsoni* in Australia (Browne 1968), *P. quadricollis* is not known to infest or kill healthy trees. This dampwood termite would compete with native insects that degrade and decompose dead or dying host material. This termite will occasionally attack untreated wood, but only if conditions are damp, with poor ventilation. The damage, although difficult to detect, is less serious than that caused by drywood termites (Moore 1979). If introduced, however, these termites would have to compete with the other 43 species of termites already found in the United States. In forest situations, these termites would be of no economic concern, limiting their attack to dead trees, stumps, and well-aged logs.

6. **Environmental damage potential:** ***Low (MC)***
Environmental damage resulting from infestations of *P. quadricollis* would be minimal in forest situations. Their feeding activity in dead trees and stumps would contribute to the decomposition process.

7. **Perceived damage (social and political influence):** ***Low (MC)***
These termites would not cause aesthetic damage in the forest. Damage to wood in use could cause public concerns, as with other termite species. Controls for termites are available, but can be expensive.

Pest risk potential: ***Low*** (probability of establishment = *Low*; consequences = *Low*)

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Reviewers' comments:

(See reviewers' comments and the team response following the IPRA on termites associated with pine.)

Individual Pest Risk Assessments: Pathogens of Coigüe and Tepa

Lists of possible quarantine fungi were developed for coigüe (*Nothofagus dombeyi*) (table 5-2) and tepa (*Laurelia philippiana*) (table 5-3), using criteria in table 3-1 (page 18). In turn, individual pest risk assessments were prepared for those fungi causing stain and wood decay. Reviewers' comments pertaining to specific pathogens, together with responses by the assessment team, accompany each IPRA.

Table 5-2. Summary of possible quarantine fungi associated with imported logs of coigüe (*Nothofagus dombeyi*) from Chile, including host range, location on the host, and pest category

Species	Other hosts	Location					Pest category*
		Seedlings in nursery	Foliage/ other	Bark cambium	Sapwood	Heartwood	
Armillariella procera (Speg.) Singer	N			X	X	X	1a
Ceratocystis nothofagi Butin	N			X	X		1a
Ganoderma applanatum (Pers.) Pat.	P, C, N, E				X	X	2c
Ophiostoma (= *Ceratocystis*) *piceae* (Munch) Syd. & P. Syd.	P, N			X	X		2c
Ophiostoma valdiviana (Butin) Har.	N				X	X	1a
Phlebia crysocrea (Berk. et Curt.)Burdsall	N				X	X	2c
Phellinus senex (Nees et Mont) Imaz.	N			X			3a
Phytophthora spp.	N			X	X		2d
Schizophyllum commune Fr.	P, C			X	X		2c
Stereum spp.	N				X	X	2c
Trametes versicolor (L.: Fr.) Pilat	P, C, N				X	X	2c
Verticicladiella sp.	N			X	X		2c

P = *Pinus* spp., C = other conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* See table 3-1 on page 18 for definitions of categories; fungi in category 2 are also found in the United States.

Table 5-3. Summary of possible quarantine fungi associated with imported logs of tepa (*Laurelia philippiana*) from Chile, including host range, location on the host, and pest category

		Location					
Species	Other hosts	Seedlings in nursery	Foliage/ other	Bark cambium	Sapwood	Heartwood	Pest category*
Aecidium aridum Diet & Neger			X	X			2d
Armillariella procera (Speg.) Singer	N				X	X	1a
Ceratocystis moniliformis (Hedgc.) C. Moreau					X		2c
Ganoderma applanatum (Pers.) Pat.	P, C, N, E				X	X	2c
Ophiostoma (= *Ceratocystis*) *picea* (Munch) Syd. & P. Syd.	P, N			X	X		2c
Phellinus senex (Nees et Mont) Imaz.	N			X			3a
Schizophyllum commune Fr.	P, C			X	X		2c
Stereum spp.	N				X	X	2c
Trametes versicolor (L.: Fr.) Pilat	P, C, N				X	X	2c

P = *Pinus* spp., C = other conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* See table 3-1 on page 18 for definitions of categories; fungi in category 2 are also found in the United States.

Stain and Vascular Wilt Fungi of Coigüe and Tepa

Scientific names of pests: *Ophiostoma piceae* (Munch) Syd. & P. Syd. (= *Ceratocystis piceae* (Munch) Bakshi), *Ophiostoma valdiviana* (Butin) Harrington (= *Ceratocystis valdiviana* Butin), *Ceratocystis moniliformis* (Hedgc.) C. Moreau, *Ceratocystis nothofagi* (Butin).

Scientific names of hosts: In Chile, *Ophiostoma picea* on *Laurelia philippiana, Nothofagus* spp. including *N. dombeyi*, *Pinus radiata*; in other regions of the world on many other coniferous and hardwood hosts. Other species of *Ophiostoma* and *Ceratocystis* on *Nothofagus* spp. and *Laurelia* spp. in Chile and Argentina (Butin and Peredo 1968).

Distribution: *Ophiostoma piceae* and *C. moniliformis*--worldwide; *C. nothofagi* and *O. valdiviana*--Chile and Argentina.

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*) and its anamorphs *Leptographium* and *Graphium*, cause disease in standing trees (Boyce 1961, DeHoog and Scheffer 1984, Upadhyay 1984). Definite links with bark beetle vectors have been established in some cases, but not others (Harrington 1988). Most of those that are associated with bark beetles (family Scolytidae) are involved with their vectors in tree killing. When introduced into a host by bark beetles, these fungi invade the sapwood, occlude water-conducting vessels, and contribute to killing the tree. They assist their vectors in a mutualistic fashion by stopping host defense reactions and creating conditions conducive to brood production (Graham 1967, Dowding 1984). Virtually all bark beetles as well as some cerambycids, curculionids, dipterans, predatory beetles, mites, and nematodes have one or more *Ophiostoma* spp. associates (Francke-Grosman 1963b, Whitney 1982, Harrington 1988).

Ophiostoma spp. form fruiting bodies (both perfect and imperfect types) 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 with them and inoculate the fungi into new hosts when feeding or constructing galleries. Some bark beetle species have specialized fungus-carrying structures (mycangia) whereas others carry spores passively on their exoskeletons or in their digestive tracts. Spores may be carried long distances by the vectors. *Ophiostoma piceae* and *Ceratocystis moniliformis* have been identified on native trees in the United States (Farr et al. 1989, Hepting 1971). *Ophiostoma piceae*, isolated from sawn timber of *Nothofagus pumilo*, and from bark and wood of *N. dombeyi* (Butin and Aguilar 1984), is cosmopolitan in distribution. *Ophiostoma piliferum*, isolated from sawn timber of *N. pumilo* (Butin and Aguilar 1984), also is cosmopolitan. Both species were associated with a grey-black discoloration of the *N. pumilio* wood surface. *Ceratocystis nothofagi* was described as a new species in bark of *N. dombeyi* in Chile, and *O. valdiviana* as a new species under the bark and on the wood of *N. alpina* and *N. dombeyi* in Chile (Butin and Aguilar 1984).

Ophiostoma valdiviana is a frequent representative of the genus *Ophiostoma* in natural stands of *Nothofagus* in the Chilean rain forest, colonizing the underside of dead bark and the surface of fallen stems or stumps of different species of *Nothofagus.* Butin and Aguilar (1984) report that *O. valdiviana* seems to be limited to trees dying slowly under natural conditions, and that it was never observed on logs being stored in sawmills, where it was replaced by *O. piceae.*

Several species of *Ceratocystis* (*Ophiostoma*) have been reported from *Laurelia* in Chile (Peredo unpublished), including *O. piceae* on *L. philippiana* and *L. sempervirens*, and *C. moniliformis* on *L. philippiana*. Both fresh logs and sawn green lumber of *L. philippiana* are much more susceptible to stain fungi than is *Nothofagus dombeyi* (H. Peredo and others, personal communication).

Several species of *Chalara*, an anomorph of *Ophiostoma*, are associated with *Nothofagus* species. *Chalara brevicaulis, C. dualis*, and *C. nothofagi* are saprophytes on fallen leaves of *N. dombeyi* in Argentina (Arambarri et al. 1981, Gamundi et al. 1977). *Chalara australis* is a vascular pathogen of *N. cunninghamii* in Australia (Kile and Walker 1987). An unidentified species of *Verticicladiella*, an anomorphic genus of *Ophiostoma*-type fungi (Harrington 1988), is reported from *N. alpina* in Chile (Peredo unpublished).

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin: *Moderate* for coigüe; *High* for tepa *(RC)***
   The species mentioned above have been identified as occurring on *Nothofagus* and *Laurelia* in Chile. There is a high probability that these and other *Ophiostoma* spp. will occur on native hardwood logs, particularly those of *L. philippiana*. Coigüe logs from previously healthy trees that are decked and left in the forest for several months have a high probability of being colonized by insects and associated *Ophiostoma* spp. Logs of *L. philippiana* are more prone to staining than is coigüe, despite the fact that this species is not infested with bark- or wood-boring insects to serve as vectors. According to Roberto Perez (BOMASA), wood-staining fungi are not a serious problem for mills in Chile that process coigüe; veneers can be left untreated for months without staining.

2. **Entry potential: *High (VC)***
   Entry potential for *Ophiostoma* spp. is high. These fungi survive well for some time in logs (more than a year with favorable temperature and moisture regimes). They would be favored by the conditions that could be expected to prevail during transport of the logs (many logs packed close together in an enclosed, moist environment). Bark removal would not prevent survival in transit, as these fungi occupy the entire sapwood cylinder of the logs. These fungi fruit prolifically in insect galleries, bark, and wood cavities, and on the undersides of logs, bark, and 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 extremely high. Logs of *L. philippiana* shipped to Europe from Chile in the past have become severely infected with stain fungi, facilitated by the high temperatures and humidity encountered as the ships passed through tropical climates (Tomás Monfil, personal communication).

3. **Colonization potential: *High (VC)***
The probability that these organisms will come into contact with a North American host is high. Because many of these fungi are not host specific (Harrington 1988), they could conceivably infect conifers as well as hardwoods. The probability of effective vectoring also would be high. Even if exotic vectors do not accompany the *Ophiostoma* spp., native insects would likely fill the vector role. This has already occurred in North America with a closely related fungus: the native bark beetle *Hylurgopinus rufipes* is a vector of the introduced pathogen *Ophiostoma ulmi* (cause of Dutch elm disease).

4. **Spread potential: *High (VC)***
If established, *Ophiostoma* spp. have great potential for rapid and distant spread. Fungi associated with insect vectors are not limited in their spread by their own growth rates. Rather, the distances travelled by their insect associates are the critical factors. Bark beetles and cerambycids are capable of flying distances of several miles and can be carried even further 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. Spread of *Ophiostoma* spp. and associated insects would also be increased substantially by human transport of harvested logs and firewood.

B. Consequences of establishment

5. **Economic damage potential: *Low/High (RU)***
Introduction of blue staining *Ophiostoma* spp. would add an additional blue stain agent that could cause lumber degrade. Economic damage from the introduction of a new blue stain fungus would be minimal (low risk), as numerous species of blue stain fungi already present in the United States are associated with trees attacked by bark beetles. In contrast, if a tree-killing *Ophiostoma* species is introduced, either on or in logs or with its insect vector, economic damage potential would be extremely high. Such an introduction conceivably could have the potential impact of *O. ulmi* (Buism.) Nannf. (the cause of Dutch elm disease) or *Ceratocystis fagacearum* (Bretz) Hunt (the cause of oak wilt). The greater number of species of these genera associated with native tree species compared to Monterey pine, and the possible existence of additional unidentified species in native forests, increase the likelihood that a tree-killing strain of these fungi is present (high risk). Strains on Chilean hardwoods may infect hardwoods in the United States and cause economic impacts on shade and urban trees.

6. **Environmental damage potential: *Low/High (RU)***
Introduction of an additional blue stain fungus would have negligible environmental damage potential. In contrast, introduction of a tree-killing *Ophiostoma* or *Ceratocystis* species could result in changes in tree species composition of forests and lead to other adverse economic impacts. Chile's indigenous forests are much more likely to harbor undiscovered pathogens than are recently established plantations of exotic tree species.

7. **Perceived damage potential (social and political influences): *Low/High (RU)***
There would be no perceived damage if additional blue stain fungi were introduced. However, mortality associated with a tree-killing species of *Ophiostoma* or *Ceratocystis* and the insect vector would have serious social and political impacts, particularly if high-value shade or urban trees were affected (e. g., as with Dutch elm disease and oak wilt).

Pest risk potential: ***Coigüe: Moderate/High*** (probability of establishment = *Moderate*; Consequences = *Low/High*); ***Tepa: Moderate/High*** (probability of establishment = *High*; consequences = *Low/High*)

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Reviewers' comments:
"I do not have quick access to Butin & Aguilar (1984). Do they rule out the possibility that *O. valdiviana* is a wilt pathogen that slowly kills it host? If not, such a potential should be seriously considered." (Cobb)

Response to comments: There is a general lack of information and many unknowns regarding *Ophiostoma* species and other potential pathogens on native Chilean hardwoods. This lack of knowledge increases the risk of introducing an unknown virulent pathogen that could become successfully established in the United States and cause unacceptable losses. Even though no tree-killing *Ophiostoma* species have been identified in Chile, there is a much greater possibility that a serious pathogen exists in the native forests than in plantations of exotic Monterey pine. The information given on *O. valdiviana* in the IPRA summarizes all that is known about this species. It is associated with declining *Nothofagus* trees but has not been identified as the mortality agent. This fungus has not been isolated from logs of *Nothofagus*, presumably due to replacement by *O. piceae*. This very scarcity of information on a native fungus of the genus *Ceratocystis* emphasizes why the components comprising consequences of establishment are ranked as low/high and the overall pest risk potential for this group of microorganisms is ranked as moderate/high. The high ranking should prevail until more compelling evidence can be obtained that no tree-killing strains of these fungi are present in the native forests of Chile.

Decay Fungi of Coigüe and Tepa

Scientific names of pests: *Ganoderma applanatum* (Pers.) Pat., *Phellinus* senex (Nees et Mont) Imaz., *Trametes versicolor* (L.:Fr.) Pilat, *Schizophyllum commune* Fr., *Stereum* spp., *Phlebia chrysocrea* (Bert. et Curt.) Burdsall, and others.

Scientific names of hosts: In Chile, *Nothofagus* spp., including *N. dombeyi*; *Laurelia philippiana*. In other regions of the world, on wide variety of conifer and hardwood hosts.

Distribution: Worldwide in some cases, others restricted to one or the other of these host genera.

Summary of natural history and basic biology of the pests: Wood decay fungi, which occur in numerous genera, are found world wide. Although some species are only saprophytic and are important decomposers of woody debris on the forest floor, others are pathogens that cause decay in roots, butts, and trunks of living trees (Sinclair et al. 1987). The fungi associated with decay of native hardwoods in Chile have not been studied in detail. Few species have been reported on *Nothofagus dombeyi* and *Laurelia philippiana* (Butin and Peredo 1986, D. W. French and F. H. Tainter unpublished, H. Peredo unpublished). Many more obviously occur but, because of the paucity of mycologists and forest pathologists in Chile, they have gone unreported.

Ganoderma spp. occur world wide (Overholts 1953). Some species are pathogens on hardwoods, causing root and butt rot. Some species of *Phellinus* cause a white rot of logging slash. *Trametes versicolor* occurs throughout the temperate zones of the world as a saprophyte on sapwood of many angiosperms and occasionally conifers. It is an opportunistic pathogen, able to kill and colonize sapwood of trees and shrubs stressed by drought, freeze damage, or wounding. *Schizophyllum commune* is both a saprophyte and an opportunistic pathogen of monocots, angiosperms, and gymnosperms throughout the world. Following entry through various types of wounds, the fungus causes a white rot of sapwood (Cooke 1961). Other species that enter trees through wounds are common decay fungi of hardwoods and conifers.

In addition to the above, other genera and species of decay fungi would be expected to occur on native Chilean hardwoods. French and Tainter (unpublished) mention the common occurrence of heart rots in *Nothofagus* and other hardwood species. Several species of decay fungi, including *Ganoderma applanatum* and *Phlebia chrysocrea*, frequently invade trunks of *N. dombeyi* in Chile (Donoso 1968, Peredo 1987). Decay fungi enter trees through wounds, dead twigs, broken tops and branches, or roots (Boyce 1961). They develop within the tree, usually with no visible external signs of defect, and they may eventually produce fruiting bodies and spores that spread the fungus to other trees. Wood decay caused by these fungi is the result of digestion by extracellular enzymes from the mycelium.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***High (VC)***
   Decay fungi are commonly associated with *Nothofagus dombeyi* and *Laurelia philippiana* logs.

2. **Entry potential:** ***High (VC)***
   Logs with visible heart rot would probably not be shipped. However, incipient or early stages of decay would not be detected at logging or shipping sites. These fungi would remain viable in wood for extended periods of time.

3. **Colonization potential:** ***Moderate (RC)***
   For many genera and species of decay fungi, suitable hosts and sites for initial infection would be common in the vicinity of ports of entry. It would be necessary for these fungi to form fruiting bodies and produce spores to infect the hosts. Conks already present on or in logs before shipment and those that develop on logs during shipment would produce spores.

4. **Spread potential:** ***High (RC)***
   Once established, these decay fungi would produce fruiting bodies and wind-disseminated spores. The fungi are likely to spread to standing trees through wounds; they may also infect woody debris. This results in a high spread potential.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate (RC)***
   Some of the decay fungi known to occur on Chilean hardwoods are ubiquitous and already occur in the United States. However, the decays of *Nothofagus dombeyi* and *Laurelia philippiana* have not been specifically studied, and the probability of the existence of new or different decay organisms occurring in shipped logs (or chips) is high. The probability of these new or different decay fungi causing increased economic damage in North America, although not certain, is probably moderate.

6. **Environmental damage potential:** ***Low (RC)***
   Because many of the saprophytic wood-decay fungi known from Chile are species that also occur in North America, reintroduction will cause very little, if any, additional environmental damage. The establishment of a previously unknown decay fungus would only add to the extensive list of known decay fungi and have little or no negative impact on the environment.

7. **Perceived damage potential (social and political influences):** ***Low (RC)***
Introduction of known species that already exist in the United States would likely result in very little or no increase in damage. Therefore, the social and political impact would be minimal. The introduction of a new species could have potentially damaging, but unknown, impact, depending on the virulence of the fungus and its effects on host trees. Because of the normal modes of action and spread of these fungi, the perceived damage would probably be low.

Pest risk potential: *Moderate* (probability of establishment = *Moderate*; consequences = *Moderate*)

Selected bibliography:

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Reviewers' comments:

"The risk assessment assigns a low spread potential and low probability of establishment for decay fungi of coigüe and tepa in spite of the fact that pest with host at origin and entry potential are 'high,' colonization potential is 'moderate,' and the fungi spread by wind-disseminated spores (see spread potential). Since wind-disseminated spores would allow the fungi to spread widely and quickly, we believe the probability of pest establishment should be 'high' or at least 'moderate.' (Hilburn, Griesbach, Johnson, Wright)

"Your assessment has indicated high entry potential, partially because the fungi remain viable for long periods of time. It has indicated a moderate colonization potential because of abundant suitable hosts and sites (wound) for initial infection. Then on spread potential you rank it low because the sites for infection are wounds and, even more likely, wood debris. Where...is the rationale for this ranking?" (Cobb)

"Decay fungi cause huge losses in *Quercus* spp.. and many other hardwood species in North America. I suggest a pest risk potential of moderate instead of low." (Solomon)

Response to comments: Much of this consideration concerning the risk of introducing decay fungi of the Chilean native hardwoods was the same as that of introducing the root- and stem-rots of pine. The probability of successful establishment in North America is certainly the same because the fungi involved have the same biology, needing to form basidiomes (spore-producing fruiting bodies) before dissemination of the fungus is possible. However, in this case, the consequences of such an introduction were re-evaluated because of the possible impact of the many unknown fungi that may be associated with these hardwoods and the numerous species of hardwoods in North America that might be affected. Accordingly, and as suggested by reviewers, spread potential was increased to high and economic damage potential was increased to moderate. As a result of these revisions, the pest risk potential becomes moderate for this complex of decay fungi.

Chapter 6. OTHER POTENTIAL PESTS OF PINE, COIGÜE, AND TEPA

Although not assessed in as much detail, several other types of potential pests were considered during this pest risk assessment, including other defoliating insects on pine, common insect pests of other Chilean tree species, nursery pests, wetwood of coigüe and tepa, mistletoes on native hardwoods, nematodes, weeds, and mollusks.

Insect Defoliators of Pine

Several other native Lepidoptera have been observed to cause noticeable defoliation to *Pinus radiata* in Chile, but these species are less abundant than *Ormiscodes cinnamomea* (Naray 1979, Parra et al. 1985a). Worthy of mention are defoliating caterpillars of the genera *Macromphalia* and *Polythysana*. These insects have life cycles similar to *Ormiscodes*, with the exception that pupae are attached to the trunk or branches of host trees, a characteristic that may increase the likelihood of their occurrence on *P. radiata* logs.

Another native insect that occasionally causes defoliation of *P. radiata* plantations in Chile is the walking stick, *Bacunculus phyllopus* Gray (Gara 1992). This insect required chemical control in 1989 when it defoliated some 170 hectares near Curepto (region VII). This is the only recorded case of the insect causing economic damage, however, and outbreak populations seldom last more than one season (Luís Cerda, personal communication). Walking sticks lay their eggs indiscriminately on the forest floor and tree stems (Gara 1992), but little else is known about their biology. The probability of this pest being imported on logs as a hitchhiker is considered low because it seldom reaches outbreak numbers in pine plantations. Also, because the walking stick does not fly, infestations of these insects are localized and capable of only limited expansion (Wilson 1964).

Two species of native weevils, *Cyphometopus marmoratus* (Blanchard) and *Geniocremnus chilensis* (Boheman), have recently been discovered defoliating *Pinus radiata* in Chile (Saiz and Goma 1982). Larvae of these insects live in the soil and adults feed on pine foliage in late fall or early winter, causing damage to individual needles. Defoliation caused by this maturation feeding is much less than that observed for *Ormiscodes cinnamomea.* These weevils have only been reported on *P. radiata* from region V and are not likely to be associated with exported logs.

Insect Pests of Other Native Trees

There are many insect pests of tree species other than coigüe and tepa in Chile that are worthy of mention as potential pests. Although these insects have not been documented to be associated with coigüe or tepa (and are thus excluded from appendix B, table B-1), they may be abundant in forests where coigüe and tepa are significant components and could possibly be found on coigüe or tepa log shipments as incidental "hitchhikers." A few of these insects with annotations on their hosts and feeding habits are listed in appendix B, table B-2. Of the potential hitchhikers, an undescribed species of Margarodidae (R. H. González, personal communication) on roble, spiny caterpillars of the genus *Ormiscodes* on *Nothofagus* spp., and a sawfly *(Nematus desantisi)* on *Salix* are among the most abundant insect pests encountered in central and southern Chile.

Nursery Pests

Various insect pests are known to cause problems in pine nurseries (Herrera 1962, Rodríguez 1978, Rodríguez et al. 1980, Peredo et al. 1981). Primarily, these consist of soil-inhabiting insects of the families Scarabaeidae, Elateridae, and Noctuidae (Ramírez 1983). Two species of thrips, *Thrips tabaci* and *Heliothrips haemorrhoidales*, have caused severe damage to pine seedlings in nurseries on occasion (Gara 1978, Cerda 1980, Rodríguez 1980). *Thrips tabaci* is more commonly encountered as a pest in pine nurseries than is *H. haemorrhoides* (Rodríguez et al. 1980).

Several fungi have been associated with and isolated from *P. radiata* seedlings in nurseries or greenhouse situations in Chile (Herrera 1962, Butin and Peredo 1986, Kunstmann et al. 1986, Gastón González, personal communication). These include the following soil-borne "damping off" fungi: *Cylindrocarpon* Wollenw., *Fusarium oxysporum* Schlecht. emend. Snyd. et Hans., *F. sambucinum* Fuckel, *F. moniliforme* Sheldon, *Pythium aphanidermatum* (Edson) Fitz., *Pythium ultimum* Trow, *Pythium debaryanum* Hesse, *Phytophthora* spp., *Phoma* spp., and *Rhizoctonia solani* Kuhn; the charcoal root rot pathogen *Macrophomina phaseolina* (Tassi) Goid.; and the foliar pathogens *Botrytis cinerea* Pers. ex Fr. and *Colletotrichum acutatum* Simmds. f. sp. *pinea* Ding. et Gilm. The latter pathogen causes "terminal crook" of seedlings in Chile (Peredo et al. 1979) and in New Zealand (Dingley and Gilmour 1972).

The soil-borne insects and fungi are controlled by fumigation of nursery soil with methyl bromide and good sanitary procedures (Herrera 1966b). These pests have been associated only with *P. radiata* seedlings in nurseries and, with the possible exception of adult scarabs (*Hylamorpha* sp., *Brachysternus* sp., etc.), they would not be found on harvested trees. All of the identified genera of soil-borne fungi already exist in the United States.

Wetwood of Coigüe and Tepa

A wetwood of coigüe, believed to be caused by a bacterium (F. Tainter, personal communication), can occur on up to 80% of the stems. This wetwood is unique to coigüe and has not been found in other species of *Nothofagus*. There is no internal checking or honeycombing associated with the wetwood. The risk that this wetwood might pose to North American forest species is unknown.

Mature trees of tepa commonly develop a brown discoloration in the centers of the stems. This stain typically is restricted to the core of mature trees and appears in the shape of an adult butterfly, clearly visible on the ends of infected logs. The "butterfly stain" of tepa produces a potent and foul-smelling odor, which diminishes the value of tepa lumber for use in construction. The odor largely disappears with kiln drying, although the brown discoloration remains. The "butterfly" stain is unique to tepa logs. The casual agent of this stain is unknown. It appears to be incited by bacteria and may be similar to wetwood found in some hardwoods, particular oaks in the United States. The likelihood of such stained logs being unnoticed by inspectors and being exported to the United States is low.

Mistletoes of Native Hardwoods

Several mistletoes, in the families Viscaceae, Loranthaceae, and Mysodendraceae, occur on native hardwoods in Chile (Engler and Krause 1935, Skottberg 1935, Muñoz 1959, Tainter and French 1971b). Several species of *Mysodendron*, including *M. brachystachyum*, *M. linearifolium*, *M. gayanum*, and *M. punctulatum*, commonly occur on species of *Nothofagus* (Tainter and French 1971b).

Because mistletoes are obligate parasites, they would not survive once the host tree was cut. It is conceivable that seeds of the mistletoe could survive for short periods in bark crevices or that the internal endophytic system of the mistletoes could survive short periods in host cambial regions. Most of these mistletoes are relatively host specific and, even if they were introduced into the United States, they may not find a suitable host. However, some of the Chilean mistletoes have developed heavy infections on *Populus* species and on various exotic fruit species introduced into Chile.

Nematodes

Although recent surveys have been conducted by Servicio Agrícola y Ganadero personnel, pine wood nematodes (*Bursaphelenchus xylophilus* and *B. mucronatus*) have not been found associated with *Pinus radiata* in Chile. The insect vector for these nematodes (wood-boring cerambycids of the genus *Monochamus*) also have not been collected to date in Chile (M. Beéche, personal communication). No surveys are known to have been conducted on nematodes associated with native hardwoods in Chile. For a summary of recent research on the incidence, control, and risks of the pine wood nematode *B. xylophilus* and its *Monochamus* vectors in softwood products exported from North America, see Dwinell and Nickle (1989).

Weeds

Polly Lehtonen, a botanist on the APHIS Biological Assessment Support Staff, examined the possibility that one or more harmful weeds could enter the United States on Chilean logs. One weed species (*Imperata condensata*) of possible concern was identified. *Imperata condensata*, a species of cogongrass native to Chile and Argentina, is considered by one authority (Hubbard 1944) as a variety of *I. cylindrica*, a notorious noxious weed of wide distribution in Australia, Asia, India, the western Mediterranean, and Africa. Holm et al. (1977) include it among the 10 worst weeds of the world. The species entered the United

States at Mobile Bay, Alabama, about 1914 and has since spread throughout southern Alabama, into coastal Louisiana, Mississippi, and the Florida panhandle (Dickens 1974, Patterson et al. 1981). Although normally confined to areas that are quite warm, it also is found in Japan and New Zealand at latitudes of 45° in both the Northern and Southern Hemispheres (Holm et al. 1977).

Imperata cylindrica (= *condensata*) is a well-adapted weed, spreading aggressively by rhizomes and seeds. The plants prosper in a wide variety of environmental conditions and in poor soils. This weed is unable to survive in deeply plowed soils but invades tree crops, nurseries, and pastures, where it produces chemical inhibitors and sharp-pointed rhizomes able to penetrate the roots of crop species. Holm et al. (1977) lists crops infested with *H. cylindrica* throughout its range; included are rubber, citrus, tea, and coconut and oil palms. In Chile, it is distributed from region III to X in the foothills of the Andes and the central valley but is uncommon throughout this range (M. Beéche, personal communication).

Imperata cylindrica is generally recognized to be a light-loving plant that can be "shaded out" under a heavy canopy (Holm et al. 1977). Thus, varieties of this weed are unlikely to persist under the closed canopy of *Pinus radiata* sawtimber stands in Chile (M. Beéche, personal communication). It is possible that airborne seed plumes of *I. condensata* originating from nearby open habitats could become lodged in the bark and be imported on raw logs from Chile. According to APHIS records for the period 1984-1991, however, this weed was not intercepted from Chile despite high volumes of agricultural and forest product imports during this interval (P. Lehtonen, personal communication). The risk of importing this weed on log shipments from Chile is considered to be low.

Mollusks

No potential pest mollusks were identified in association with logs of Monterey pine, coigüe or tepa in Chile. Joyce Cousins, of the APHIS Biological Assessment Support Staff, reviewed this agency's plant protection quarantine records for the period June 1988 to present for snails and slugs intercepted on Chilean commodities entering the United States. None was found.

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Reviewers' comments:
"I would strongly recommend deleting all references to the pine wood nematode from this document. The risk assessment should deal only with pests reported on pine in Chile. You open up Pandora's box when you start including unreported pests. Although I'm in full agreement that the pine wood nematode does not occur in radiata [Monterey] pine in Chile, I wouldn't buy the argument presented in the risk assessment." (Dwinell)

"Has anyone ever performed a well-designed detection survey for *Bursaphelenchus xylophilus* on *Bursaphelenchus mucronatus* in Chile? What other nematode identification records, nematode host lists, and nematode survey distribution records exist for Chile?" (Hackney)

"We need to know all of the microorganisms, i.e., nematodes (e.g., *Bursaphelenchus xylophilus*, *Bursaphelenchus mucronatus*, and any other plant parasitic nematodes) that were detected in shipments of logs from Chile." (Hackney)

"Has anyone really looked for nematodes?...It would surprise me if there were not some in the more moist, warmer forests." (Cobb)

"There is an apparent lack of survey data on pine wood nematode. From our review of the literature, wherever a concerted effort has been made, some species of pine wood nematode has been found (Canada, California, Siberia). Previous introductions of novel populations have proved disastrous in Japan and China. The risk assessment does not provide an adequate review of this major pathogen." (Hilburn, Griesbach, Johnson, Wright)

"There is no mention of the possibility of accidental introduction of predators or parasites that might have adverse effects upon the forested ecosystems of North America. No mention is made of mites as potential pests...especially on ornamental plants where the possibilities are rather great. No real mention is made about any Homoptera, especially scale insects." "Some of these are parthenogenetic and thus are able to become established without a male. The same applies to aphids..." (Lattin)

"I'm a little taken back with the limited discussion of weed introductions. Noxious weeds are a tremendous problem in the western U. S.; annually causing millions of dollars of impact and control costs. I would think that the potential introduction of one of the '10 worst weeds in the world,' *Imperata cylindrica*, into the western U. S. would warrant more discussion and an individual pest risk assessment." (Holsten)

Response to comments: There are many organisms associated with harvested logs, and forests in general, for which we have little biological information. Among these are nematodes, mites, aphids, scales, and others. The information regarding these organisms is lacking in most geographic areas of the world. Chile is no exception.

The team made an effort to determine the state of the science with regard to nematodes in Chile and have little information to report. According to the Servicio Agrícola y Ganadero, surveys have been conducted since March 1992 to detect the pine wood nematode and its insect vector (*Monochamus*) in pine sawmills. Neither has been recovered. Based on this information and the lack of further documentation, the team cannot address the possibility of the pine wood nematode being a pest for possible introduction.

With reference to *Imperata cylindrica*, we were able to obtain more information on the abundance and distribution of this noxious weed in Chile. This information was incorporated into the final document. Due to its scarcity in Chilean sawtimber stands, we concluded that the introduction of this pest is much more likely to occur from tropical countries in the world where this weed abounds than from Chile. Mitigation measures aimed at insect hitchhikers and bark beetles on imported logs also should largely eliminate any weed seeds.

Chapter 7. SUMMARY AND CONCLUSIONS

Several forest industries in the United States propose to import logs of Monterey pine (*Pinus radiata*) from Chile, primarily for processing on the Pacific Coast. Small quantities of two native species, coigüe (*Nothofagus dombeyi)* and tepa (*Laurelia philippiana*), also may be imported as unprocessed logs to produce veneer and lumber. In the absence of specific log import regulations, the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) requested that the USDA Forest Service prepare a risk assessment that identifies potential pests, estimates the probability of their entry on Chilean logs and establishment in the United States, and evaluates the economic, environmental, social, and political consequences. Major emphasis is placed on the risk of Chilean pests to the resources of the western United States because of similarities in climate, high value of these resources, and the fact that most Chilean logs are to enter at western ports. However, the assessment and conclusions are expected to be applicable to the entire United States.

The climate in Chile where *Pinus radiata* plantations have been established is very similar to that of northern California. Furthermore, the cooler and wetter climate in southern Chile where native forests are found is comparable to that of western Oregon, Washington, British Columbia, and southeast Alaska. Many of the native tree species that grow near Pacific Coast ports have been successfully grown in Chile and are known to be suitable hosts for insect and disease pests found in Chile (particularly those that infest pine). Thus, conditions for the possible entry of undesirable insects and diseases on imported logs and establishment on the Pacific Coast of North America are very favorable. Future shipments may also arrive at ports along the Gulf of Mexico, but dissimilarities in climate and hosts are considered major constraints to the establishment of Chilean insects and diseases in this region.

To compile this pest risk assessment, a six-member team of forest pest specialists provided technical expertise from the disciplines of forestry, entomology, pathology, mycology and economics. Three of the team members had previously worked in forest entomology programs in Chile. The team also was assisted by representatives from APHIS, the USDA Forest Service and several Chilean organizations. In November 1992, the team traveled to Chile, accompanied by an APHIS representative (see appendix E for details). Team members met with Chilean agricultural and forestry officials, entomologists, pathologists, and forest industry representatives to discuss the export of pine and native hardwood logs or other Chilean exports. The group also toured harvest areas, inspected processing plants and ports, evaluated Chilean industry mitigation procedures, and viewed pest problems in both pine plantations and native forests. In addition, the document incorporates comments by selected persons representing government agencies, universities, and private forest industries in the United States, Canada, and Chile who provided critical reviews of an earlier draft. Finally, a comprehensive bibliography of Chilean forest insects and diseases was compiled and included as part of this risk assessment.

Major Pests of Monterey Pine on Imported Logs

Sawlogs of Monterey pine destined for import into the United States from Chile are grown on a 25-year rotation in intensively managed plantations. Exotic pine plantations in Chile are host to a greatly reduced number of serious insect and pathogen pests compared to natural conifer stands in other regions of the world (Baker 1972, Furniss and Carolin 1977, USDA Forest Service 1991). The assessment team compiled lists of insects and microorganisms known to be associated with Monterey pine in Chile. From these lists, insects and pathogens having the greatest risk potential as pests on imported logs were identified using risk analysis procedures recommended by APHIS.

Of the 14 pests of *Pinus radiata* in Chile for which individual pest risk assessments were prepared, four insects and one group of pathogens (those causing needle diseases) are of concern only as potential hitchhikers on the bark surface of imported logs (table 7-1). (The insects also may pose a threat as hitchhikers in shipments of native hardwood logs or other Chilean exports, due to their attraction to lights and/or abundance around ports at certain seasons.) However, the overall pest risk potential of hitchhiking insects is rated as low in association with logs exported to the United States. As emphasized by Ohmart (1982), meristematic insects and defoliators are unlikely to be potential pests of quarantine importance on logs. These types of pests seldom are encountered at ports of entry (Wylie and Yule 1977, Williams and La Fage 1979).

Insects that inhabit the inner bark and wood have a higher probability of being introduced with imported logs, particularly in the absence of mitigation measures. Of the six groups of bark- and wood-inhabiting insects assessed in detail in association with *P. radiata* logs from Chile (table 7-2), only the European bark beetle *Hylurgus ligniperda* merits a high pest risk potential. This bark beetle is of primary concern because of its abundance in Chile and the possibility that, if introduced into the United States, it could serve as a vector of black stain root disease, caused by *Leptographium wageneri*. Also, APHIS Plant Protection and Quarantine records document that larvae, pupae, and adults of this bark beetle are commonly intercepted in shipments of unprocessed wood, crating, and dunnage arriving at U. S. ports from various countries (Richard Orr, personal communication). This bark beetle alone is sufficient justification for requiring mitigation measures for *P. radiata* logs entering the United States from Chile.

The other two species of European bark beetles, *Hylastes ater* and *Orthotomicus erosus*, are less abundant and/or less widely distributed in Chile. Also, there is evidence that these two recent immigrants are being displaced in Chile by *Hylurgus* (Cogollor 1991). On these bases, they were given moderate ratings for pest risk potential, as were most of the other bark- and wood inhabiting insects associated with pine sawlogs (table 7-2). Of the insect pests of pine analyzed in detail, only the anobiid *Ernobius mollis* was assigned a low pest risk potential, primarily because this insect is already established in the United States.

Table 7-1. Summary of risk potentials for Chilean pests of Monterey pine (*Pinus radiata*), coigüe (*Nothofagus dombeyi*), and tepa (*Laurelia philippiana*) of concern as hitchhikers on bark of exported logs

Pest	Probability of establishment				Consequences of establishment			Pest risk potential
	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environment damage	Perceived damage	
Insects:								
Spiny pine caterpillar* (*Ormiscodes cinnamomea*)	L	H	M	M	M	L	M	**M**
Bagworm (*Thanatopsyche chilensis*)	L	M	L	L	L	L	L	**L**
White grubs* (*Hylamorpha*, *Brachysternus*, *Sericoides*)	L	L	M	M	M	L	L	**L**
European pine shoot moth (*Rhyacionia buoliana*)	L	L	H	H	M	L	M	**L**
Pathogens:								
Needle diseases (*Dothistroma*, *Cyclaneusma*, *Lophodermium*)	M	M	M	M	L/M†	L/M†	L/M†	**M†**

See appendix B, table B-2 for names of common insect pests of native tree species associated with coigüe and tepa, some of which also may be of concern as potential hitchhikers on log shipments from Chile. L = low, M = moderate, H = high.

* May also be potential hitchhikers on shipments of native hardwood logs from Chile, due to attraction of adults to lights around ports.

† The moderate rating in this case is based solely on the possible existence of strains more virulent than these pathogens appear to be in Chile.

Table 7-2. Summary of risk for Chilean pests of Monterey pine (*Pinus radiata*) of concern in or under the bark, or deep within the wood, of exported logs

	Probability of establishment				Consequences of establishment			
Pest	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environment damage	Perceived damage	Pest risk potential
Pests in or under the bark								
Pine bark beetles* (*Hylurgus*)	H	H	H	H	M	M	L	**H**
(*Hylastes*, *Orthotomicus*)	M	H	H	H	M	M	L	**M**
Bark weevils* (*Rhyephenes*)	H	H	H	M	L	L	L	**M**
Pine bark anobiid (*Ernobius mollis*)	M	H	H	M	L	L	L	**L**
Pests deep within the wood								
Siricid wood wasp (*Urocerus gigas*)	H	H	H	H	L	L	L	**M**
Wood-boring beetles (*Buprestis*, *Colobura*)	M	H	M	H	M	L	L	**M**
Termites* (*Neotermes*, *Porotermes*)	M	M	M	M	M	L	L	**M**
Shoot blight (*Sphaeropsis sapinea*)	M	H	M	M	L/M†	L/M†	L/M†	**M†**
Stain and vascular wilt fungi (*Ophiostoma*)(= *Ceratocystis*)	H	H	H	H	L/M†	L/M†	L/M†	**M/H†**
Root diseases (*Armillaria*, *Phellinus*)	L	H	L	L	L	L	L	**L**

* Adults also of concern as hitchhikers. H = high, M = moderate, L = low.
† Moderate or high rating in this case is based solely on possible existence of a different strain, more virulent than these species appear to be in Chile.

Several pathogens may inhabit the heartwood and/or sapwood of *Pinus radiata* logs imported from Chile. Of greatest concern are fungi belonging to the genus *Ophiostoma* (*Ceratocystis*). To date, only two species of *Ophiostoma* (*O. piceae* and *O. piliferum*) have been identified from *P. radiata* in Chile; both are considered saprophytic, causing blue stains in freshly cut logs and lumber. These fungi are very abundant in the sapwood of untreated logs and their probability of establishment in the United States would be high in the absence of mitigation. Because both species also occur in the United States, the consequences of establishment of these organisms in North America would be minimal if it were certain that the Chilean strains are the same as, or no more virulent than, those indigenous to the United States. Until further studies are conducted, however, the possibility that the strains are more virulent, or that other species remain to be identified in Chile, cannot be dismissed. Thus, the potentials for economic, environmental, and perceived damage were rated as low/moderate and the overall pest risk potential rated as moderate/high for this group of fungi.

The same uncertainty concerning virulence resulted in pest risk potentials of moderate for those fungi causing shoot blight (*Sphaeropsis sapinea*) and needle diseases (*Dothistroma pini, Lophodermium* spp., among others), even though these species also occur in the United States. The consequences of establishment of these pathogens would vary from low (if strains are the same as those already present in North America) to moderate (if Chilean strains prove to be more virulent). Those fungi causing root/stem rots (*Armillaria* spp., *Phellinus spp.*) merit a low risk potential because they are less likely to be found in fast-grown *P. radiata* sawlogs (and are already distributed worldwide).

In assessing risk of potential pests, it should be recognized that insects and microorganisms invade logs in a predictable temporal sequence, dictated by the condition of the host (table 7-3). At the time of felling, logs will contain any pathogens present in the main 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 *Hylurgus*, *Hylastes*, or *Orthotomicus* bark beetles. Also, *Urocerus* wood wasps may oviposit on logs shortly after harvest. After the logs have aged for 1 to 12 months and resin flow has subsided, they may be colonized by *Rhyephenes* weevils, *Ernobius mollis,* the ambrosia beetle *Xyleborinus saxeseni* (already established in the United States), and decay fungi. Other secondary insects are found primarily in logs that have aged for at least a year. These insects include various wood borers (*Buprestis novemmaculata*, *Colobura alboplagiata*) and termites (*Neotermes, Porotermes*). Such insects will be more common in shipments of well-aged pulpwood (Schroeder 1990, appendix C-1), because pulpwood logs tend to remain longer at the harvest site or in sort yards prior to export than do sawlogs.

Whether blue stain fungi or bark- and wood-boring insects will be common in exported logs will depend on how rapidly the logs are removed from harvest sites and loaded on ships. The greatest concentration of Chilean pine plantations is located in region VIII, within 100 miles of the principal export ports at Concepción. The delivery of logs to sort yards generally can be accomplished in a timely manner. The goal of Chilean forestry companies is to have the freshly cut export logs debarked and treated with fungicide for blue stain within 48 hours after harvesting. This protocol would reduce infestation of logs by these secondary less-aggressive pest invaders.

Table 7-3. Common pests associated with Monterey pine (*Pinus radiata*) logs exported from Chile in relation to condition of host and primary export product

Condition of host	Primary export product	Insects	Pathogens
Log < 1 month old	Sawlogs, pulpwood	*Hylurgus** *Hylastes** *Orthotomicus** *Ormiscodes** † *Thanatopsyche** † *Rhyephenes**	*Ophiostoma* *Sphaeropsis*† *Armillaria*† *Phellinus*† Needle diseases (*Dothistroma* et al.)* †
Log 1 to 12 months old	Sawlogs, pulpwood	*Rhyephenes* *Urocerus* *Hylurgus* *Hylastes* *Orthotomicus* *Ernobius* *Xyleborinus*	*Ophiostoma* *Armillaria* *Phellinus* Decay fungi (*Trametes* et al.)
Log > 12 months old	Pulpwood	*Buprestis* *Colobura* *Callideriphus* *Neotermes* *Porotermes*	*Ophiostoma* *Armillaria* *Phellinus* Decay fungi (*Trametes* et al.)

* On logs as hitchhikers.
† May occur on or within living tree at time of felling.

With the exception of the European pine shoot moth (*Rhyacionia buoliana),* Chile's plantation forests are remarkably free of destructive pests. Of the pests present, none are known to cause defoliation of extensive areas or to be tree-killers. Absent are aggressive scolytid bark beetles of the genera *Dendroctonus, Ips, Scolytus,* and *Tomicus*; ambrosia beetles of the genera *Gnathotrichus, Trypodendron*, or *Platypus*; serious defoliators such as the gypsy moth (*Lymantria dispar*) and budworms (*Choristoneura* spp.); pine wood nematodes (*Bursaphelenchus* spp.); or tree-killing pathogens of the genera *Ophiostoma, Ceratocystis,* or *Heterobasidion*. Even *Sirex noctilio*, the most destructive pest of *Pinus radiata* in New Zealand (USDA Forest Service 1992), has not been detected in Chile. No harmful mollusks or nematodes and only one weed of concern were identified as potential pests on exported logs. This weed (*Imperata condensata*, considered a variety of *I. cylindrica* or cogongrass) is apparently not common in the pine-growing regions of Chile, particularly in mature sawtimber stands (M. Beéche, personal communication).

Chilean logs destined for the export market receive special treatment, distinct from the treatment applied to domestic logs, in order to reduce the opportunity for potential pests to gain access to the logs. Each forestry company either now has, or soon will have, a system in place to survey its pine plantations for pest problems. This pest detection system should reduce the likelihood that major pest problems in plantations will go unnoticed and that pest-infested material would be harvested for the export market. Nevertheless, the adequacy of this procedure for reducing insect and disease infestations in logs exported to the United States will be determined by APHIS.

In addition, according to officials with Chile's Agriculture and Livestock Service (SAG), each shipment of logs is inspected by SAG inspectors and a phytosanitary certificate is issued if the shipment is found satisfactory from a pest standpoint (see appendix E for details). The certificate is issued in accordance with international standards developed by the United Nations Food and Agriculture Organization (FAO). SAG identifies the requirements of the importing country and inspects the cargo according to those standards as well. The Pest Risk Assessment Team does not endorse any of these activities as being sufficient for pest risk mitigation. Again, APHIS is responsible for making these determinations for logs exported to the United States.

Major Pests of Coigüe and Tepa on Imported Logs

In contrast to exotic pine plantations, native forests in Chile support a full complement of indigenous organisms. Some of these have the potential to be destructive pests if they were to become established in North America. Many insects and fungi are known to be associated with coigüe (*Nothofagus dombeyi*) in Chile and Argentina, perhaps more than with any other native forest tree species in Chile. Coigüe is prone to have heart rot, insect galleries, and other defects, especially logs coming from the central valley and coastal range. Coigüe logs are difficult to classify for quality; they sometimes have substantial internal damage not visible from outside the log. Wood-staining fungi, however, do not seem to be a serious problem in processing coigüe; veneer sheets can be left untreated for months without staining (Roberto Perez, BOMASA, personal communication).

Tepa (*Laurelia philippiana)* trees are remarkably free of insect inhabitants, but untreated logs and green lumber are especially susceptible to wood-staining fungi. Lumber or veneers left without drying or chemical treatment for just a few days will be affected by heavy staining. However, wood-staining fungi are not a problem for kiln-dried tepa. Another problem with the utilization of tepa wood is the "mancha mariposa" or butterfly stain, which discolors the wood and emits a foul odor. The odor (but not the stain) disappears with kiln drying.

Six insects (or groups of species with similar habits) of native Chilean hardwoods were the subjects of individual pest risk assessments (table 7-4). All are associated with coigüe. Moderate pest risk potentials were assigned to *Callisphyris semicaligatus* and *Chilecomadia valdiviana*, two insect borers of living coigüe. The bark-boring beetles (*Calydon submetallicum*, *Epistomentis* spp., *Rhyephenes* sp., et al.) and ambrosia beetles (*Gnathotrupes* spp.) in dead and dying coigüe also received a moderate risk rating. Other insects found inhabiting living coigüe trees (e.g., the cambium miner *Notiopostega atrata* and the cerambycid *Cheloderus childreni*, among others) are rated as low risks because they are very host specific to *N. dombeyi*. These insects may occur in exported coigüe logs and may well survive transit from Chile but are very unlikely to encounter suitable hosts in the United States. Of the termite species reported from Chile, only the dampwood termite, *Porotermes quadricollis*, is likely to be associated with native hardwood logs. But due to other limitations, this insect merits a low risk potential.

Particularly worrisome to team members and several reviewers is the fact that little is known about the pathogenic microorganisms that may be present in Chile's native forests. Among the fungi identified to date are several species of the genera *Ophiostoma* and *Ceratocystis*. Some species (*O. piceae, O. piliferum*) are cosmopolitan in distribution and of little concern, whereas other species (*C. nothofagi, C. valdiviana)* apparently are unique to Chile and Argentina and their habits are poorly understood. The genera *Ophiostoma* and *Ceratocystis* include innocuous blue-stain fungi as well as microorganisms notorious in other regions of the world for causing destructive vascular wilts such as Dutch elm disease and oak wilt. To date, no tree-killing strains of these genera have been identified in either exotic or native forests in Chile. However, the scarcity of biological information on potential pathogens present in the native forests and the possibility that Chilean strains may be more virulent if introduced into a different habitat is justification for increasing the potential risk for this complex of fungi to higher levels than those assigned to related fungi in exotic pine plantations. Decay fungi (*Ganoderma*, *Phellinus*, *Trametes*, among others) are common in native hardwood logs and are rated as moderate pest risks. Other potentially destructive insects and diseases of native hardwoods may exist in Chile but have yet to be identified.

Table 7-4. Summary of risk potentials for Chilean pests of coigüe (*Nothofagus dombeyi*) and tepa (*Laurelia philippiana*) of concern in or under the bark or deep within the wood

Pest	Host		Probability of establishment				Consequences of establishment			Pest risk potential
	coigüe	tepa	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environment damage	Perceived damage	
Pests in or under the bark										
Cambium miner (*Notiopostega atrata*)	X		M	L	L	M	M	L	L	**L**
Bark-boring beetles (*Calydon, Rhyephenes* et al.)	X		H	H	M	M	L	L	L	**M**
Pests deep within the wood										
Wood-borers of living coigüe (*Callisphyris, Chilecomadia*)	X		M	H	M	M	M	M	L	**M**
(*Cheloderus* et al.)	X		M	H	L	L	L	L	L	**L**
Ambrosia beetles (*Gnathotrupes*)	X		H	H	M	M	M	L	L	**M**
Dampwood termite (*Porotermes quadricollis*)	X		M	L	L	L	L	L	L	**L**
Stain and vascular wilt fungi on coigüe (*Ophiostoma, Ceratocystis*)	X		M	H	H	H	L/H*	L/H*	L/H*	**M/H***
Stain and vascular wilt fungi on tepa (*Ophiostoma, Ceratocystis*)		X	H	H	H	H	L/H*	L/H*	L/H*	**M/H***
Decay fungi (*Ganoderma Phellinus*, et al.)	X	X	H	H	M	H	M	L	L	**M**

L = low, M = moderate, H = high.

* High rating in this case is based solely on possible existence of a tree-killing strain, more virulent than these species appear to be in Chile.

In contrast to plantation-grown *Pinus radiata*, logs of native tree species are extracted from unmanaged, natural stands that are very prone to a variety of insect and disease problems. Undoubtedly, the extraction process from more remote harvest sites to ports will be much more prolonged than characteristic for pine, but annual volumes available for export to the United States will be much smaller. The pest risk potential associated with logs of native tree species, coigüe in particular, is more difficult to assess due to the general paucity of biological information. Consideration should be given to these constraints when regulating the importation of logs from Chile's native hardwood forests.

Chapter 8. COMPREHENSIVE BIBLIOGRAPHY

The following list of references includes all available literature the assessment team was able to obtain on insects and microorganisms associated with both exotic and native forests in Chile. To our knowledge, this is the most comprehensive bibliography on Chilean forest pests compiled to date. The citations marked with an asterisk represent those references cited in the text of this document and/or listed in the selected bibliographies that accompany individual pest risk assessments.

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APPENDICES

Appendix A: Insects and Fungi Associated with Monterey Pine in Chile

Appendix B: Insects and Fungi Associated with Coigüe and Tepa in Chile

Appendix C: Lists of Insects and Fungi Intercepted on Logs Exported from Chile

Appendix D: Common and Scientific Names of Tree Species

Appendix E: Report on the Pest Risk Assessment Team's Site Visit to Chile, November 8-30, 1992

Appendix F: Summary of Reviewers' Comments and Team's Responses

Appendix A
Insects and Fungi Associated with Monterey Pine in Chile

Table A-1. Insects associated with Monterey pine (*Pinus radiata*) in Chile, including host range, location on host, and pest category

Table A-2. Fungi associated with Monterey pine (*Pinus radiata*) in Chile, including host range, location on host, and pest category

Appendix A, Table A-1. Insects associated with Monterey pine (*Pinus radiata)* in Chile, including host range, location on host, and pest category

ORDER Family *Species*	Other hosts	Location on host: Seedlings in nursery	Location on host: Foliage/ other	Location on host: Bark/ cambium	Location on host: Sapwood/ heartwood	Location on host: Wood in use	Pest category*	Comments
ORTHOPTERA								
Phasmidae								
Bacunculus phyllopus Gray	N		X				3a	
ISOPTERA								
Kalotermitidae								
Cryptotermes brevis Walker	P, C, N, E					X	1b	North Chile
Neotermes (Kalotermes) chilensis (Blanch.)	N, E			X	X	X	1a	
Termopsidae								
Porotermes quadricollis (Rambur)	N			X	X	X	1a	
THYSANOPTERA								
Thripidae								
Heliothrips haemorrhoidalis (Bouché)	N, F	X					1d	Rare on pine
Thrips tabaci Lindeman	N, F	X					2b	Uncommon on pine
HEMIPTERA								
Apateticus sp.			X				3e	AOC
HOMOPTERA								
Adelgidae								
Pineus börneri Ann.	P		X	X			1d	Introduced
Aphididae								
Eulachnus sp.	P		X				3b	
COLEOPTERA								
Anobiidae								
Ernobius mollis L.	P, C			X			1b	Introduced

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops, AOC = adults only collected from *Pinus radiata*, larvae not known to feed on pine.

* See table 3-1 on page 18 for definitions of categories.

Appendix A, Table A-1. Insects associated with Monterey pine (*Pinus radiata*) in Chile, including host range, location on host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location on host: Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Pest category*	Comments
Buprestidae								
Anthaxia conncina Mann.	N						3e	AOC
Buprestis novemmaculata L.	P		X	X	X		1a	Introduced
Ectinogonia buqueti Spinola	N						3e	AOC
Tyndaris sp.	N						3e	AOC
Carabidae								
Antarctia sp.			X				3d	
Calasoma vagans Dej.			X				3d	
Ceroglossis chilensis Esch.			X				3d	
Cerambycidae								
Acanthinodera (= *Ancistrotus*) *cummingi* (Hope)	N				X		3d	Rotten logs, stumps
Aconopterus sp.	N				X		3e	AOC
Callideriphus laetus Blanch.	N		X	X	X		1a	Prefers small branches
Chenoderus testaceus Blanch.	N, E		X				3e	AOC, uncommon
Colobura alboplagiata Blanch. o Sol.	N		X	X	X		1a	
Microplophorus castaneus Blanch.	N		X				3e	AOC, uncommon
Phymatioderus sp.	N		X				3e	AOC, uncommon
Chrysomelidae								
Dictyneis asperatus (Blanch.)	N		X				3b	Larvae in soil
Coccinellidae								
Eriopis connexa Germ.			X				3d	Predator
Curculionidae								
Cyphometopus marmoratus Blanch.			X				3b	Feed on needles
Geniocremnus chilensis Boheman			X				3b	Feed on needles
Rhyephenes gayi (Guér.)	N			X			3c	
Rhyephenes humeralis (Guér.)	N			X			1a	Weakened, fire-killed trees
Rhyephenes literalis (Guér.)	N			X			3c	
Rhyephenes mallei (Gay et Sol.)	N			X			1a	Weakened, fire-killed trees
Strangaloides aureosignatus (Blanch.)	N		X				3e	AOC

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops, AOC = adults only collected from *Pinus radiata*, larvae not known to feed on pine.

* See table 3-1 on page 18 for definitions of categories.

Appendix A, Table A-1. Insects associated with Monterey pine (*Pinus radiata*) in Chile, including host range, location on host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location on host					Pest category*	Comments
		Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use		
Elateridae								
Crigmus sp.	F	X	X	X			3a	Under old bark
Grammophorus niger Sol.		X					3b	
Medonia dermomecoides Schwz.		X					3b	
Pyrophorus spp.	F	X	X	X			3a	
Lampyridae								
Pyractonema haemorhoa Germ.			X				3d	
Lucanidae								
Pycnosiphorus spp.					X		3d	Rotten logs
Sclerostomus baccus Hope					X		3d	Rotten logs
Melodidae								
Epicauta pilma Mol.			X				3d	
Oedemeridae								
Laboglosa varipennis Sol.			X				3e	
Scarabaeidae								
Brachysternus prasinus Guér.	N	X	X			X	1a	Larvae in rotten logs
Hylamorpha elegans (Burm.)	N	X	X			X	1a	Larvae in rotten logs
Hylamorpha cylindrica Arrow	N	X	X				1a	Nursery pest
Oryctomorphus bimaculatus Guér	N		X				3d	Larvae in rotten logs
Oryctomorphus maculicornis Burm.	N		X				3e	AOC
Phytholaema herrmanni (= *mutabilis*) Sol.	N	X	X				3e	AOC
Sericoides germaini Dalla Torre	N	X	X				1a	Nursery pest

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops, AOC = adults only collected from *Pinus radiata*, larvae not known to feed on pine.

* See table 3-1 on page 18 for definitions of categories.

Appendix A, Table A-1. Insects associated with Monterey pine (*Pinus radiata*) in Chile, including host range, location on host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location on host: Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Pest category*	Comments
Scolytidae								
Hylastes ater (Paykull)	P, C			X			1a	Introduced
Hylurgus ligniperda (F.)	P			X			1a	Introduced
Orthotomicus erosus Wollaston	P, C			X			1a	Introduced
Xyleborinus (Xyleborus) saxeseni (Ratzburg)	P				X		1d	Introduced
Tenebrionidae								
Epipedonota spp.			X				3d	
Heliofugus impressus Guér.			X				3d	
Heliofugus sp.			X				3d	
Nycterinus abdominales Esch.			X				3d	
Oligocara nitida Sol.			X				3d	
Praocis abdominalis Sol.			X				3d	
Praocis curta Sol.			X				3d	
Praocis sp.							3d	
LEPIDOPTERA								
Geometridae								
Omphax gnoma Butler	N		X				3b	
Paragonia arenosa Butler	N		X				3b	
Paragonia cinerea Butler	N		X				3e	AOC
Tetracis chilenaria Butler	N		X				3b	
Hepialidae								
Maculella noctuides Pfitz.		X					3b	
Lasiocampidae								
Macromphalia dedecora Feisth.	N		X				3a	Pupates on tree
Macromphalia spadix Draudt	N		X				3a	Pupates on tree
Lymantriidae								
Orgyia antiqua (L.)	N, F		X				2b	Rare on pine

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops, AOC = adults only collected from *Pinus radiata*, larvae not known to feed on pine.

* See table 3-1 on page 18 for definitions of categories.

Appendix A, Table A-1. Insects associated with Monterey pine (*Pinus radiata*) in Chile including host range, location on host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location on host: Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Pest category*	Comments
Noctuidae								
Agrotis ypsilon (Rott.)	N, F	X					3b	Pupates in soil
Copitarsia naeniodes Butler	N, F	X					3b	Pupates in soil
Euxoa sp.	N, F	X					3b	Pupates in soil
Feltia anexa Butler	N, F		X				3b	Pupates in soil
Pseudoleucania bilitura (G.M.)		X					3b	Pupates in soil
Pseudaletia punctulata Blanch.		X					3b	Pupates in soil
Olethreutidae (Tortricidae)								
Rhyacionia buoliana (Schiff.)	P	X	X				2c	Major pest of pine
Psychidae								
Thanatopsyche chilensis Phil.	C, N, E, F		X				1a	Pupates on tree
Saturniidae								
Automeris erythrops Blanch.	N		X				3e	
Catocephala (= *Ormiscodes*) *marginata* (Phil.)	N, E		X				3a	Pupates in duff
Catocephala (= *Ormiscodes*) *rufosignata* Blanch.	N		X				3a	Pupates on tree
Catocephala (= *Ormiscodes*) spp.	N, E		X				3c	
Ormiscodes cinnamomea Feisth. (=*Dirphia amphimone* Berg.)	C, N		X				1a	Pupates in duff
Polythysana cinerascens Phil.	N		X				3a	Pupates on tree
HYMENOPTERA								
Siricidae								
Urocerus gigas (L.)	P				X		2a	Introduced

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops, AOC = adults only collected from *Pinus radiata*, larvae not known to feed on pine.

* See table 3-1 on page 18 for definitions of categories.

Appendix A, Table A-2. Fungi associated with Monterey pine (*Pinus radiata*) in Chile, including host range, location on host, and pest category

Species	Other hosts	Location: Seedlings in nursery	Location: Foliage/ other	Location: Bark cambium	Location: Sapwood	Location: Heartwood	Pest category*
Armillaria spp.	P, C, N			X	X	X	1a
Botrytis cinerea Pers:Fr.	N		X				2b
Caliciopsis pinea Peck	P		X				2d
Cercoseptoria pini-densiflorae Hori & Nambu	P, C		X	X			2c
Colletotrichum acutatum Simmds. f. sp. *pinea* Ding. et Gilm.	P	X		X	X		2d
Cyclaneusma minus (Butin) DiC., Per. & Min.	P		X				2c
Cyclaneusma niveum (Pers. Fr.) DiC., Per. & Min.†	P, C		X				2c
Cylindrocarpon sp.	P	X					2b
Dothistroma pini Hulbary‡	P, C		X	X			2c
Fusarium oxysporum Schlecht.	P	X					2d
Lachnellula subtilissima (Cooke) Dennis	P			X			2d
Lophodermium conigenum (Brun.) Hilitz.	P		X	X			2c
Lophodermium pinastri (Schrad. ex Hook.) Chev.	P		X	X			2c
Lophodermium seditiosum Minter, Staley & Millar	P		X	X			2c
Macrophomina phaseolina (Tassi) Goid.	P	X					2d
Massarina morthieri (Fuckel) v. Arx & Müller	P			X			2d
Mycosphaerella dearnesii Barr, (= *Scirrhia acicola*)	P, C, N		X	X		X	2c
Ophiostoma (= *Ceratocystis*) *piceae* (Munch) Syd. & P. Syd.	P, C, N			X	X	X	2c
Ophiostoma (= *Ceratocystis*) *piliferum* (Fr.: Fr.) Syd. & P. Syd.	P			X	X	X	2c
Pestolotia funerea Desm.	P	X	X	X			2d
Phaoecryptopus gaeumannii (T. Rhode) Petr.	P			X	X		2d
Phellinus spp.	P, C, N				X	X	2c
Phoma spp.	P, C, N	X	X				3d
Phytophthora spp.	P, C	X					2d
Pythium aphanidermatum Edson (Fitzp.)	P, C	X					2d
Pythium debarianum Auct. non Hesse	P, C	X					2d
Pythium ultimum Trow.	P	X					2d
Rhizoctonia solani Kühn	P, C	X					2d
Schizophyllum commune (Fr.) Fr.	P		X	X	X	X	2d
Sclerophoma pithyophila (Corda) v. Höln.	P		X	X			2d
Sphaeropsis sapinea (Fr.) Dyko & Sutton	P		X	X	X		2c
Stereum hirsutum (Wild.: Fr.) S. F. Gray	P			X	X	X	2d
Stereum sanguineolentum (Alb. & Schw.: Fr.) Fr.	P, C			X	X	X	2d
Strassaria geniculata (Berk. & Br.) v. Höln.	P		X	X			2d
Trametes versicolor (L.: Fr.) Pilat.	P, C			X	X	X	2d

P = *Pinus* spp., C = other conifers, N = native hardwoods, E = exotic hardwoods, F = fruit trees and other agricultural crops.

* See table 3-1 on page 18 for definitions of categories; all fungi in category 2 are found in the United States.

† Found only on *Pinus pinaster* to date in Chile.

‡ = *Dothistroma septospora* (Dorguine) Morelet, *Scirrhia pini* Funk & Parker, and, most recently, *Mycosphaerella pini* Rostr. in Munk.

Appendix B
Insects and Fungi Associated with Coigüe and Tepa in Chile

Table B-1. Insects associated with coigüe (*Nothofagus dombeyi*) in Chile, including host range, location on host, and pest category

Table B-2. Selected insects that feed on tree species growing in association with coigüe (*Nothofagus dombeyi*) and/or tepa (*Laurelia philippiana*) in Chile

Table B-3. Fungi associated with *Nothofagus* spp. and *Laurelia* spp. in Chile

Appendix B, Table B-1. Insects associated with coigüe (*Nothofagus dombeyi*) in Chile, including host range, location on host, and pest category

ORDER / Family / *Species*	Other hosts	Location on host: Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Pest category*	Comments
ISOPTERA								
Kalotermitidae								
Cryptotermes brevis Walker	P, C, N					X	1b	North Chile; tepa wood
Kalotermes gracilignathus Blanch.						X	3b	Juan Fernández Island
Neotermes (Kalotermes) chilensis (Blanch.)	P, C, N			X	X	X	1a	
Termopsidae								
Porotermes quadricollis (Rambur)	P, C, N			X	X	X	1a	
THYSANOPTERA								
Thripidae								
Heliothrips haemorrhoidalis (Bouché)	P, N	X					1d	
HOMOPTERA								
Coccidae								
Aspidiotiphagus citrinus	C		X†				3a	Also on *Podocarpus*
Pseudoparlatoria chilina Lindgr.	C		X†				3a	Also on *Saxegothea*
COLEOPTERA								
Anobiidae								
Hadrobregmus incisicoli Pic.	C				X		3a	Dead wood
Lyctidae								
Lyctus cinnereus (Blanch.)	N, E					X	3b	Wood in use
Lyctus planicollis LeC.	N, E					X	3b	Wood in use
Bostrichidae								
Dexicrates robustus (Blanch.)	N, E					X	3b	Wood in use
Polycaon chilensis (Erich.)	N, E					X	3b	Wood in use

P = *Pinus* spp., C = conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* See table 3-1 on page 18 for definitions of categories.

† Location on host uncertain.

Appendix B, Table B-1. Insects associated with coigüe (*Nothofagus dombeyi*) in Chile, including host range, location on host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location on host: Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Pest category*	Comments
Buprestidae								
Conognatha viridiventris Sol.	N			X	X		3a	
Epistomentis pictus Gory	N			X	X		1a	Common; dead & dying trees
Epistomentis vittata Phil.	N			X	X		3a	
Cerambycidae								
Achenoderus (*Chenoderus*) *octomaculatus* Faim.				X	X		3a	Dead & dying wood
Adalbus crassicornis F. & G.	N			X	X		3b	Small live branches
Callideriphus laetus Blanch.	P, N, E			X	X		1a	Dead & dying wood
Callisphyris semicaligatus F. & G.	N, E			X	X		1a	Live branches
Calydon submetallicum Blanch.	N, E			X	X		1a	Fresh logs
Cheloderus childreni Gray	N			X	X		1a	Live trunks
Chenoderus testaceus Blanch.	N, E			X	X		3a	Dead & dying wood
Grammicosum flavofasciatum Blanch.	N, E			X	X		3a	Dead & dying wood
Holopterus chilensis Blanch.	N			X	X		3c	Living trees
Lautarus concinnus Phil.	N			X	X		3a	Living trees
Maripanus decoratus Germ.				X	X		3e	
Microplophorus castaneus (*magellanicus*) Blanch.	C, N, E			X	X		3e	Dead wood
Mycetaphila brachyptera				X	X		3e	
Oxypeltus quadrispinosus Blanch.	N			X	X		3b	Live branches
Phymatioderus bizonatus Blanch.	E			X	X		3e	Dead wood
Planopus laniniensis Bosq				X	X		3a	Living trees
Planopus octaviobarrosi Cerda				X	X		3a	Living trees
Platynocera lepturoides Blanch.				X	X		3b	Twig girdler
Sibylla coimeterii Thomson	N			X	X		3a	Living trees
Sibylla flavosignata F. & G.				X	X		3a	
Sibylla integra F. & G.				X	X		3a	Living trees
Sibylla livida Germ.				X	X		3a	Living trees
Xenocompsa flavonitida F. & G.				X	X		3e	
Chrysomelidae								
Hornius grandis Phil. & Phil.	N	X	X				3b	Buds & new leaves

P = *Pinus* spp., C = other conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* See table 3-1 on page 18 for definitions of categories.

Appendix B, Table B-1. Insects associated with coigüe (*Nothofagus dombeyi*) in Chile, including host range, location on host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location on host: Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Pest category*	Comments
Curculionidae								
Nothofagobius brevirostris Kuschel			X	X			3a	Bark borer, kills buds
Nothofaginus lineaticollis Kuschel	N			X			3a	Bark borer
Aegorhinus fascicularis Kuschel				X			3a	
Aegorhinus nodipennis Hope	N			X			3a	Bark borer
Aegorhinus oculatus Kuschel				X			3a	Bark borer
Aegorhinus silvicola Kushel				X			3a	Bark borer
Aegorhinus vitulus bulbifer Kuschel				X			3a	Bark borer
Aegorhinus vitulus vitulus Fab.	N			X			3a	Bark borer
Polydrusus nothofagi Kushel	N		X				3b	Defoliator
Rhyephenes mallei (Gay & Sol.)	P, N, E			X			1a	Dead & dying trees
Elateridae								
Grammophorus niger Sol.	N, F	X					3b	
Scarabaeidae								
Hylamorpha elegans (Burm.)	P, N, E	X	X				1a	
Sericoides germaini Dalla Torre	P, N, E	X	X				3a	
Scolytidae								
Gnathotrupes caliculus (Schedl)							3a	AOC
Gnathotrupes cirratus Schedl							3a	AOC
Gnathotrupes fimbriatus (Schedl)	N				X		1a	Logs, lumber
Gnathotrupes impressus (Schedl)							3a	AOC
Gnathotrupes longipennis (Blanch.)	N				X		1a	Logs, lumber
Gnathotrupes longiusculus (Schedl)							3a	AOC
Gnathotrupes nanulus (Schedl)							3a	AOC
Gnathotrupes naumanni (Schedl)							3a	AOC
Gnathotrupes nothofagi (Schedl)							3a	AOC
Gnathotrupes pauciconcavus Schedl							3a	AOC
Gnathotrupes pustulatus Schedl							3a	AOC

P = *Pinus* spp., C = other conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops, AOC = adults only collected, larval habits unknown.

* See table 3-1 on page 18 for definitions of categories.

Appendix B, Table B-1. Insects associated with coigüe (*Nothofagus dombeyi*) in Chile, including host range, location on host, and pest category (continued)

ORDER Family *Species*	Other hosts	Location on host: Seedlings in nursery	Foliage/ other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Pest category*	Comments
Gnathotrupes similis Schedl							3a	AOC
Gnathotrupes solidus Schedl							3a	AOC
Gnathotrupes vafer (Schedl)							3a	AOC
Gnathotrupes velatus Schedl							3a	AOC
LEPIDOPTERA								
Cossidae								
Chilecomadia valdiviana (Phil.)	N, E, F				X		1a	Living trees
Opostegidae								
Notiopostega atrata Davis				X			1a	Cambium miner, pith fleck
Saturniidae								
Polythysana cinerascens Phil.	P		X				3b	

P = *Pinus* spp., C = other conifers, N = other native hardwoods, E = exotic hardwoods, F = fruit trees and/or agricultural crops, AOC = adults only collected, larval habits unknown.

* See table 3-1 on page 18 for definitions of categories.

Appendix B, Table B-2. Selected insects that feed on tree species growing in association with coigüe (*Nothofagus dombeyi*) and/or tepa (*Laurelia philippiana*) in Chile

ORDER Family *Species*	Hosts	Location on host Seedlings in nursery	Foliage other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Hitch-hiker*	Comments
ORTHOPTERA								
Pseudophasmatidae								
Bacunculus phyllopus Gray	P, N		X				X	
HOMOPTERA								
Margarodidae								
Llaveiae sp.	N		X	X			X	Roble branches (Cameron)
COLEOPTERA								
Buprestidae								
Pterobothris corrosus F. & G.	N			X	X			Lenga
Cerambycidae								
Callysphiris macropus Newman	N				X			
Callysphiris vespa Germ.	N, F				X			Important in agriculture
Chenoderus tricolor F. & G.	N, F				X			
Holopterus annulicornis Phil.	N				X			
Curculionidae								
Aegorhinus spp.	N			X				
Empleurus dentipes Boheman	N				X			Borer of dead trees
Rhyephenes spp.	P, N			X			X	
LEPIDOPTERA								
Cossidae								
Chilecomadia moorei (Silva)	N, F				X			Living trees, abundant
Geometridae								
Omaguacua longibursae Parra/Beéche	N		X					Roble

P = *Pinus* spp., C = other conifers, N = native hardwoods other than coigüe and tepa, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* Indicates those insects that may be abundant around ports or attracted to lights during some stage of their life cycle, providing opportunity to be imported as "hitchhikers" on the surface of untreated logs or in ships.

Appendix B, Table B-2. Selected insects that feed on tree species growing in association with coigüe (*Nothofagus dombeyi*) and/or tepa (*Laurelia philippiana*) in Chile (continued)

ORDER Family *Species*	Hosts	Location on host Seedlings in nursery	Foliage other	Bark/ cambium	Sapwood/ heartwood	Wood in use	Hitch-hiker*	Comments
LEPIDOPTERA								
Oecophoridae								
Doina clarkei Parra & Ibarra-Vidal	N		X					Damages raulí seeds
Perzelia sp.	N		X					
Lymantriidae								
Orgyia antiqua L.	P, N, E, F		X				X	
Saturniidae								
Catocephala (= *ormiscodes*)								
Ormiscodes cinnamomea Feisth. (= *Dirphia amphimone* Berg.)	P, N		X				X	*Pinus*, *Nothofagus* spp.
Ormiscodes marginata (Phil.)	N		X				X	*Nothofagus obliqua*
Ormiscodes nigrosignata Phil.†	N		X					
Ormiscodes n. sp.	N		X					
Tortricidae								
Ithutomus formosus Butler	N		X					*Drimys winteri*
DIPTERA								
Cecidomyiidae								
Rhopalomyia nothofagi Gagné	N		X					*Nothofagus obliqua*
HYMENOPTERA								
Pergidae								
Cerospastus volupis Konow	N		X					*Nothofagus alpina*
Tenthredinidae								
Nematus desantisi Smith	N		X				X	*Salix* spp.

P = *Pinus* spp., C = other conifers, N = native hardwoods other than coigüe and tepa, E = exotic hardwoods, F = fruit trees and/or agricultural crops.

* Indicates those insects that may be abundant around ports or attracted to lights during some stage of their life cycle, providing opportunity to be imported as "hitchhikers" on the surface of untreated logs or in ships.

† Only insect species recorded from *Laurelia philippiana* trees in Chile.

Appendix B, Table B-3. Fungi associated with *Nothofagus* spp. and *Laurelia* spp. in Chile

Species	Pathogen	Non-pathogen	Pest category*
***Nothofagus* spp.**			
Anthostoma allantosporum Speg.		X	3d
Anthostoma urodelum Speg.		X	3d
Anthracoderma selenospermum Speg.		X	3d
Aposphaeria clausa (Wint.) Speg.		X	3d
Auricularia sambucina Mart.		X	3d
Chalara brevicollis Arambarri Gamundi		X	3d
Chalara dualis Arambarri Gamundi		X	3d
Chalara nothofagi Nag Raj & Kendrick		X	3d
Chlorosplenium aeruginosum (Ded.) Den.		X	3d
Corticium levae Pers.		X	3d
Corticium majusculum Speg.		X	3d
Corticium triviale Speg.		X	3d
Cucurbitaria antarctica Speg.		X	3d
Cyphella vibellina (Lev.) Pat.		X	3d
Cytosporium fuegianum Speg.		X	3d
Exidia auricula-judae Fr.		X	3d
Exidia nucleata (Schw.) Burt		X	3d
Ganoderma spp.		X	2c
Gymnopilus amarissimus Murr.		X	3d
Gymnopilus chrysopellus (Berk. & Curt.) Murr.		X	3d
Hirneola antarctica Speg.		X	3d
Hypoxylon bovei Speg.		X	3d
Hypoxylon creoleucum Speg.		X	3d
Hypoxylon diatrypelloide Speg.		X	3d
Hypoxylon pseudopachyloma Speg.		X	3d
Hysterographium magellanicum Speg.		X	3d
Irpex obliquus (Schrad.) Fr.		X	3d
Laestadia diffusa (Crie) Sacc. & Trav.		X	3d
Peziza echinospora Karst.		X	3d
Pleurotus ostreatus (Jacq.) Fr. var. *salignus* (Pers.: Fr.) Konr. & Maubl.		X	3d
Stereum spp.		X	2c
Trametes versicolor (L.: Fr.)		X	2c
Tremella brasiliensis (Möller) Lloyd		X	3d
Nothofagus alpina			
Ceratocystis valdiviana Butin	X		1a
Melampsora fagi Diet. et Neger	X		3b
Mikronegeria fagi Diet.	X		3b
Verticicladiella sp.	X		3b
Nothofagus antarctica			
Agaricus (Claudopus) variabilis Pers.		X	3d
Agaricus (Crepidotus) brunswickianus Speg.		X	3d
Agyrium antarcticum Rhem		X	3d
Aposphaeria freticola Speg.		X	3d
Colocera cornea Batsch.		X	3d

* See table 3-1 on page 18 for descriptions of categories; all fungi in category 2 are found in the United States.

Appendix B, Table B-3. Fungi associated with *Nothofagus* spp. and *Laurelia* spp. in Chile (continued)

Species	Pathogen	Non-pathogen	Pest category*
Nothofagus antarctica (continued)			
Corticium lacteum Fr.		X	3d
Corticium tremullinus Berk.		X	3d
Cortinarius (Myxacium) darwini Speg.		X	3d
Cortinarius (Myxacium) tacnensis Speg.		X	3d
Cyttaria alba Phil.	X		3b
Cyttaria darwinii Berk.	X		3b
Cyttaria harioti Fisch.	X		3b
Cyttaria hookeri Berk.	X		3b
Diderma antarctica (Speg.) Sturgis		X	3d
Durella bagnisiana Sacc.		X	3d
Fistulina antarctica Speg.		X	3d
Fomes fomentarius (Fr.) Kickx.		X	3d
Gnomonia magallanica Speg.	X		3b
Helotium epiphyllum Fr.		X	3d
Hirneola antarctica Speg.		X	3d
Hirneola vitellina Speg.		X	3d
Hymenochaete tenuissima Berk.		X	3d
Hypoxylon magallanicum Speg.		X	3d
Hysterographium cylindrosporum Rhem		X	3d
Hysterographium fuegianum Speg. Fr. *intermedium* Rhem	X		3b
Licea antarctica Speg.		X	3d
Melittosporium coeruleum Rhem		X	3d
Parthenolecanium persicae Speg.		X	3b
Phoma clausa Wint.	X		2d
Phoma hariotana Wint.	X		2d
Pleonectria vagans Speg.	X		2d
Pleosphaeria patagonica Speg.	X		2d
Propolis pulchella Speg.		X	3d
Rosellinia magellanica Speg.	X		3b
Schizostoma vicinissimun (Speg.) Fr.		X	3d
Solecosporium fagi Lib.		X	3d
Sphaerella antarctica Speg.		X	3d
Sphaeronaema sticticum Berk.		X	3d
Sporocybe antarctica Speg.		X	3d
Stereum rugosum Fr.		X	3d
Stereum sarmienti Speg.		X	3d
Xylographa paralella (Arch.) Fr.		X	3d
Zignoella patagonica Speg.		X	3d
Nothofagus betuloides			
Ameghiniella australis Speg.		X	3d
Calosphaeria antarctica Speg.		X	3d
Cenagium australe Speg.		X	3d
Coryne sarcoides (Jacq.) Tul.		X	3d
Cucurbitaria antarctica Speg.	X		3b
Cylindrium fuegianum Speg.	X		3b

* See table 3-1 on page 18 for descriptions of categories; all fungi in category 2 are found in the United States.

Appendix B, Table B-3. Fungi associated with *Nothofagus* spp. and *Laurelia* spp. in Chile (continued)

Species	Pathogen	Non-pathogen	Pest category*
Nothofagus betuloides (continued)			
Cytospora antarctica Speg.	X		3b
Cyttaria darwinii Berk.	X		3b
Cyttaria harioti Fisch.	X		3b
Cyttaria hookeri Berk.	X		3b
Eriosphaeria vulgaris Speg.		X	3d
Eurotium chilensis Mont.		X	3d
Fistulina antarctica Speg.		X	3d
Fumago pannosa (Berk.) Speg.		X	3d
Harknessia antarctica Speg.		X	3d
Helotium citrinum (Hedw.) Fr.		X	3d
Helotium gregarium Boud.		X	3d
Helotium ochraceum Boud.		X	3d
Lophodermium histerioides (Pers.)	X		3b
Melanconis antarctica Speg.	X		3b
Melanconium stromaticum Corda	X		3b
Phoma desolationis Speg.	X		3b
Pleonectria vagans Speg.	X		3b
Septoria fagicola Speg.	X		3b
Sphaeronaema conicum (Tode) Sacc.	X		3b
Tympanis antarctica Speg.		X	3d
Nothofagus dombeyi			
Antennaria pannosa Berk.	X		3b
Antennaria scoriadea Berk.	X		3b
Armillariella procera (Speg.) Singer	X		1a
Boletus sp.		X	3d
Ceratocystis nothofagi Butin	X		1a
Cyttaria harioti Fischer	X		3b
Cyttaria johowii Espinosa	X		3b
Cyttaria sp.	X		3b
Fistulina hepatica Fr.		X	3d
Flammulina velutipes (Pres.: Fr.) Singer		X	3d
Galerina victoriae Singer		X	3d
Ganoderma applanatum (Pers.) Pat.	X		2c
Gloeosoma vitellinum (Lev.) Bresadola		X	3d
Gymnopilus prupuratus (Cooke & Massee) Singer		X	3d
Hybogaster giganteus Singer		X	3d
Macrophomina phaseolina (Tassi) Goid.	X		2d
Micronigeria fagi Diet.et Neger	X		3b
Ophiostoma (*Ceratocystis*) *piceae* Munch) Syd. & P. Syd.	X		2c
Ophiostoma (*Ceratocystis*) *valdiviana* (Butin) Harrington	X		1a
Phellinus senex (Nees et Mont.) Imaz.	X		3a
Phlebia chrysocrea (Berk. et Curt.) Burdsall	X		2c
Phytophthora sp.	X		2d
Pleuroflammula croceo-sanginea (Mont.) Singer		X	3e
Schizophyllum commune Fr.	X		2d
Verticicladiella sp.	X		2c

* See table 3-1 on page 18 for descriptions of categories; all fungi in category 2 are found in the United States.

Appendix B, Table B-3. Fungi associated with *Nothofagus* spp. and *Laurelia* spp. in Chile (continued)

Species	Pathogen	Non-pathogen	Pest category*
Nothofagus obliqua			
Agaricus (Pleurotus) gossypinulus Speg.		X	3d
Cyttaria berteroi Berk.	X		3b
Cyttaria hookeri Berk.	X		3b
Helotium epiphyllum Fr.		X	3d
Hirneola vitellina Lev.		X	3d
Hypocrea gelatinosa (Tode) Fr.		X	3d
Hypocrea rufa (Pers.) Fr.		X	3d
Hypoxylon annulatum (Schw.) Mont.		X	3d
Hypoxylon coccineum Bull.		X	3d
Hypoxylon rubricosum Fr.		X	3d
Melampsora fagi Diet. & Neger	X		3b
Ophiobolus antarcticus Speg.	X		3d
Polyporus australis Fr.		X	3d
Nothofagus pumilio			
Ophiostoma (= *Ceratocystis*) *piceae* (Munch) Syd. & P. Syd.	X		2c
Ophiostoma (= *Ceratocystis*) *piliferum* (Fries) C. Moreau	X		2c
Sporothrix sp.	X		2e
Laurelia philippiana			
Aecidium aridum Diet. & Neger	X		2d
Armillariella procera (Speg.) Singer	X		1a
Ceratocystis moniliformis (Hedgc.) C. Moreau	X		2c
Coprinus disseminatus (Pers.: Fr.) Gray		X	3e
Epicoccum sp.		X	3e
Flammulina velutipes (Pers.: Fr.) Sing.		X	3e
Ganoderma applanatum (Pers.) Pat.	X		2c
Marasmiellus alliodorum Murrill		X	3d
Marasmiellus juniperinus Murrill		X	3d
Mycena haematopus (Fr.) Quelet		X	2b
Naematoloma sublateritium (Fr.) Karsten		X	2b
Ophiostoma (= *Ceratocystis*) *piceae* (Munch) Syd. & P. Syd.	X		2c
Phellinus senex (Nees et Mont) Imaz.	X		3a
Schizophyllum commune Fr.	X		2d
Stereum spp.	X		2c
Trametes versicolor (L.: Fr.)	X		2c
Laurelia sempervirens			
Ophiostoma (= *Ceratocystis*) *piceae* (Munch) Syd. & P. Syd.	X		2c

* See table 3-1 on page 18 for descriptions of categories; all fungi in category 2 are found in the United States.

Appendix C
Insects and Fungi Intercepted on Logs Exported from Chile

Appendix C-1. Insect species found in 14 shipments of Monterey pine (*Pinus radiata*) pulpwood logs exported from Chile to Sweden

Appendix C-2. Insects and fungi intercepted in Japan on Monterey pine (*Pinus radiata*) logs exported from Chile

Appendix C-3. Insects and fungi intercepted in Turkey on Monterey pine (*Pinus radiata*) logs exported from Chile

Appendix C-4. Insects intercepted in the United States on Monterey pine (*Pinus radiata*) logs exported from Chile

Appendix C-5. Fungi intercepted in the United States on Monterey pine (*Pinus radiata*) logs and dunnage exported from Chile

Appendix C-6. Fungi intercepted in the United States on coigüe (*Nothofagus dombeyi*) logs exported from Chile

Appendix C, Table C-1. Insect species intercepted in Sweden on 14 shipments of Monterey pine (*Pinus radiata*) pulpwood logs exported from Chile (from Schroeder 1990)

ORDER Family *Species*	Insect stage	No. of infested shipments
ISOPTERA		
Kalotermes chilensis (Blanch.)	A	3
COLEOPTERA		
Staphylinidae		
Stichoglossa sp.	A	1
Atheta coriaria (Kraatz)	A	4
Atheta fungi (Grav.)	A	4
Atheta sodalis (Erichs.)	A	1
Atheta euryptera (Steph.)	A	1
Atheta sp.	A	1
Stenagria concinna (Erichs.)	A	2
Phloeonomus lapponicus (Zett.)	A	2
Phloeonomus pusillus (Grav.)	A	1
Phloeonomus sp.	A	2
Megarthrus sinuatocollis (Lacordaire)	A	1
Anomognathus cuspidatus (Erichs.)	A	1
Lucanidae		
Pycnosiforus vittatus Eschscholtz	A	1
Elateridae		
Unidentified species	L, A	2
Unidentified species	L	1
Buprestidae		
Buprestis novemmaculata (L.)	L, A	7
Anobidae		
Ernobius mollis (L.)	L, A	7
Ptinidae		
Ptinus villiger Rttr.	A	1
Melyridae		
Unidentified species	L	1
Cucujidae		
Uleiota chilensis Blanch.	A	1
Silvanus unidentatus (Ol.)	A	3
Cryptophagidae		
Henoticus californicus)(Mannerheim)	A	1
Cryptophagus dorsalis Sahlb.	A	1
Atomaria lewisi Rttr.	A	2
Corylophidae		
Sericoderus lateralis (Gylh.)	A	1
Orthoperus atomarius (Heer)	A	3
Orthoperus mundus Matthews	A	1
Latridiidae		
Aridius nodifer (Westw.)	A	5
Aridius bifasciatus (Rttr.)	A	1
Aridius subfasciatus (Rttr.)	A	2
Cartodere constricta (Gylh.)	A	5
Cartodere sp.	A	1
Melanophthalma sp.	A	1
Latridius minutus (L.)	A	1
Cisidae		
Cis sp.	A	1
Colydiidae		
Endophloeus porteri Breth.	A	2
Melandryidae		
Unidentified species	L	1
Mycetophagidae		
Litargus sp.	A	1
Cerambycidae		
Unidentified species	L	3
Colobura alboplagiata Bl. o Sol.	L, A	3
Chrysomelidae		
Unidentified species	A	1
Curculionidae		
Rhyephenes humeralis (Guer.)	L, A	9
Rhyephenes mallei Gay & Sol.	L, A	2
Scolytidae		
Xyleborinus saxeseni (Ratz.)	L, A	4
Hylurgus ligniperda (F.)	L, A	10
HYMENOPTERA		
Siricidae		
Unidentified species	E, A	10
ORTHOPTERA		
Gryllidae		
Unidentified species	A	1

A = adults, L = larvae or pupae, E = emergence holes (only noted for Siricidae).

Appendix C-2. Insects and fungi intercepted in Japan on Monterey pine (*Pinus radiata*) logs exported from Chile

Japan has been a major importer of untreated Monterey pine logs from Chile in recent years. To obtain a list of insects and microorganisms intercepted in Japan on Chilean logs, the following persons were contacted:

Mr. Funihiko Ichinohe
Insect Pest Section
Yokahama Plant Protection Station
Shinyama Shita 1-16-10
Nakaku
Yokahama 231, Japan

Mr. Akira Nobichi
Forest Zoology
Forest and Forest Products Research Institute
P. O. Box 16, Isukuba Norin Kenkyu
Danchi-Nai
Ibaraki 305, Japan

Mr. Nobichi responded on November 24, 1992, stating that the Forestry and Forest Products Research Institute had intercepted only one insect species (a pine bark beetle of the genus *Orthotomicus*) in *P. radiata* logs shipped from San Vicente, Chile. No reply had been received from Mr. Ichinohe as of August 1, 1993.

Appendix C-3. Insects and fungi intercepted in Turkey on Monterey pine (*Pinus radiata*) logs exported from Chile

In an effort to obtain information on insects and microorganisms intercepted in Turkey on shipments of debarked *Pinus radiata* logs from Chile, letters of inquiry were sent to the following persons in Turkey.

Balyemez Selahattin
Orman Boge Basmudurlugu
Orman Zararlilari Ile Mucadele
Gurup Muduru
Buyukdere Istanbul
Turkey

Gokhan Eligin
Istanbul Universitesi
Orman Fakultesi
Orman Botanigi Birimi
Buyukdere Istanbul
Turkey

Muzaffer Selik
Forest Pathologist
Istanbul Universitesi
Orman Fakultesi
Orman Botanigi Birimi
Buyukdere Istanbul
Turkey

Faik Surmeli
Forest Entomologist
Orman Bolge Basnudurlugu
Orman Zararlilari Ile Mucadele
Gurup Muduru
Antalya
Turkey

As of August 1, 1993, only M. Selik had responded. In a letter dated March 12, 1993, Dr. Selik stated that, to date, only fungi causing blue stain (*Ophiostoma* spp.) have been identified and observed on sawlogs imported from Chile. No other wood-destroying fungi have been observed. Also, it is unknown whether any insects have been intercepted.

Appendix C-4. Insects intercepted in the United States on Monterey pine (*Pinus radiata*) logs exported from Chile

A shipment of *Pinus radiata* logs from Chile was examined upon arrival in Seattle, Washington by Dr. Daniel J. Hilburn, entomologist with the Oregon Department of Agriculture. Samples of bark containing insects and mites were collected on September 3, 1992, and placed in Burlese funnels. Vials CL-1, CL-2, and CL-3 contained organisms from fumigated logs; vials CL-4 through CL-11 from unfumigated logs.

Fumigated

CL- 1	Aphid	1 nymph
CL- 2	Spider	1
CL- 3	Mites	17

Unfumigated

CL- 4	Staphylinids	2 adults, 46 larvae
CL- 5	Sciarids	25 adults, 6 pupae, 18 larvae
CL- 6	Mites	20
CL- 7	Homoptera	1 nymph
CL- 8	Collembola	2
CL- 9	Lepidoptera	1 adult*
CL-10	Miscellaneous Diptera	1
CL-11	Psocid	1

* Determined by APHIS to be member of family Nepticulidae (*Stigmella* sp.). Larvae mine leaves of hardwood; not known to occur in Chile. APHIS concluded that this moth was probably domestic to the United States (Personal communication from Kathleen Johnson to Oregon Department of Agriculture, September 23, 1992).

Appendix C-5. Fungi intercepted in the United States on Monterey pine (*Pinus radiata*) logs and dunnage exported from Chile

The following fungi were isolated by mycologists at the USDA Forest Service Forest Products Laboratory in Madison, Wisconsin, from increment cores taken from *Pinus radiata* logs and accompanying dunnage shipped from Chile into Seattle, Washington. The increment cores were from two different log shipments and were received at the laboratory on July 7 and August 21, 1992. Cores were tested for fungal contaminants by cutting off 3 cm pieces and placing them into 2% malt agar + streptomycin and potato-dextrose agar + streptomycin (T. J. Volk, personal communication).

<u>Ascomycotina</u>

Ophiostoma (= *Ceratocystis*) spp.
Chaetomuim indicum

<u>Basidiomycotina</u>

Sistotrema c.f. *biggsiae*
Sistotrema sp.*

<u>Oomycotina</u>

Unidentified sp.

<u>Deuteromycetes</u>

Penicillium spp.
Aspergillus flavus
Scopulariopsis sp.*
Paecilomyces sp.*
Alternaria sp.*
Geotrichum sp.
Fusaruim sp.
Trichoderma viride
Idriella sp.

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* Isolated only from dunnage.

The following notes, extracted from Thomas J. Volk's unpublished report to the Forest Products Laboratory, are of interest.

"The cores [from the first shipment] were relatively clean, with little fungal growth taking place from the surface of the core pieces. In fact, some core pieces have failed to produce a fungal colony after 5 weeks on the agar plates. In those that did produce fungi, mostly molds, especially in the genera *Penicillium* and *Aspergillus*, were noted. There are several other fungi isolated that have not yet been identified.

"The dunnage, on the other hand, was obviously contaminated with many surface molds as well as internal molds. One of the [dunnage] logs was nearly covered with very young, immature perithecia of an *Ophiostoma* or *Ceratocystis* species that we have not yet identified. On the surface of another [dunnage] log we observed several rhizomorph-like cordons. These were isolated and identified as *Sistotrema* sp., near *Sistotrema biggsiae*. This isolate is particularly aggressive, actually growing over the top of a colony of *Penicillium* that was originally isolated along with it. Another as yet unidentified *Sistotrema* has also been isolated. Many molds were also present including *Scopulariopsis*, *Paecilomyces*, *Alternaria*, *Geotrichum*, *Fusarium*, *Trichoderma*, and an unidentified immature oomycete in the Saprolegniales.

"All the increment cores from one of the logs [from the second shipment] produced a perithecial ascomycete *Chaetomium indicum*, a soft rot fungus first described from India. It has subsequently been found in the United States, primarily on the East Coast, in Massachusetts, North Carolina, and Tennessee. It has also been found in South America, in Argentina.

"Increment cores from two of the logs produced an undescribed *Idriella* species. The spores are much too large to fit with any of the known species of *Idriella*, and the chlamydospores are also quite unusual. This species should be regarded as a potential pathogen, since another species in the genus, *Idriella lunata*, is a known pathogen of strawberry (Nelson, Paul and Stephen Wilhelm, 1956. An undescribed fungus causing a root rot of strawberry. Mycologia 48:547-551).

"*Sistotrema biggsiae* was again isolated, this time from increment cores. This basidiomycete was very aggressive, actually growing over the top of *Trichoderma viride*, which is itself known to be a pathogen of fungal hyphae.

"Another basidiomycete with clamps was isolated from the cores, but is as yet unidentified. It grows very slowly but is able to grow even among *Trichoderma*. Once it is isolated in pure culture it will be further characterized."

Appendix C-6. Fungi intercepted in the United States on coigüe (*Nothofagus dombeyi*) logs exported from Chile

Samples from logs of *Nothofagus dombeyi* from Chile also were evaluated by mycologists at the Forest Products Laboratory. A species of *Neurospora* (Ascomycotina) was the only noteworthy fungus identified from these samples (H. Burdsall, personal communication).

Appendix D
Common and Scientific Names of Tree Species

Table D-1. Common and scientific names of native tree species and those widely planted as ornamentals in North America

Table D-2. Common and scientific names of tree species native to Chile

Appendix D, Table D-1. Common and scientific names of native tree species and those widely planted as ornamentals in North America*

Common name	Scientific name	Family
I. Conifers		
Austrian pine†	*Pinus nigra* Arn.	Pinaceae
Baldcypress‡	*Taxodium distichum* (L.) Rich.	Taxodiaceae
Bishop pine	*Pinus muricata* D. Don	Pinaceae
Coast redwood‡	*Sequoia sempervirens* (D. Don) Endl.	Taxodiaceae
Coulter pine	*Pinus coulteri* D. Don	Pinaceae
Cypress‡	*Cupressus* spp.	Cupressaceae
Douglas-fir‡	*Pseudotsuga menziesii* (Mirb.) Franco	Pinaceae
Engelmann spruce‡	*Picea engelmannii* Parry	Pinaceae
Giant sequoia‡	*Sequoiadendron giganteum* (Lindl.) Buchholz	Taxodiaceae
Grand fir‡	*Abies grandis* (Dougl. ex D. Don) Lindl.	Pinaceae
Incense cedar	*Libocedrus decurrens* (Torr.) Florin	Cupressaceae
Juniper‡	*Juniperus* spp.	Cupressaceae
Loblolly pine	*Pinus taeda* L.	Pinaceae
Lodgepole pine‡	*Pinus contorta* Dougl.	Pinaceae
Maritime pine† ‡	*Pinus pinaster* Ait.	Pinaceae
Monterey pine‡	*Pinus radiata* D. Don	Pinaceae
Mugho pine†	*Pinus mugo* Turra	Pinaceae
Noble fir‡	*Abies procera* Rehd.	Pinaceae
Pacific silver fir‡	*Abies amabilis* Dougl. ex Forbes	Pinaceae
Ponderosa pine‡	*Pinus ponderosa* Dougl. ex Laws.	Pinaceae
Port-Orford-cedar‡	*Chamaecyparis lawsoniana* (A. Murr.) Parl.	Cupressaceae
Red pine‡	*Pinus resinosa* Ait.	Pinaceae
Scotch pine† ‡	*Pinus sylvestris* L.	Pinaceae
Sitka spruce‡	*Picea sitchensis* (Bong.) Carr.	Pinaceae
Stone pine†	*Pinus pinea* L.	Pinaceae
Sugar pine‡	*Pinus lambertiana* Dougl.	Pinaceae
Torrey pine	*Pinus torreyana* Parry	Pinaceae
Western hemlock‡	*Tsuga heterophylla* (Raf.) Sarg.	Pinaceae
Western larch‡	*Larix occidentalis* Nutt.	Pinaceae
Western redcedar‡	*Thuja plicata* Donn ex D. Don	Cupressaceae
Western white pine‡	*Pinus monticola* Dougl. ex D. Don	Pinaceae
White fir‡	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.	Pinaceae
White spruce‡	*Picea glauca* (Moench) Voss	Pinaceae

* Includes only those tree species cited in the text of this report.

† Not indigenous to North America, but serves as host to a pest mentioned in the text.

‡ Grown as an exotic in Chile.

Appendix D, Table D-1. Common and scientific names of native tree species and those widely planted as ornamentals in North America* (continued)

Common name	Scientific name	Family
II. Hardwoods		
American basswood†	*Tilia americana* L.	Tiliaceae
American beech†	*Fagus grandifolia* Ehrh.	Fagaceae
American elm†	*Ulmus americana* L.	Ulmaceae
Ash†	*Fraxinus* spp.	Oleaceae
Birch†	*Betula* spp.	Betulaceae
Black locust†	*Robinia pseudoacacia* L.	Leguminosae
California laurel	*Umbellularia californica* (Hook and Arn.) Nutt.	Lauraceae
Chestnut†	*Castanea* spp.	Fagaceae
Hickory†	*Carya* spp.	Juglandaceae
Magnolia†	*Magnolia grandiflora* L.	Magnoliaceae
Maple†	*Acer* spp.	Aceraceae
Oak†	*Quercus* spp.	Fagaceae
Poplar†	*Populus* spp.	Salicaceae
Red alder†	*Alnus rubra* Bong.	Betulaceae
Sweetgum†	*Liquidambar styraciflua* L.	Hamamelidaceae
Sycamore†	*Platanus occidentalis* L.	Platanaceae
Walnut†	*Juglans* spp.	Juglandaceae
Willow†	*Salix* spp.	Salicaceae

* Includes only those tree species cited in the text of this report.

† Commonly grown as an exotic in Chile.

Appendix D, Table D-2. Common and scientific names of tree species native to Chile*

Common name	Scientific name	Family
Alerce	*Fitzroya cupressoides* (Mol.) Johnston	Cupressaceae
Algarrobo	*Prosopis chilensis* (Mol.) Stuntz	Mimosaceae
Arrayán	*Myrceugenella apiculata* (DC.) Kaus.	Myrtaceae
Avellano	*Gevuina avellana* Mol.	Proteacae
Canelo	*Drimys winteri* Forst.	Winteraceae
Ciprés de la cordillera	*Austrocedrus chilensis* (D. Don) Florin et Boutelje	Cupressaceae
Ciprés de las Guaitecas	*Pilgerodendron uvifera* (D. Don) Florin	Cupressaceae
Coigüe	*Nothofagus dombeyi* (Mirb.) Oerst.	Fagaceae
Coigüe de Chiloé	*Nothofagus nitida* (Phil.) Krasser	Fagaceae
Coigüe de Magallanes	*Nothofagus betuloides* (Mirb.) Oerst.	Fagaceae
Laurel	*Laurelia sempervirens* (R. et Pav.) Tul.	Lauraceae
Lenga	*Nothofagus pumilio* (Poepp. et Endl.) Krasser	Fagaceae
Lingue	*Persea lingue* Nees	Lauraceae
Luma	*Amomyrtus luma* (Mol.) Legr. et Kaus.	Myrtaceae
Maitén	*Maytenus boaria* Mol.	Celastraceae
Mañío	*Podocarpus salignus* D. Don	Podocarpaceae
Mañío hembra	*Saxegothaea conspicua* Lindl.	Podocarpaceae
Mañío macho	*Podocarpus nubigena* Lindl.	Podocarpaceae
Maqui	*Aristotelia chilensis* (Mol.) Stuntz	Eleocarpaceae
Molle	*Schinus latifolius* (Gill.) Engler	Anacordiaceae
Ñirre	*Nothofagus antarctica* (Forst.)	Fagaceaee
Notro	*Embothrium coccineum* Forst.	Proteacea
Olivillo	*Aextoxicon punctatum* R. et Pavon	Aextoxicaceae
Peumo	*Cryptocarya alba* (Mol.) Looser	Lauraceae
Pino araucaria	*Araucaria araucana* (Mol.) C. Koch	Araucariaceae
Quillay	*Quillaja saponaria* Mol.	Rosaceae
Radal	*Lomatia hirsuta* (Lam.) Diels	Proteaceae
Raulí	*Nothofagus alpina* (Poepp. et Endl.) Krasser	Fagaceae
Roble	*Nothofagus obliqua* (Mirb.) Oerst.	Fagaceae
Roble blanco	*Nothofagus glauca* (Phil.) Krasser	Fagaceae
Sauce chileno	*Salix chilensis* Mol.	Salicaceae
Tamarugo	*Prosopis tamarugo* Phil.	Mimosaceae
Tepa	*Laurelia philippiana* Looser	Lauraceae
Tineo	*Weinmannia trichosperma* Cav.	Cunoniaceae
Ulmo	*Eucryphia cordifolia* Cav.	Eucryphiaceae

* Includes only those tree species cited in the text of this report.

Appendix E
Report on the Pest Risk Assessment Team's Site Visit to Chile
November 8-30, 1992

Appendix E: Report on the Pest Risk Assessment Team's Site Visit to Chile; November 8-30, 1992

Nov 8 The Chile Pest Risk Assessment Team, (RONALD BILLINGS, SCOTT CAMERON, ANDRIS EGLITIS, HAROLD BURDSALL, JOHN KLIEJUNAS, and MELVIN BELLINGER), accompanied by APHIS/PPQ representative DAVID REEVES, arrived in Santiago.

Nov 9 The team met with HERBERT MURPHY, Regional Director of APHIS, and with his assistant, PERCY HAWKES. We discussed the nature of planned exports of logs to the United States and learned that forest industries along the Pacific Coast are most interested, although other areas of the country also may eventually receive log shipments. We learned that all agriculture and forest product exports leaving Chile are inspected by Chile's Agriculture and Livestock Service (SERVICIO AGRICOLA Y GANADERO or SAG). Mr. Murphy discussed the relationship between the Chilean Export Association and APHIS/SAG, which are both well-supported by the agricultural sector.

In the afternoon we met with numerous representatives from SAG including LEOPOLDO SANCHEZ, National Director, and ORLANDO MORALES, Director of the Division of Agricultural Protection. They discussed the importance of agriculture and forestry to the nation's economy. Chile exports products to some 100 countries throughout the world.

ANTONIETA URRUTIA, head of SAG's Department of Agricultural Defense, described the organizational structure of the Ministry of Agriculture, which consists of four agencies:

SAG--Servicio Agrícola y Ganadero (Agriculture and Livestock Service)
INDAP--Instituto del Desarrollo Agropecuario (Institute of Agricultural and Animal Development)
INIA--Instituto Nacional de Investigaciones Agropecuarias (National Institute of Agricultural and Animal Research)
CONAF--Corporación Nacional Forestal (National Forestry Corporation)

Within SAG, there are 13 regional directors who report to the National Director in Santiago.

Ms. Urrutia discussed the types of regulations that govern the phytosanitary condition of international trade in agriculture and forestry. She distinguished between Decree Laws, passed by Congress, and Resolutions, which are imposed by the agency (SAG). She also described the organization of her department which deals with detection, identification, and quarantine of products of international trade.

With regard to exports, there is a certificate of phytosanitary health that accompanies all exported material. In addition, the special requirements of importing countries are identified and exports are inspected in accordance with those requirements as well. The European and North American markets are the most important for Chile's exports. Europe receives 46% and North America 42% of Chile's fruit and horticultural exports.

MARCOS BEECHE, a forest engineer with SAG, described the regulations governing the importation and exportation of wood products. As of 1991, Chile has 1.5 million hectares (3.8 million acres) of forest plantations, of which 84% are Monterey pine (*Pinus radiata*). In 1986, the total value of Chilean wood products exports was U. S. $403 million. This value more than doubled by 1991 (U. S. $915 million). The dramatic increase has been possible due to the high growth rates and lack of forest pests associated with *Pinus radiata*. The importation of wood into Chile is regulated by Resolution 14 (1990) which prohibits the entry of logs or wood with bark. Resolution 1854 (1991) requires that sawn woods be accompanied by a phytosanitary certificate. Wood crating, the suspected source of many forest pest problems, has its own regulations which have been recently developed. Upon arrival, 10% of all crates are inspected. In storage, 100% are inspected for signs of pests. The entry of dunnage material is not permitted. Each year SAG produces a list of pests intercepted at the ports of entry.

In the afternoon, the Spanish-speaking members of our team (Billings, Eglitis, and Cameron) gave slide presentations on objectives of our mission, forest resources and major pest problems in various regions of the United States, and the methodology involved in the pest risk assessment process.

Nov 10 We visited Santiago's Arturo Merino Benitez International Airport and met with SAG officials VELIA ARRIAGADA, JUAN CARLOS MORONI (entomologist), and MANUEL FREDES, who described the procedures used to inspect products entering and leaving the country. Specifically, Ms. Arriagada described the inspection process for crating, which is considered a very likely source of pest problems entering the country. She gave the example for a 10-month period (January through October 1992) during which 123 shipments arriving in Chile contained insects or their damage, and only 10 shipments were totally clean. Most commonly, the problems involve galleries or dead insects, with live insects associated with about 20% of the shipments. The inspection begins with looking for bark. Any crating that arrives with bark will automatically be fumigated. Next, the crating material is inspected for galleries and/or exit holes. These are marked and samples are sent to the laboratory for evaluation and insect identification. If live insects are found, the crating material is either fumigated with methyl bromide or destroyed. Most of the potential pest problems have been beetles, including wood borers, ambrosia beetles, and bark beetles. An additional detection measure that is used at the airport involves the use of sticky traps baited with resin and ethanol as a general attractant for scolytid and platypodid beetles.

Mr. Beéche described the program of early detection for *Sirex noctilio*, a wood wasp that is not yet found in Chile but does occur in neighboring Argentina, Uruguay, and Brazil. Entry of the wood wasp could occur through the transport of crating or packaging material, because some larvae have already been intercepted. The early detection strategy involves the use of "bait trees" in plantations where risks of introduction of the wood wasp are considered to be high. The bait trees are injected with an herbicide (banvel) in the spring, which weakens them gradually and makes them susceptible to insects such as the wood wasp. The trees are monitored throughout the spring and summer for evidence of attack by *Sirex*, and are cut and dissected for inspection in the fall. Sixty bait-tree installations have been established throughout the country for early detection of *Sirex*. This project is being carried out cooperatively between SAG, CONAF, and private forest industries. The 60 parcels are distributed throughout regions V through XII, with the greatest concentration in regions VIII and X. Although no individuals of the genus *Sirex* have been intercepted to date, low numbers of some other insects that commonly occur on dead or weakened trees have been found. These include the bark beetles *Ernobius mollis* and *Hylurgus ligniperda*, native weevils of the genus *Rhyephenes*, and the wood wasp *Urocerus gigas*.

We met with FERNANDO RAGA, Vice-President and Director of Development of the Forestry Sector for the company FORESTAL MININCO. He also serves as an official of The Wood Products Corporation (CORPORACION DE LA MADERA or CORMA). He discussed Chile's forest resource and how he sees the future in terms of its role in the Chilean economy. Of the 75 million hectares in Chile, nearly half (34 million hectares) are suitable for forestry and 1.5 million hectares presently have "forest crops" in the form of exotic plantations. Native forests occupy some 9 million hectares. *Pinus radiata* occurs on 1.3 million hectares, mostly as young plantations. Most of the rest of the exotic forest is composed of eucalyptus, which will be about 300,000 hectares by the year 2000. (Significant harvest volumes will not be available until 1998.) Projections indicate that 9 million cubic meters of eucalyptus (*Eucalyptus globulus*) will be harvested per year by the year 2025, as compared to 20 to 25 million cubic meters per year of *Pinus radiata*. In 1992, the total forest harvest was 23.2 million cubic meters, 7.0 million of which was in native forest and the rest in Monterey pine and eucalyptus.

The Chilean forestry sector has increased markedly in terms of its importance to the country's export trade. In 1970, 3.9% of Chile's total exports were forest products. In 1991, forest products represented 10.2% of the country's exports. In total, these exports represented U. S. $913 million in 1991. Among the very diverse forest products exported, chemical pulp heads the list, and will increase proportionately in the future. Exports in general will need to increase, as Chile is planting about three times as much surface area as it is harvesting each year. (In 1970, 16,000 hectares were planted; in 1991, 83,000 hectares). Some emerging opportunities, as described by Mr. Raga, include the fast-growing eucalyptus, remanufactured lumber, logs for veneer, veneer for plywood, clear logs (from 25% of Chile's pine plantations), and structural lumber. Some key trends that he sees in Chile's future are the growing forces from the environmental community, possible decreasing competitiveness due to the dropping of the exchange rate, higher costs of human resources, competition from the fast-growing tree species of other countries (New Zealand and Brazil), and the need for additional forest industries, given the wood volumes that will be available in the future. He sees the primary competitors as being New Zealand for logs and northern Europe for chemical pulp.

RICARDO YOMA, Technical Director for CONAF, also spoke about the Chilean forestry resource. He related that plantation forestry is totally independent from the native forests and now represents the economic base of forestry in Chile. Native forests were relatively more important before 1940. In 1931 the Forest Law was passed, and called for the development of exotic forests. An exemption from taxes was provided as an incentive for the establishment of these exotic forests. These forests were established by the state until 1974 when the Decree Law 701 was passed, which effectively transferred the reforestation effort into private hands. Between 1940 and 1974, the state planted 11,000 hectares per year. From 1975, with the passage of the Decree Law, over 70,000 hectares have been planted each year. The Decree Law provides an incentive wherein the state pays for 75% of the costs of establishment and maintenance (for 10 years) of exotic *P. radiata* plantations; these plantations are managed by the private forestry sector. About 4 million hectares are eroded in Chile; some of these have been rehabilitated through the planting of exotic species, and others will be rehabilitated in the future. Within the native forest, about 5.5 million hectares are considered as having commercial potential. Incentives similar to the exotic forests are being contemplated for these native forests.

OSVALDO RAMIREZ, head of the Section of Forest Pests within CONAF, explained the functions of his agency in the realm of forest pest management. Mr. Ramirez also described the relationship between SAG and CONAF, a relationship not unlike the one between the USDA's Forest Service and the Animal and Plant Health Inspection Service. In Chile, SAG and CONAF work in close cooperation with regard to forest pests. SAG is responsible for reducing the possibility of introductions of foreign pests and takes charge of obligatory controls of exotic pests. Once exotic pests become established, the charge for their control/management reverts to CONAF. With regard to the detection and management of native or established pests, CONAF assists small landowners with these functions, while the larger private companies are responsible for their own pest programs. CONAF heads the National Committee of Forest Health, which was established in 1988 to oversee and coordinate matters of forest health for the country. The Committee is overseen by a governing board and consists of representatives from CONAF, SAG, INIA, the universities, the Forestry Institute (Instituto Forestal), and 12 of the major private forestry companies in

Chile. The Committee helps define long- and short-term strategies for protecting the Chilean forest resource, sets priorities on research topics, conducts training, and proposes and analyzes resolutions regarding quarantines.

Prior to our trip to Chile, we had submitted a list of insects and diseases known to be associated with *Pinus radiata* in Chile. In the afternoon, we met with entomologists LUIS CERDA (SAG) and PATRICIO SANTA CRUZ (contractor with FORESTAL BIO-BIO), who discussed the relative importance of these insects and diseases. Mr. Cerda pointed out that most of the insects we had identified were secondary in nature and had never been limiting problems for the management of *P. radiata*. Many are associated with wood in an advanced state of deterioration. The only exceptions thus far would be the European pine shoot moth (*Rhyacionia buoliana*), which was recently introduced from Argentina, and to a lesser extent, the European bark beetle *Hylurgus ligniperda*. Similarly, Mr. Santa Cruz discussed the diseases we had identified in the preliminary list and also pointed out that with minor exceptions (e.g., *Dothistroma pini*, *Sphaeropsis sapinea*), the fungi associated with *P. radiata* have not been major concerns for forest management.

Nov 11 We visited the UNIVERSITY OF CONCEPCION--CHILLAN and met with pathologist Dr. GASTON GONZALES. He pointed out that the work at that campus is primarily with pathology rather than mycology, and with exotic plantations rather than with native forests. Presently, there is more interest in *Eucalyptus* than in *Pinus radiata* at the University of Concepción. With regard to *P. radiata*, Mr. Gonzáles mentioned that *Ceratocystis* (*Ophiostoma*) has been associated with two or three insect species (including *Hylurgus*) in dying trees. About 2% of the insects are associated with either *Ceratocystis* or two species of *Graphium* (an anamorph of *Ceratocystis*). The only diseases of occasional importance on pine appear to be caused by *Sphaeropsis sapinea* (*Diplodia pinea*), which occasionally causes top dieback in live trees. The incidence of armillaria root rot appears to be decreasing with continued management in Chile, as is *Dothistroma pini*, a needle pathogen.

Nov 12 We visited the private forestry company FORESTAL CHOLGUAN, S. A., where technical director FERNANDO MOLINARE discussed the workings of his company. Forestal Cholguan is 100% Chilean-owned, and its holdings comprise 60,000 hectares. Located entirely within region VIII, 65% of the company's holdings are in the area of extremely sandy soils known locally as the "arenales". The plantations provide wood to local industries, including sawmills and producers of particle board. We toured a local Cholguan sawmill that produces finger-jointed lumber and moldings free of knots. The company's annual production is about 500,000 cubic meters per year of *Pinus radiata* logs, 350,000 of which are pulp logs, and the remainder is sawlogs for export to Korea and Turkey. The company hopes to include the United States as a future importer of their logs. We also met with GEORGINA HERRERA, pest protection specialist for the company. She described local pest problems, which include the European pine shoot moth (*Rhyacionia buoliana*) and the bark beetle *Hylurgus ligniperda*. The shoot moth is beginning to be detected on their lands, and some projects are underway to examine various control strategies. Problems with *Hylurgus* have been rare, but limited tree mortality has occurred, particularly when prunings are done at an improper time of year. Management practices are such that very little slash remains after harvesting, which minimizes buildup of these beetles. Some minor disease problems have been noted with *Dothistroma* and *Sphaeropsis*. The company conducts its own detection survey through systematic ground sampling. This program has been in effect since 1984. In a visit to company lands, EDUARDO MONTERO, head of silviculture for Forestal Cholguan, demonstrated some of the intensive prunings and thinnings being carried out to produce high-quality sawlogs.

In the afternoon we travelled to Concepción and met with personnel from the company FORESTAL BÍO BÍO. We were attended by SIMON BERTI, production manager for the company. We learned that Forestal Bío Bío is owned entirely by FLETCHER CHALLENGE of New Zealand. This part of Chile is able to produce pine and eucalyptus logs 30 cm in diameter in 15 years, which makes the area particularly appealing for forest industry.

The company, consisting of forest and production areas, is supported by 51 administrators, 31 forest workers, and 20 contractors who employ about 1,200 workers. MANUEL AMIGO, head of forest protection, described the production area which consists of export sawlogs, domestic sawlogs, and pulp logs. The company owns 40,000 hectares of land, the vast majority of which are in plantations less than 15 years old. Both *Pinus radiata* and *Eucalyptus* are being planted; 82% will be managed for clear wood, and 18% for construction wood. Presently, sawlogs are being exported to Turkey and South Korea, pulp logs to Spain and France, and lumber to Argentina. Future foreign markets will include Japan, China, the Pacific Coast of the United States, and Mexico.

Nov 13 We met in the morning with RAMON VERGARA and FRANCISCO LASO of ARAUCO, a complex of companies including CONSTITUCION S. A., CELULOSA ARAUCO, and FORESTAL ARAUCO. In total, the companies own 450,000 hectares, of which 300,000 hectares are currently planted.

We visited the private PORT OF LIRQUEN, administered by JORGE BAKSAI. This is primarily a port for export of forestry products, principally pulp (80%), pulp logs, and sawlogs. Some covered storage is available, but most of the storage is in the open. We learned that logs could remain at the port for up to 3 weeks before to shipment. As of February, the newly developing facility will be able to debark and dip logs for export to highly demanding markets such as Turkey.

We also visited the HUALPEN LTDA. storage yard, which is jointly owned and operated by Forestal Cholguan and Forestal Bío Bío. We were escorted through the facility by yard manager SERGIO AGUILERA of Forestal Bío Bío. The storage yard has capacity for handling 100,000 cubic meters of wood, which represents about three shiploads. The time required to gather enough logs to load one ship is about 30 days. The companies inspect the shipments, as does SAG, either on the day before shipment, or on the day of shipment. The Hualpen yard has a debarker and the capability to treat debarked logs to prevent infection by blue stain. Export logs are debarked and treated on the same day they arrive; domestic logs are less urgent and are treated within 1 week. Treated logs are placed on other logs, which are in contact with bare ground.

Later in the day we visited the sort/storage yard used by Forestal Arauco. This yard, near the port of TALCAHUANO, is used for export material only. Each log arriving at the storage yard is marked and registered with its own computerized tag, so that logs can be sorted according to destination. The quality control has been such that very few logs have been rejected at the sort yard; occasionally some have been rejected for blue stain, but not for presence of insects.

We met with SAG official ALEJANDRO SESNIC who is in charge of all inspections done at the four ports of Talcahuano (Talcahuano and Lirquén) and SAN VICENTE (San Vicente and CAP). Talcahuano, Lirquén and San Vicente are equipped to export logs, whereas the CAP port handles only wood chips for export. Mr. Sesnic described the procedure of inspection used by SAG. The process begins with the request for inspection from the private company planning to export a wood product. SAG then goes to the sort yard or port to carry out the inspection. During the inspection, the shipment is either approved or rejected. If rejected, it could be a definitive rejection (will not be shipped) or temporary, where some mitigation measure must occur before shipment. The measure would be either spraying or fumigation, followed by another inspection to determine if the problem has been eliminated. All wood exports, including finished products, are inspected by SAG before being released for shipment. Mr. Sesnic pointed out that wood chips have been inspected, but no fungi have been found. He also mentioned that there would be great difficulty in assuring that no insects or fungi would be associated with older materials such as pulp logs. We also learned that all products coming into Chile must have a sanitary certificate and must be from areas free of the wood wasp *Sirex noctilio* and the ambrosia beetle *Platypus sulcatus*. In the afternoon, we traveled to Monterey pine plantations located near Concepción and viewed regeneration sites and thinned stands. At several different locations, we inspected stands for visible evidence of insects and diseases, but found no significant problems.

Nov 14-15 Weekend in Concepción. We visited a botanical garden in the town of Lota where many hardwood and conifer species native to North America have been planted. We observed that virtually all of these exotic species seemed to be growing well without major impacts from local insects or diseases.

Nov 16 We toured the Arauco sawmill (ASERRADERO ARAUCO) at Esquadrón, managed by RAUL AVARIA. This sawmill processes 70% of Arauco's material, which is destined for United States markets. The majority of the production is shop lumber. Since volumes are small, their production is shipped from Valparaíso or San Antonio rather than being sent from Concepción. All lumber is dried and treated with NP-1 to control blue stain; only dried lumber is shipped to the United States.

We visited the ESTACION EXPERIMENTAL ESCUADRON (experiment station) belonging to FORESTAL MININCO, one of three private forestry companies comprising the forestry sector of COMPANIA MANUFACTURERA DE PAPELES y CARTONES (CMPC). We met with LUIS DE FERARI, head of forest pest protection for the CMPC companies, and CLAUDIO GOYCOOLEA, in charge of forest protection for Forestal Mininco. Mr. De Ferari described the organization of CMPC, which has four pulp mills on the industrial side and three forestry companies that provide the raw materials for the industrial sector. Within the forestry sector, the experiment station conducts tree improvement in its genetics program and handles seedling production. Part of the facility at Escuadrón includes a seed orchard. In 1991, 1,500 kg of seed were harvested at the seed orchard, and 35 million seedlings were produced in the adjacent nursery. The company currently has 390,000 hectares, of which 225,000 are planted in Monterey pine and 19,000 in eucalyptus. Of the surface area dedicated to pine, 34% is managed intensively with pruning and thinning, 18% with just thinning, and 48% has no management. About 62% of the production is pulp logs, 22% is sawlogs and 10% is fuelwood. Korea and Turkey are currently major recipients of the company's exports.

Since 1989, each of the three forestry companies within CMPC has had its own forest pest protection program, and Mr. De Ferrari oversees all three. Each has a systematic survey conducted each year to monitor the general condition of the plantations. In addition, there are undirected surveys that serve as a "random" check for pests within high-risk areas not covered by the systematic survey. The companies have an intensive training program for their woods workers to develop awareness of potential pest problems.

Forest protection specialist, MIGUEL POBLETE, described the forest protection program for BOSQUES ARAUCO, which manages 120,000 hectares of pine plantations. The pest protection program also involves a systematic survey, carried out in all plantations less than 13 years old. His company also spends considerable time in training of woods workers in the recognition of pest problems. The company is beginning to utilize aircraft in detection surveys; the company's entire 130,000 hectares can be surveyed in 2-1/2 hours. Specific pest problems of concern have been dothistroma needle blight, which was treated with a copper compound, and the European pine shoot moth, *Rhyacionia buoliana*, which is just entering their holdings and is being surveyed with pheromone traps. We visited a harvest site (clearcut with high-lead yarding) and a series of *P. radiata* growth and yield plots maintained by Forestal Arauco.

We visited the sawmill (ASERRADERO COLORADO), owned and operated by ROBERTO BRAVO. This is the most modern sawmill in Chile, equipped with German and U. S. machinery. The sawmill has been in operation for two years, is contracted by Arauco, and employs 120 people from the local community of Curanilahue.

Nov 17 With Luís De Ferari and JORGE URRUTIA from Forestal Mininco, we toured some of CMPC holdings near Angol. We visited a young pine plantation where workers were being trained to use New Zealand pruning shears, which will eventually replace handsaws as the desired pruning tool for producing high-quality sawlogs. The shear enables an individual worker to prune 220 trees per day, about three times the production with saws.

We also saw a test site where Marshall Suscon controlled-release insecticidal pellets are being tested as a control for the European pine shoot moth in young pine plantations. Later we visited an installation of bait trees for early detection of *Sirex noctilio*, located near the Arauco pulp mill.

Nov 18 We met with SAG officials of region IX in Temuco: LUIS PALMA, regional director; HECTOR ESPINOSA, who directs the national project for control of the European pine shoot moth since its discovery in Chile; and JAIME LUNA, SAG entomologist. Mr. Espinosa described the shoot moth project in detail and how the agency dealt with the problem from its discovery until 1991 when the project terminated.

The European pine shoot moth was first discovered near Ensenada in region X in 1985, but the presence of older damage indicated that the pest had become established 5 to 7 years before that time. An extensive survey was done in cooperation with CONAF, and another infestation center was found near Pucón considerably further to the north. In 1985, the total area where shoot moth was believed to be established was around 1,000,000 hectares, so eradication was considered impossible. Foreign experts were brought in to help assess the situation. Fernando Robredo from Spain recommended a chemical control to slow the spread of the shoot moth to the north. In 1986 the agency treated 15,500 hectares with a combination of dimilin and Sevin-4-oil. In 1986, Dr. Dieter Schroeder, an expert in biological control from Switzerland came to Chile and recommended that the Chileans initiate a biological control program using the larval parasite *Orgilus obscurator*. An agreement was drawn up between SAG and INIA wherein the latter agency would develop a facility to mass-produce the parasitic wasps to be used against the shoot moth in the biological control program.

Meanwhile, for the next 4 years, SAG continued with the chemical spray program, now concentrated against infestation centers and applied at the head of the infestation as it advanced to the north. In 1990-91 the chemical control program was discontinued and efforts were concentrated entirely on biological control. The production facility for INIA, located at the ESTACION

EXPERIMENTAL REMEHUE in Osorno, produced its first wasps for release in 1988. In that year, 144 wasps were released in three areas where shoot moth populations were high (Cascadas, La Union, Huequecura). In 1989, 466 additional wasps were released, and another technique was employed as well; 5,000 parasitized shoot moth larvae were implanted into pine shoots in the field. At this time, the private sector is involved in the production of the parasitic wasps. Four additional facilities will be constructed for the mass production of *Orgilus* wasps.

In the afternoon we visited Pucón near Lago Villarrica, one of the two sites where the European pine shoot moth first became established in Chile. It was interesting to note that in spite of the very harsh sites (soils of coarse volcanic deposits) and longevity of exposure to the insect (at least 12 years), there were many trees that suffered little impact from shoot moth infestation.

Nov 19 We visited the Southern University of Chile (UNIVERSIDAD AUSTRAL DE CHILE) in Valdivia where we met with pathologists Dr. HERNAN PEREDO and MOISES OSORIO, and with entomologists DOLLY LANFRANCO and ANGELICA AGUILAR. We discussed the pest problems associated with the native forests, in particular, with coigüe (*Nothofagus dombeyi*) and tepa (*Laurelia philippiana*), since there is interest in exporting these two species to the United States. The general feeling among the insect and disease specialists at the University was that there was extremely little written information available on these pests. Tepa has an interesting but little known problem. In some logs, a stain develops in the heartwood and produces an outline in cross-section which resembles a butterfly; accordingly, the problem is commonly referred to as "la mancha mariposa" (butterfly stain). There is a very strong and offensive odor associated with this problem that has caused some of the wood to be rejected in the marketplace. We discussed other pests associated with various *Nothofagus* and *Laurelia* species. In many cases, the knowledge does not go far beyond the level of "association" and the biology has not been studied for many of the organisms. We were told that the wood products market drives the research, and because there has been little interest in harvesting anything but the most sound trees from the native forest, there has been very little support for research on pests of native tree species.

In the afternoon we met with GABRIEL COGOLLOR, professor of entomology at the UNIVERSITY OF CHILE (Santiago) and contractor for the private research company BIOFOREST, LTDA. We visited the biological station LOS CASTANOS where work is underway to test the efficacy of the shoot moth biological control agent, *Orgilus obscurator*. In the field, we were able to observe the implanting of parasitized shoot moth larvae, which is part of Professor Cogollor's study. We also met with SUSANA OJEDA at the biological station. She is in charge of experiments to mass produce the egg parasite *Trichogramma* as another biological control agent to be used against the shoot moth.

Nov 20 We visited a Finnish-owned company called BOMASA (BOSQUES Y MADERA, S. A.) and toured their veneer mill in Malalhue. They primarily process coigüe, which represents 75% of their veneer production, and tepa. About half of their veneer production is exported, mostly to European countries. The mill has been in operation for 2-1/2 years, and is one of five mills in Chile producing veneer from native hardwoods. The company owns about 55,000 acres of native forest land, of which 22,000 are commercially productive. They maintain a nursery and reforest cutover lands with raulí. We observed evidence of some insects associated with the coigüe logs, including the cambium miner (larva of the moth *Notiopostega atrata*) and an ambrosia beetle, possibly of the genus *Gnathotrupes*. We learned that logs may remain in the sort yard for several months prior to processing. No logs are exported by this company, and those not suitable for veneer are sawn into lumber. The native hardwood veneer often forms the core of plywood containing either eucalyptus or a durable phenolic paper on the exterior.

In the afternoon we visited another mill belonging to BOMASA near the town of Neltume. We were accompanied by ROBERTO PEREZ, a forester for BOMASA, and were shown the NELTUME CARRANCO sawmill operation. This sawmill processes native hardwood logs exclusively.

Nov 23 We visited the private company INFODEMA/INFOREST in Valdivia and toured a veneer mill with its production manager, ANDRES BOSCH. The mill processes various species of native hardwoods, including coigüe, tepa, roble, raulí, ulmo, mañío, and olivillo. Eucalyptus also is used but primarily as exterior facing. We discussed some of the pest problems associated with these species. Blue stain is a problem for both tepa and olivillo, and the mill uses sprinklers in the sort yard to limit the establishment of the fungus. Tepa also has the "butterfly stain" associated with about 20% of the logs. Mr. Bosch pointed out that defects in coigüe are extremely difficult to identify in standing trees. Heart rot and damage from a cerambycid wood borer are two of the primary problems associated with coigüe. Heart rot also is a problem with ulmo, particularly with larger diameter logs.

We visited the company EMASIL in Valdivia and toured its mill with CLAUDIO CHANDIA and EDMUNDO CORNUY. The mill processes native hardwoods, primarily tepa (70%) and roble (30%). Primary pest problems associated with their hardwoods include blue stain and the "butterfly stain" in tepa, and wood borers in young stands of roble. The company owns 30,000 hectares of native forest land and plans to grow several native species in the future on a 35-year rotation.

We travelled to the town of Entre Lagos near Puyehue and visited a mill belonging to the company PEXMASA. TOMAS MONFIL described the workings of the mill. Primary species processed at the mill include the native hardwoods mañío and tepa. Some wood has been shipped by this company to the United States, primarily as dried squares. Mr. Monfil felt that there would be limited capability on the part of most Chilean companies to ship large quantities of raw native hardwood logs to the United States. He did feel, however, that the Swiss-owned company in Neltume might be able to gather sufficient quantities for significant export.

Nov 24 In Puerto Montt, we met with SAG officials EDUARDO GODOY, head of agriculture protection for region X, RAUL DE LA JARA, head of the Valdivia sector, and RENE ARAYA, head of the Puerto Montt sector. They described the recent history of wood products exports from the southerly ports of Puerto Montt and Calbuco as well as the role of SAG in the inspection of these exports. If export wood has galleries it is fumigated; if it has superficial insects, it is sprayed, and if it has stain, it is rejected. We then visited the port facility at Puerto Montt and observed the loading of a ship with 35,000 tons of native hardwood chips destined for Japan.

A final stop for the field trip portion of the visit was at a chipping facility co-shared by the companies FORESTAL OSORNO and FORESTAL PUERTO MONTT. We learned that there is relatively little quality control for native logs to be chipped. Material may sit in the sort yard for over a year before being processed, and may become highly deteriorated before being chipped. We examined several logs with insect galleries and extensive decay which were to be chipped.

Nov 25-26 We spent two days in Valdivia preparing for a final meeting with SAG and Chilean forest companies, before to returning to Santiago.

Nov. 27 The assessment team returned to Santiago.

Nov 30 The final meeting was held with officials from SAG and private forestry companies. The Spanish-speaking members of our team presented a review of our findings during the trip and discussed the pest risk assessment process and our role within that process.

Dec 1 The assessment team returned to the United States.

Appendix F
Summary of Reviewers' Comments and Team's Responses

Appendix F: Summary of Reviewers' Comments and Team's Responses

Introduction

A draft of the Chile Pest Risk Assessment was provided to each of 40 reviewers in the United States, Canada, and Chile (see pages i-v for their names and addresses). Individual reviewers were selected on the basis of their knowledge of forestry and forest pests in Chile, their interest and participation in previous pest risk assessments for imported logs (USDA Forest Service 1991, 1992), or their expertise in specific taxonomic groups of pest organisms. All reviewers offered their services voluntarily and received no financial compensation.

Certain reviewers were chosen by professional/industrial organizations having a special interest in log importation and/or potential impact of pests. A list of these organizations and the individuals they chose to serve as reviewers follows:

Society of American Foresters (Fields Cobb, David Wood)

American Phytopathological Society (Lewis Roth, Charles Shaw III)

Society of Nematologists (David Dwinell, Robert Hackney)

American Forest and Paper Association (John Mentis, Scott Berg)

American Plywood Association (Steve Zylkowski)

Servicio Agrícola y Ganadero (Marcos Beéche, Luis Cerda, Roxanna Vallejos)

Corporación National Forestal (Patricio Ojeda, Aida Baldini)

Forest industries in Chile (Mario Ramírez, Ramón Vergara, Rafael Campino)

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:

> "I find your Chilean Pest Risk Assessment to be outstandingly fine. I don't know how it might have been done better. You were particularly fortunate in having a strong corps of Spanish-speaking specialists working on the project. The on-site visits seemed invaluable. I'm impressed that so many contacts with such a broad range of knowledgeable and skilled Chileans, and the resulting over-lapping and counter-checking, generated more and better information than ever could have been obtained from the literature and usual sources." (Roth)

> "The authors that prepared this document did a commendable job. I cannot think of any potential pests that were omitted. The literature review was well done and no pertinent references were overlooked that I am aware of. I therefore have no major criticisms of the document, and have no significant additions or corrections." (Bright)

> "You and your team are to be commended for a thorough, concise, and well written risk assessment. Not only does it serve as an excellent risk assessment, it is equally valuable as a reference document for anyone interested in Chilean forestry and the associated pest interactions." (Holsten)

> "I enjoyed reading the fine pest risk assessment report that you and your team prepared. It was professionally done, succinct, and easy to read." (Gara)

> "I...was impressed with the accomplishments of the team, and the high quality of the document." "This document will be a valuable reference for years not only for us here in the United States, but for the Chileans as well as others who import/export wood products." (Ollieu)

> "... your team did a very thorough job at gathering and interpreting the scattered information on insects and diseases." "I also found appropriate the method used in the evaluation." (Alfaro)

> "My conclusion is that your team has done an outstanding job at bringing together what is known about the Chilean forest insects and evaluating the risk of their establishment in the United States." (Foltz)

> "Overall, I find the assessment well-written and well-researched. I do have reservations about the [risk assessment] process and a number of conclusions drawn in the report, ranging from mild to very strong." (Cobb)

"The report should provide a good basis for developing protocols for importing logs." "I agree with the contents of the report and the judgements of the team." (Kanaskie)

"In general, I believe the risk assessment team has produced a very good report." (D. Wood)

"I recommend against publishing the Chilean log assessment until the nematology component can be revised." (Hackney)

"This is a useful document providing reviews of the insects and diseases covered." "The present document provides references on each species discussed and generally made relevant literature available. There were some major omissions however, especially references providing adequate background on the comparisons between Chile and western North America." (Lattin)

Major Issues of Reviewers

Other comments from reviewers not pertaining to specific pests were condensed into ten 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 the Chile Pest Risk Assessment Team.

Issue 1: Inadequacy of the pest risk assessment process

What they said: 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 Chile.

"The risk assessment approach used...has some major weaknesses, the chief one being multiplication of the first four elements and then the addition of the last three. The last three elements are most difficult to document, and if rated low, pull down the product of the first four that really deal with the heart of the analysis presented here. The evaluation should deal with the first four elements where the expertise of the committee rests..." (Lattin)

"By excluding from the IPRA process many potential insect and disease pests 'because insufficient information is available on their biology' clearly underlines my strongest objection to this process of risk assessment. A process that excludes dangerous pests that could cause losses potentially measurable in billions or trillions of dollars (e.g., chestnut blight) because of lack of information is flawed beyond reason." (Cobb)

Response to comments: The risk assessment process used by the pest risk team was derived from the National Research Council's section on Ecological Risk Assessment as published in their 1993 "Issues in Risk Management" and represents the state of the art as it now stands for conducting ecological risk assessments.

APHIS and the USDA Forest Service recognize that the process is not perfect and that 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 assessment can provide.

Confusion among some reviewers originated from the use of mathematical symbols in the pest risk assessment model (figure 3-1, page 20). These symbols have been removed from the final draft because they represented an incorrect, overly simplistic, view of how the process is done.

Another area of concern was the inherent difficulty in determining the impact of an introduced pest. This led one reviewer to recommend that the pest risk team concentrate its expertise to the first four elements and minimize the last three elements in the pest risk model that dealt with consequences. It is granted that the last three elements are judgmental, but we believe that they are a necessary component for a risk evaluation because risk is defined as a balance of likelihood and consequences. Also we agree with a number of reviewers that the seven elements in the pest risk model are not always equal and they should not be (and were not) evaluated as such.

The assessment process serves as a guide to help scientists place biological and economic information into a format that can be understood and used by policy makers. We understand that the assessment process is intended to be used as a guide and not as an absolute step-by-step set of instructions. We believe that such fluidity is necessary if scientists are to effectively communicate the dynamics of pest risk to the policy makers in APHIS.

Issue 2: Unknown/sleeper pests

What they said: One of the most frequently voiced concerns among reviewers dealt with organisms that are not recognized as pests in their country of origin (in some cases due to a lack of information), but may reach pest status when introduced into a new environment.

> "History has taught us that it is impossible to predict accurately which organisms could become pests." (Hilburn, Griesbach, Johnson, Wright)

> "The recent introduction of poplar rusts to the Pacific Northwest points out the risk associated with introduced pathogens and the difficulty of limiting their spread once introduced. Many previous introductions of plant pathogens (not necessarily forest pathogens) were unexpected. Any mitigation measures adopted should address the

unknown or unexpected pest introduction. If the risk assessment is to provide a basis for mitigation measures and import policy, then it should contain an assessment or discussion of unidentified or unknown potential pests." (Kanaskie)

"When you consider that many of our most serious pests are not pests in their country of origin, nor were they even thought they might become pests, one questions the predictive capabilities, as did Simberloff." (Lattin)

"We also recognized [in the Siberian Pest Risk Assessment] that it is quite possible that an insignificant or undiscovered organism can have disastrous consequences once it is introduced into a new environment..." (Tkacz)

"...it is <u>not</u> reasonable to limit the assessment to organisms that are known to be associated with the trees. As for potential pathogens, I would estimate that for <u>each</u> one known, there are more than ten unknowns." (Cobb)

"It's the unknowns, not the knowns, that particularly challenge us here, the "hitch-hikers." (Roth)

"Any risk assessment which fails to consider the potential risk of importing a hitherto unknown pathogen is fatally flawed." (Denison)

<u>Response to comments:</u> One of the main functions of a risk assessment is to address uncertainty. Indeed, if uncertainty did not exist there would not be a need for a risk assessment. From the APHIS standpoint, in order to regulate a commodity, a pest risk must be demonstrated. 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 has to show an "absolute" demonstrable pest risk in order to meet the legal requirements of placing a regulation into law.

The USDA Forest Service's pest risk team and APHIS recognize that organisms that demonstrate a high degree of biological uncertainty do represent a real risk. This need to balance "demonstrated risks" against "biological uncertainty" is and will continue to be a difficult issue to address.

One of the main responsibilities of the pest risk team is to communicate the degree of biological uncertainty that exists on the Chilean log issue to the APHIS mitigation committee. However, it will be the responsibility of the APHIS mitigation committee, alone, to weigh the degree of uncertainty along with the known risks in developing mitigation measures.

Issue 3: Unknown virulence of pathogens

<u>What they said</u>: Several reviewers commented that the individual pest risk assessments for certain pathogens (*Sphaeropsis, Ophiostoma/Ceratocystis, Dothistroma*) should include more consideration to unknown virulence or to an assumed existence of different strains. In contrast, Chilean specialists believe the strains of pathogens in Chile are the same as those already present in the United States, and present no additional risk.

> "The document notes, but perhaps should emphasize even more, the taxonomic uncertainty of some of the organisms (*Sphaeropsis, Leptographium*) involved. In the absence of more definitive information, it would seem prudent to assume what exists... is different from what is now here in the U. S." (Shaw)

> "Importation of potential tree-killers in the genus *Ophiostoma* (which includes the causal agents of oak wilt and Dutch elm disease) is of major concern. The two species of *Ophiostoma* analyzed are known to attack a wide range of hardwood trees in addition to conifers. Since these pathogens are moved both by insect and human activity, eventual introduction and establishment are a virtual certainty if Chilean log shipments are allowed. Should this happen, we could only hope these isolates would prove to be benign." (Hilburn, Johnson, Griesbach, Wright)

> "The introduction of *Lophodermium* into other areas of the Northern Hemisphere has caused problems, as has *Dothistroma*. Since I totally reject your assumption that any introduction would not be a new fungus strain or race, I cannot accept your conclusion of a low damage potential. As you pointed out earlier, there are three recognized varieties of *D. pini*, only one of which has been reported on the West Coast." (Cobb)

(See also reviewer comments at end of IPRA's for pathogens of pine, coigüe, and tepa).

<u>Response to comments:</u> The individual pest risk assessments for fungi of pine, coigüe, and tepa discuss the possibility of more virulent strains in Chile. The possible existence of virulent strains and lack of specific studies, especially with the native hardwoods, 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. Accordingly, the pest risks for certain fungi (*Ophiostoma, Sphaeropsis*) were developed with and without consideration being given to more virulent strains.

Issue 4: Paucity of biological information

What they said: Many reviewers commented on the recognized scarcity of biological information on known insects and diseases in Chile, particularly those associated with native hardwoods, and cautioned against assuming that little information equated to low risk.

> "Why...haven't you raised the point much more strongly in a statement about the devastating inadequacy of the information available and the approach that is being used to make the assessment?" (Cobb)

> "This comment might seem repetitious, i.e., that knowledge essential to a proper assessment using the guidelines as presented is clearly not available. However, I am compelled to insert it each time that a situation arises that illustrates this potentially fatal flaw." (Cobb)

> "The repeated statement about 'the paucity of biological information available on most insects and fungi' is unsettling." (Lattin)

> "One aspect of the risk assessment process that should be discussed in greater detail is how the team dealt with the lack of data or uncertainty about specific organisms or groups of organisms." (Tkacz)

> "Serious, long-range efforts to investigate the neotropical insect fauna must be made as it becomes increasingly important area in the world economy. At present, we honestly do not know enough to answer the questions that are being and should be asked." (S. Wood)

Response to comments: The risk of importing a damaging plant pest (for which little information is known) is probably small for any specific organism but the risk becomes much higher when you consider large numbers of unknown or little known organisms. Demonstrating that a commodity has a "heavy" concentration of foreign plant pests for which little information exists has at times convinced APHIS to apply additional regulations on a commodity. A good example of this is the present prohibition of raw logs from temperate Asia due to the large number of unknowns as revealed in the Siberian log risk assessment.

The Chile Pest Risk Assessment Team has been advised by APHIS 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. One of the reasons for this is that 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 (e.g., hitchhikers, bark inhabitants, wood dwellers, etc.).

Issue 5: Risks do not apply to the entire United States or Canada

__What they said:__ There was concern that the risk assessments were made solely on the basis that log entry would occur within the Pacific Northwest of the United States and that pest threats to the adjacent and contiguous forests of California, British Columbia, Alaska, or elsewhere in North America were not considered. An additional point was made that conclusions about pest risk should not be made solely on the basis of climatic similarities between Chile and the Pacific Northwest west of the Cascade Mountains.

> "The statement is made that this report concentrates on western United States but can be applied to all of the U.S.--not really, because the forestry practices and the environmental conditions in other parts of the U. S. are far different than in the West and no comparison is offered between Chile and other parts of the country." (Lattin)
>
> "I would increase the risk a bit to timber resources of southeast Alaska due to similarities between the Chilean and SE Alaska temperate rain forests." (Holsten)
>
> "If logs are to be imported into California, some statement about the coast range and Sierra Nevada forest composition and value should be given." (D. Wood)
>
> "...the forests of western Canada are contiguous with those of the United States, are composed of the same species, have climates similar to those of a) Oregon and Washington and b) southern Chile and...are a natural pathway for pests to reach the forests of northeastern U. S." (Raske)
>
> "...assumptions of low risk based on climate comparisons are inappropriate and certainly should not be in such an assessment as this where the values we are trying to protect are immense." (Cobb)

__Response to comments:__ This pest risk assessment does presume that log entry will occur in the Pacific Northwest, but the analysis of individual pests did not envision that the logs or their associated organisms would be confined to the west side of the Cascades, or to Oregon and Washington. In dealing with pests of Monterey pine, we assumed that some pines would be in the vicinity of the port of entry, and in the case of hardwood pests, we assumed that ornamental and native trees near the port of entry could serve as potential hosts. In this sense, we feel that there may be some applicability of our risk assessment to other parts of the country even though we did not directly consider those areas.

Our judgments about climatic similarities between Chile and the Pacific Coast of the United States (from Alaska to southern California) led us to believe that organisms from Chile would find the climatic conditions along the Pacific Coast of the United States to be equally favorable to conditions in their natural range. In contrast, climatic dissimilarities along the Gulf Coast and eastern shores of Canada, for example, could present major barriers to establishment of insects and fungi introduced from Chile. Thus, risk ratings developed for the Pacific Coast should be equal to or greater than for areas having dissimilar climates. Nevertheless, mitigation measures developed by APHIS for the Pacific Coast will be required throughout the United States, regardless of reduced risks due to possible climatic barriers in other regions.

Issue 6: Wood chips and other native hardwoods as imports

What they said: Several reviewers questioned why the pest risk assessment did not include consideration of pests associated with wood chips, or with other native Chilean tree species, that may be imported into the United States.

> "Why wasn't part of your mandate the question of possible risk of importing pests on chips?" (Gara)
>
> "The chipping process may eliminate some of the insect pests, but it will not mitigate the pathogens or the nematodes." (Cobb)
>
> "Chips from typically mixed native species would also be very difficult to develop mitigation procedures for." (Burger)
>
> "We know very little about potential pest movement via chips." (Lattin)
>
> "Why didn't you analyze lenga, *Nothofagus pumilio*?" (Gara)

Response to comments: Consideration of pests associated with wood chips or with native Chilean hardwoods other than *Nothofagus dombeyi* and *Laurelia philippiana* was beyond the scope of the risk assessment. The risk assessment team was requested by APHIS to prepare a document that focused on the importation of *Pinus radiata*, *N. dombeyi,* and *L. philippiana* logs from Chile. The risk assessment deals only with unprocessed logs of these three species because these are the species most likely to be imported into the United States from Chile. In fact, several shipments of these species have already entered the United States on a trial basis (see appendices C-4, C-5, and C-6 for lists of organisms found on these early shipments).

With regard to chips, the risk assessment team visited several chipping facilities in Chile and noted little quality control of chips, particularly from native logs. Logs of various native hardwoods with extensive decay, mycelial mats, rhizomorphs, and numerous insect galleries were observed being chipped. The team agrees that one or more potential pests certainly will be associated with imported untreated wood chips. APHIS will need to recognize this risk when mitigation measures are developed.

Issue 7: Other types of potential pests not directly associated with logs (hitchhikers)

<u>**What they said:**</u> Concern was expressed about log shipments being the vehicle for potential entry of other noxious pests, in addition to forest insects and diseases.

> "While this report focused upon forest related problems, there is virtually no mention of other attendant problems associated with the importation of raw logs from Chile. There is little discussion of the opportunities for passive transport of other types of organisms, especially those of an agricultural nature." (Lattin)

> "With the assumption of no mitigation, how can you exclude organisms that might simply hitchhike on the surface of the logs? Without mitigation to exclude those, how can you limit your assessment to organisms on three genera of trees? It is not an acceptable approach." (Cobb)

> "The risk is not 'zero' in the absence of log-imports. I do not know how this should be addressed in the analysis but it is worthy of a footnote." (Shaw)

<u>**Response to comments:**</u> The pest risk assessment was focused, as requested by APHIS, on those pests directly associated with logs. The possible occurrence of other non-indigenous plant pests that are not normally associated with logs, but might travel with the logs into the United States, is recognized. The issue of hitchhiking (non-timber) pests on logs coming from Chile 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 non-indigenous organisms that are not considered as potentially damaging to agricultural resources (e. g., most predators and saprophytes) are presently outside of the legal authority of APHIS to regulate.

Issue 8: Greater concern about pests associated with native hardwoods

<u>**What was said:**</u> Special concern was expressed by several reviewers about the lack of information available on insects and diseases that might be associated with the native hardwoods, coigüe and tepa. Due to the greater uncertainty, several reviewers recommended more stringent regulations for the importation of native hardwood logs than for those of *Pinus radiata*.

> "...even more stringent mitigation measures are needed if we are to import logs of species that are indigenous to Chile." "...our knowledge of the occurrence and biology of microbes and arthropods on such material is extremely limited. For example, I would be considerably more concerned with the potential of an exotic *Armillaria* entering the U. S. on a beech log than a pine log." (Shaw)

> "Regarding [coigüe and tepa], there seems to be inadequate research and information available on which to recommend anything less than a ban or the most stringent mitigation procedures." "With regards to coigüe, the frequent referrals to 'paucity' of available information and the fact that numerous insects and diseases are found in this indigenous species would tend to make me consider coigüe in a similar category as Siberian larch." (Burger)
>
> "I have greater concerns about the possible importation of *Laurelia* and *Nothofagus*, genera native to Chile." "South America is now the most poorly known major area of the world for the [Scolytidae and Platypodidae]. I seriously doubt that 50 percent of the neotropical species are named." "Before the exportation [of] *Nothofagus* begins, serious efforts to study the insect pests of that host genus should be made." (S. Wood)

Response to comments: The team generally concurs with the comments of the reviewers concerning increased risks associated with the importation of native Chilean hardwoods into the United States. To document the difference in levels of knowledge about the organisms associated with the native hardwood species versus those associated with Monterey pine, we tallied the numbers of organisms that were classified as "3a" (considered a potential pest due to habits, abundance and/or wide host range in Chile, but insufficient information is available on biology to prepare an IPRA). There are 36 potential pests on coigüe and tepa with too little information available to prepare an IPRA while only 8 are listed in this category for *Pinus radiata*. Undoubtedly, there are many additional potential pests which remain to be identified and studied in detail, particularly in the native forests in Chile.

In addition to the uncertainties associated with the lack of information on potential pests, the native hardwoods may pose a greater risk than pine for several other reasons, including: (1) native hardwoods are likely to have a greater diversity of organisms associated with them since the indigenous organisms have co-evolved with these trees; (2) many of the native forests have been high-graded, leaving poor quality, overmature specimens, some of which may have defects and potential pests associated with them; (3) there may be less quality control for the hardwoods because they have grown in native forests without significant investments in regeneration, management, and pest control; and (4) the extended time between harvest of the hardwoods in remote areas and shipping from distant ports would increase the probability for contamination by potential pests.

Issue 9: Chile prohibits log imports, so why doesn't the United States?

What they said: Several reviewers commented on the fact that, for many years, Chile has prohibited the importation of logs or wood products containing bark and believe that the United States should do likewise.

> "The most damning part of this entire document is the fact that [the Chileans] will not themselves accept raw logs. Why then should we do so?" (Lattin)

"If Chile prohibits the import of logs, why would we be so ill-informed to allow import of logs into the U. S. from Chile or anywhere else? It just doesn't make sense to me." (Cobb)

"Chile prohibits the import of logs for the same reason the U. S. should! In spite of this prohibition, several insect pests have been introduced. The message is clear, at least to the scientific community." (D. Wood)

"We find it ironic that, to protect their forest, Chile prohibits importation of logs and very carefully regulates crating and dunnage, yet the U. S. is considering allowing log imports which could endanger our much larger forest resources. Especially sobering [are the lists of] insects recently introduced to Chilean forests in spite of their vigilance." (Hilburn, Griesbach, Johnson, Wright)

Response to comments: The responsibility of the Pest Risk Assessment Team was to address what the pest risk would be if logs were imported from Chile. The responsibility of whether logs should or should not be imported falls within the purview of the Animal and Plant Health Inspection Service (APHIS) and, therefore, was not addressed in the assessment.

It is important to understand that the request for importation of logs has been made by U.S. citizens and firms who have a legal right to request consideration for such importations. It is also important to understand that APHIS will develop its regulations based on the pest risk potential and without regard to Chile's log import regulations.

Issue 10: Mitigation measures are needed

What they said: Several reviewers recommended that mitigation measures of some form be placed on Chilean logs, either directly upon arrival, or immediately afterwards in order to avoid the possibility of pest establishment. Concerns about pest introductions apply not only to the port of entry, but also to sites far removed from the port of entry, where logs could be transported for subsequent processing. Some of these concerns involve the unknown or unexpected organisms, the low efficacy of debarking and/or fumigation as preventive measures, and specific concerns about ambrosia beetles and termites being introduced in wood. Some reviewers from the forest products industry expressed concern and frustration that the extent of mitigation remains an unknown. Others identified measures that would be taken by their company to process logs in a timely manner as a means to reduce pest introductions.

"We believe comprehensive log import regulations covering logs of all tree species from all sources need to be implemented to provide a sound basis for Oregon's timber industry to import exotic logs while protecting Oregon's forests, agriculture, and ornamental plantings from exotic pests. Potential insect and disease pests can be expected to occur from the bark to the inner wood in logs from all sources..." (Hilburn, Griesbach, Johnson, Wright)

"I wish to reiterate my support for the pasteurization treatment of unprocessed logs... Even with this treatment we know that it will not be 100% effective in preventing entry of pestiferous fungi and insects into North American forests via unprocessed logs." (D. Wood)

"...the report...is certainly supportive of my position of requiring mitigation measures for *Pinus radiata* logs entering the United States from Chile...*Hylurgus ligniperda* alone is ample justification for requiring such mitigation measures." "[Logs] should be processed at a mill very close to the port of entry--not one several hundred miles away. (Shaw)

"Without mitigation, any organism in the forests from which the logs come may survive transit on or in these logs and be introduced into North America." (Cobb)

"Just exactly who will address the question of proper and adequate protocol to guarantee pest-free logs?" (Lattin)

"Most of our members [American Forest and Paper Association] expressed frustration that the assessment seems incomplete without mitigation discussion...who will determine whether any mitigation measures are necessary? Will the mitigation...be regional or national in application...?" (Mentis, Berg)

"I strongly urge...careful inspection for pests...before shipment. There is probably enough evidence for mitigation procedures also to prevent introductions." (Solomon)

"There are various phases of plywood production which expose the wood to elevated temperatures and will cause mortality to the various pests under consideration." (Zylkowski)

"I believe that effective mitigation measures can and will be developed, at least for [Monterey pine], by the USDA teams but that in-country monitoring for compliance by USDA officials should be far more aggressive..." (Burger)

Response to Comments: The Pest Risk Assessment Team was specifically charged with identifying potential pests and estimating the risk to resources in the United States associated with the importation of Monterey pine, coigüe and tepa from Chile in the absence of any mitigating procedures which might eventually be imposed. Therefore, the mitigating procedures suggested by the reviewers and summarized above are beyond the scope and responsibility of this pest risk assessment. (Many of the reviewers recognized that mitigation was not within our charge, but still made these comments as a point of emphasis). With this pest risk assessment as a foundation, APHIS will assemble a group of experts to determine which specific mitigating procedures are needed to prevent unreasonable risk to the resources in the United States associated with the import of logs from Chile. We have passed on copies of all reviewer comments to APHIS for their consideration in this process. Finally, the mitigation measures APHIS imposes will pertain to all regions, regardless of where the logs enter the United States.