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Department of
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**Forest
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Executive Summary

Function of the pest risk assessment

United States companies propose to import *Pinus radiata* (known as radiata or Monterey pine) and Douglas-fir logs from New Zealand. Because the U.S. Department of Agriculture has no specific timber import regulations, the Animal and Plant Health Inspection Service (APHIS) asked the Forest Service to prepare a risk assessment that identifies potential pests, estimates the probability of their establishment, and estimates their consequences. The Pest Risk Assessment Team chose to concentrate on the risk to the resources of the Western United States because of the value of these resources and because of proposed shipments to Western ports. However, the analysis and conclusions are applicable to the entire United States.

The pest risk assessment team

Forest pest specialists provided technical expertise from the disciplines of forestry, entomology, pathology, and economics. The team was also assisted by representatives from APHIS and several New Zealand forestry organizations. In addition, a request to review the draft of this document was sent to over 80 people and more than 30 responses to the request were received and considered. In March 1992, members of the assessment team traveled to New Zealand. They examined insect and disease records provided by New Zealand agencies, toured logging areas and ports, inspected current industry mitigation procedures, and viewed pest problems in the forests.

Analysis

The team members screened the 30-year computerized list of insects and diseases reported for *Pinus radiata* and Douglas-fir in New Zealand. A screening procedure was developed to focus on species that represented those groups of organisms identified as having the greatest risk. From this process, the team members identified seven organisms to analyze in detail: *Kalotermes brouni, Leptographium truncatum, Platypus apicalis, Platypus gracilis, Prionoplus reticularis,* and the *Sirex noctilio/Amylostereum areolatum* complex. All pest analyses were approached from the assumption that proposed New Zealand industry mitigation procedures would be implemented before importation of logs would be allowed.

Conclusions and recommendations

Of the seven pests analyzed in detail using the risk assessment process, the estimated risks are as follows: low for *Kalotermes brouni* and the two *Platypus* species, moderate for *Leptographium truncatum* and *Prionoplus reticularis*, and moderate to high for the *Sirex noctilio/Amylostereum areolatum* complex.

Although the occurrence of *Sirex* in plantation forests of New Zealand is low, the potential for entry, colonization, and spread is high. Environmentally, *Sirex* and its associated fungus could reduce the genetic base of *Pinus radiata* and increase populations of other destructive pests, like bark beetles. Overstocked pine plantations and unhealthy forest stands would be particularly susceptible. Because *S. noctilio/A. areolatum* and *Prionoplus reticularis* may be found deep in the wood, currently proposed New Zealand industry mitigation measures need to be examined by APHIS to determine whether these measures will adequately mitigate the pest risk.

The Pest Risk Assessment Team recommends that APHIS consider the following points in thedevelopment of any additional protocols for log importation from New Zealand: time and place of fumigation, need for and efficacy of heat treatment, New Zealand Ministry of Forestry and APHIS inspection protocols, log handling at U.S. ports, log storage time and place in the United States, milling practices and APHIS monitoring at mills, and waste disposal.

New Zealand mitigation procedures currently proposed by industry include rapid processing from felling to shipping; debarking; fungicide and insecticide treatment; visual examination; and fumigation. This pest risk assessment assumed continuation of these procedures, and therefore the assessment is less valid if these procedures are discontinued.

Chapter 1. Introduction

Statement of purpose

This risk assessment estimates the probability of introduction and establishment of exotic insects and pathogens associated with the importation of *Pinus radiata* D. Don (Monterey or radiata pine) and *Pseudotsuga menziesii* (Mirb.) Franco (Douglas-fir) logs from New Zealand into the Western United States. This assessment also attempts to estimate the impact of these organisms if introduced into the Western United States.

The purpose of this risk assessment is to

- Identify exotic insect and disease organisms that may be introduced with imported logs from New Zealand.

- Assess the potential of introduction and establishment by introduced organisms.

- Assess the potential impacts of the organisms if they should become established.

This risk assessment is based upon the implementation of mitigation practices as proposed by New Zealand Ministry of Forestry and as described in chapter 3.

Background

The U.S. 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. APHIS also has the responsibility 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.

APHIS requested the USDA Forest Service to prepare a pest risk assessment relative to importation of *Pinus radiata* and *Pseudotsuga menziesii* logs from New Zealand. Responding to this request, the Forest Service formed a pest risk assessment team to assess the risks posed by exotic pests that might be introduced from New Zealand. The Pest Risk Assessment Team produced this report, which looks at the significance of such exotic pest introductions.

As of this writing, the USDA has no specific timber import regulations and no permits are required for importation. To date, only small volumes of logs have been imported from New Zealand. These shipments were inspected at the port-of-entry and, if pests were found, mitigating measures were applied before the logs were released. However, U.S. timber companies are now proposing to import larger quantities of New Zealand 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. Three separate log shipments have been imported into the United States from New Zealand. Detailed descriptions of two of these shipments are presented in appendix C. The first shipment was not treated with methyl bromide (the proposed New Zealand fumigation treatment) and the second shipment was treated with methyl bromide before it left New Zealand.

First shipment: no methyl bromide treatment. The Motor Vessel (M.V.) *Washington Star* arrived in Seattle, WA, in December 1991 and discharged one package of *Pinus radiata* logs. The ship then traveled to San Francisco, CA, and discharged the remaining logs by December 30, 1991. All of the logs had been machine debarked, inspected for injurious pests, sprayed with fungicide and insecticide, and washed free of soil in New Zealand. This shipment was not fumigated. Upon arrival in Seattle, the logs were inspected by APHIS personnel, who found a live scolytid larva, probably *Hylurgus ligniperda,* under a patch of bark. They also sampled decayed wood and isolated an unidentified basidiomycete. This basidiomycete has still not been identified, but comparisons with known isolates of *Armillaria limonea, A. novae-zelandiae, Amylostereum areolatum, A. sacratum*, and *Ganoderma mastoporum* did not show compatibility. Logs in San Francisco were inspected by APHIS and California Department of Food and Agriculture personnel. More than 10 live scolytid larvae, probably *H. ligniperda* or *Hylastes ater,* were found. Isolations from wood samples identified *Sphaeropsis sapinea (=Diplodia pinea), Ophiostoma pilifera, O. picea, and Leptographium procerum*, as well as a number of typical aerial contaminants (*Trichoderma, Penicillium*). These logs were fumigated at the port of entry in January 1992 and released in June 1992.

Second shipment: methyl bromide treatment. The second shipment of *P. radiata* logs arrived in Sacramento, CA, on M.V. *Balayan* on January 28, 1992. Several mitigation practices had been applied in New Zealand. The logs had been visually inspected four times for pests. Logs with fluted ends were removed. The export logs were machine debarked, hand cleaned of bark patches, sprayed with fungicide and insecticide, and fumigated in the ship's hold with methyl bromide at 80 g/m^3 for 24 hours at 18 °C. The logs were examined upon arrival by the California Department of Food and Agriculture (CDFA). Samples were removed from stained areas and isolations performed. *Sphaeropsis sapinea* was recovered. No other pest organisms were identified on this shipment. The logs were released on March 3, 1992, and were processed at mills in Marysville, Oroville, and Eureka, CA, and monitored by CDFA and California Department of Forestry and Fire Protection (CDF) personnel at the sawmill. Examination of the sawn logs found only blue-stained wood, caused by *S. sapinea.* No other damage was noted (see CDF memos, appendix C).

Characteristics of proposed importation

The New Zealand government and private companies are interested in exporting logs as part of the general trade policy of New Zealand. Wood and wood products capture a significant share of New Zealand's volume of export trade. The supply of growing stock on plantation forests is increasing and will continue to increase over the next 15 years. While local consumption will rise slightly, New Zealand expects international exports of wood and wood products to increase sixfold over the next 25 years. New Zealand industry experts expect the export of logs to the United States may reach 17 million cubic feet a year and remain at that rate through the turn of the century (Tasman Forestry, Ltd., undated; W. McCallum personal communication) (appendix E).

New Zealand grows quality timber by selectively pruning and thinning plantation forests to ensure clear (knot free), maximum-diameter growth. The pruned butt logs yield 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, *P. radiata* has only a small difference between the densities of early and late wood rings. Thus, quickly grown *P. radiata* with its wide rings has the same characteristics as slowly grown wood. This even texture means that *P. radiata* 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.

Douglas-fir grown in New Zealand offers the same product features as second-rotation logs grown in the United States, even though grown in plantations under shorter rotation regimes. The principle use is as framing timber because of its structural strength.

Resources at risk

The forests of the Western United States are part of a broad band of vegetation that extends around the Northern Hemisphere in the mid to upper latitudes. These forests have enormous economic, esthetic, recreational, wildlife, and watershed value, not only to the region, but far beyond its borders. The coast ranges and the west slopes of the Cascade Range have some of the highest quality stands of large sawtimber in the world. The east slopes of the Cascades and the lower slopes and benches of the interior mountains are covered by open pine forests and juniper. White fir and Douglas-fir associations and mixed conifer (pine, fir, cedar, Douglas-fir, and 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 are listed below.

Common names	**Scientific names**
Douglas-fir	*Pseudotsuga menziesii*
western redcedar	*Thuja plicata*
western hemlock	*Tsuga heterophylla*
Sitka spruce	*Picea sitchensis*
sugar pine	*Pinus lambertiana*
ponderosa pine	*P. ponderosa*
western white pine	*P. monticola*
noble fir	*Abies procera*
Pacific silver fir	*A. amabilis*
grand fir	*A. grandis*
white fir	*A. concolor*
incense-cedar	*Libocedrus decurrens*
Port-Orford-cedar	*Chamaecyparis lawsoniana*
western larch	*Larix occidentalis*
coast redwood	*Sequoia sempervirens*

Timber resources of Alaska and the Eastern United States will probably not be at immediate risk from pests that may be imported from New Zealand. The Pest Risk Assessment Team has chosen to concentrate on the forest resources of the Western United States because of the value of these resources and because of proposed shipments to Western ports. However, the analysis and conclusions are applicable to the entire United States.

Biological considerations

New Zealand forests. New Zealand has a total land area of 65 million acres; of these, 18 million acres (27.6%) are forested, 15 million acres are in indigenous natural forest and 3 million acres are under commercial forest plantations. A large proportion of the forest species are endemic to New Zealand and belong to genera from the Araucariaceae (e.g., *Agathis*), Podocarpaceae (e.g., *Podocarpus, Dacrydium*) and Fagaceae (e.g., *Nothofagus*). The indigenous forests are generally not available for commercial timber production.

Plantation forestry in New Zealand dates back to the beginning of the present century when it was decided that plantations should be established to provide a sustainable source of wood to replace the dwindling supply from the indigenous forests. In a search for suitable plantation species, a large number of exotic softwood and hardwood species, mainly from the Northern Hemisphere, were planted in various parts of the country. Species belonging to *Abies, Acacia, Castanea, Chamaecyparis, Cupressus, Eucalyptus, Larix, Picea, Pinus, Populus, Quercus, Sequoia, Thuja,* and *Tsuga* were included in these trial plantations. Based on these trials, *Pinus radiata* was chosen as a major plantation species; however, planting of other species continued on a much smaller scale. Exotic forest trees of New Zealand, based on Weston (1957), are listed in appendix G. Trees belonging to these species have grown in New Zealand for at least 50 years. The present species composition of the commercial forest plantation estate is *Pinus radiata* (89%), Douglas-fir (5%), other softwoods (4%), and hardwoods (3%) (New Zealand Ministry of Forestry 1991a). In addition, many exotic softwood and hardwood species are extensively planted as ornamentals.

Pest and disease organisms in New Zealand forest plantations. The organisms that cause damage to New Zealand's commercial plantations can be divided into three groups for the purposes of this report:

1. Organisms endemic to New Zealand, normally living on indigenous hosts but capable of attacking introduced tree species (e.g., *Armillaria* spp., *Pseudocoremia suavis*)

2. Organisms introduced into New Zealand from locations other than the United States that are not present in the United States (e.g., *Sirex noctilio*)

3. Organisms introduced into New Zealand that occur in the United States on hosts indigenous to the United States (e.g., *Dothistroma pini*).

   (Note: Organisms placed in groups 2 and 3 were determined as having been introduced because they are found on exotic hosts only and not on indigenous species.)

Organisms in groups 1 and 2 are considered most likely to be injurious if introduced into the United States. The possibility that organisms in group 3 may be genetically different from those of the same species in the United States has been raised, but very little information is available on the subject. New Zealand forest pathologists contend that New Zealand populations of species in this group are most likely to be small samples from the much larger and more variable United States populations of the organisms.

All New Zealand plantations are inspected (and have been since 1956) by Forest Health Officers of the Ministry of Forestry for signs of ill health. Every plantation is inspected from the air at least once a year and a ground inspection is also carried out. The work of the Forest Health Officers is supported by forest pathologists and entomologists at the New Zealand Forest Research Institute. Significant mortality in the past has been related to overstocking, poor management activities, and adverse environmental conditions. Most of the plantations are now being managed intensively to meet market demands and are in a healthy condition. The major disease of concern, Dothistroma needle blight (*Dothistroma pini*), is managed through a combination of aerial fungicidal spraying and silvicultural measures.

Climate in New Zealand. The main islands of New Zealand extend for about 1,000 miles, from approximately 34°S to 47°S latitude. Over this length, the climate varies from subtropical to cool temperate. There is sufficient and generally well-developed rainfall throughout the year. The eastern parts of both islands are usually drier than the western parts, but the contrast is more marked in the South Island. In the North Island, the average rainfall is 52 inches; In the South Island, the rainfall exceeds 100 inches annually west of the dividing range and varies from 25 inches in the north to 45 inches in the south on the eastern side of the range. Mean temperatures and annual mean rainfalls for selected towns near forested areas are given below:

		Mean daily temperature (°F)		
Locality	Latitude	Max.	Min.	Annual rainfall (in inches)
North Island				
Kaitaia	35°S	69.3	51.2	50.2
Auckland	37.5°S	64.8	53.1	49.8
Rotorua	38°S	64.9	45.3	55.2
Napier	39.5°S	64.4	48.8	32.2
Wanganui	40°S	63.3	49.1	36.1
Wellington	41.5°S	59.8	48.3	42.9
South Island				
Blenheim	41.5°S	65.4	44.4	24.6
Hokitika	43°S	59.7	45.5	114.3
Christchurch	44°S	60.8	44.1	25.5
Dunedin	46°S	58.9	44.0	36.9
Invercargill	47°S	58.4	41.9	45.2

Similarities with the Western United States. The following list shows many of the tree species of the Western United States that grow as exotics in New Zealand.

Common names	**Scientific names**
white fir	*Abies concolor*
grand fir	*A. grandis*
noble fir	*A. procera*
Port-Orford cedar	*Chamaecyparis lawsoniana*
Monterey cypress	*Cupressus macrocarpa*
western larch	*Larix occidentalis*
Engelmann spruce	*Picea engelmannii*
Sitka spruce	*P. sitchensis*
knobcone pine	*Pinus attenuata*
lodgepole pine	*P. contorta*
Jeffrey pine	*P. jeffreyi*
sugar pine	*P. lambertiana*
western white pine	*P. monticola*
bishop pine	*P. muricata*
ponderosa pine	*P. ponderosa*
Monterrey pine	*P. radiata*
black cottonwood	*Populus trichocarpa*
Douglas-fir	*Pseudotsuga menziesii*
redwood	*Sequoia sempervirens*
giant sequoia	*Sequoiadendron giganteum*
western redcedar	*Thuja plicata*
western hemlock	*Tsuga heterophylla*

All of these species have been exposed for many years to the pests and pathogens present in New Zealand under climatic conditions very similar to the coastal and lower elevation west-side conditions in the Pacific Northwest. The behavior of pests and pathogens in New Zealand should therefore provide a guide to their behavior in these areas. Further inland and south in the Western United States, conditions are warmer and drier, and it is difficult to predict the pests' behavior under these conditions.

Chapter 2. Assessment of Organisms Posing Risk

Introduction

To assess the scope and magnitude of any potential risk and its impact, an understanding of the problem of pest introduction and establishment is critical. The probability of pest introduction is determined by several related factors: 1) the likelihood of a pest traveling with and surviving on a shipment from the place of origin, 2) the likelihood of colonizing suitable hosts at the point of entry, and 3) the likelihood of subsequently spreading to adjacent territories. The probability of introduction and establishment of exotic pests depends, in large part, on the quantity and quality of logs imported and the efficacy of mitigation measures.

Many insects and pathogens could be introduced on logs into the Western United States from New Zealand. However, because it was not practical to analyze all of them in detail, some form of selection was inevitable. Selection was based on the likelihood of the pest being on or in logs, the possibility of them escaping prescribed mitigation measures, and their potential high risk to Western U.S. resources.

The Pest Risk Assessment Team was responsible for compiling and assessing pertinent data. The following discussion summarizes the analysis process used by the team. This process was developed using the recommended methodology prepared by APHIS and presented in the Siberian larch importation evaluation (USDA Forest Service 1991).

Analysis process

Information was collected about the logs that were to be imported. This included species, origin, quantity, harvesting and shipping practices, destinations, and information on potential pests that may be associated with these logs.

From the literature and from information provided by the New Zealand Forest Research Institute from its forest health databases, lists were compiled of insects and microorganisms that have been recorded from *Pinus radiata* and Douglas-fir in New Zealand (appendix A, tables A1, A2, A3). These organisms were categorized using the characteristics shown in table 2-1. Organisms in categories 1 and 2 were considered further. Some organisms in category 3 were also considered further when there were questions about strains not native to the United States.

In appendix B the pest risk assessment forms give a brief outline of the pests that were screened as potential problems. This was included to show that pests, other than the seven analyzed in detail, were considered. The form does not follow the APHIS risk assessment process as does the form for pests that were analyzed in the body of the text. Therefore, the appendix forms were added for the convenience of the reader and to document the pests that were considered in the screening process.

The insect list presented in tables A2 and A3 notes all of the recorded insect recoveries from *P. radiata* and Douglas-fir. This list was screened for insects that are found in the bark, cambium, or wood (table 2-2). It includes 16 insect species, 5 of which are analyzed in detail; 11 of the insect species from table 2-2 were eliminated from detailed analysis for the following reasons:

- Mitigation measures, including fumigation, would eliminate the bark and cambium insects, and insects that bore a short distance into the wood.

- The insects attack branches, which would be removed in the logging process.

- Their life history is such that they only attack deadwood or wood products after processing.

- The insect is already found in the United States.

The objective was to examine in detail insects found deep in the wood that may pose a chance of escaping mitigation measures.

Microorganisms that are or could be pathogens in U.S. hosts were evaluated (table 2-3). Questions about pathogenic fungi not found in the Western United States or about strains not native to the United States were assessed using the Pest Risk Assessment Form (figure 2-1) to determine overall risk (appendix B). The team identified two fungi *(Amylostereum areolatum* and *Leptographium truncatum)* to analyze in detail in the individual organism assessment section of this chapter.

Review

The draft report was reviewed by an appropriate group of scientists and specialists from universities, and Federal and State agencies (appendix I). These reviewers had the opportunity to comment on all aspects of the report (appendix J).

The following pests are analyzed in this chapter.

Kalotermes brouni
Leptographium truncatum
Platypus apicalis and Platypus gracilis
Prionoplus reticularis
Sirex noctilio/Amylostereum areolatum

Table 2-1. *Categories of pests*

Category	Pest characteristics	Place on list
1	Organisms endemic to New Zealand, normally living on indigenous hosts, but capable of attacking introduced tree species (e.g., *Armillaria* spp., *Pseudocoremia suavis*).	Yes
2	Organisms introduced into New Zealand from locations other than the United States that are not present in the United States (e.g., *Sirex noctilio*)	Yes
3	Organisms introduced into New Zealand that occur in the United States on hosts indigenous to the United States (e.g., *Dothistroma pini*)	No

Table 2-2. *Summary of Possible Quarantine Insects Associated with Imported Logs from New Zealand*

Species	NZ Host		Other Hosts	Location		Category[1]	Estimated risk without mitigation[2]
	PR	DF		Cambium and bark	Wood		
Cerambycidae							
Arhopalus tristis	*		Norway spruce	*	*	2	M
Prionoplus reticularis	*	*	softwood		*	1	M
Stenopotes pallidus	*	*	softwoods	*		1	L
Navomorpha lineata	*	*	wide range		* branches	1	L
Hexatricha pulverulenta	*	*	softwoods/hardwoods	*		1	M
Platypodidae							
Platypus gracilis	*	*	softwoods/hardwoods		*	1	M
Platypus apicalis	*	*	hardwoods/softwoods		*	1	M
Curculionidae							
Mitrastethus baridioides	*		*Pinus* spp.		*	1	L
Psepholax spp.	*	*	softwoods		*	1	L
Torostoma apicale	*	*	wide range of hosts		*	1	L
Kalotermitidae							
Kalotermes brouni	*		softwoods/hardwoods		*	1	M
Termopsidae							
Stolotermes ruficeps, etc.	*	*	many hosts		* branch stub	1	L
Scolytidae							
Hylastes ater	*	*	*Pinus, Larix, Picea*	*		2	H
Hylurgus ligniperda	*	*	*Pinus*	*		2	H
Pachycotes peregrinus	*		softwoods		*	1	M
Siricidae							
Sirex noctilio	*		*Pinus* spp.		*	2	H

1 see Table 2-1 in chapter 2 for a description of categories
2 H = high, M = moderate, L = low

Table 2-3. *Summary of Possible Quarantine Microorganisms Associated with Imported Logs from New Zealand*

Species	NZ host		Location					Found in U.S.	Category[1]	Estimated risk without mitigation[2]
	PR	DF	Foliage	Branches	Bark	Sapwood	Heartwood			
Amylostereum areolatum	*					*	*		2	H
Armillaria limonea	*	*				*	*		1	M
Armillaria novae-zelandiae	*	*				*	*		1	M
Biatorella resinae	*	*						*	3	L
Ceratocystis novae-zelandiae	*	*				*			1	L
Cyclaneusma minus	*		*					*	3	L
Dasyscypha caliciformis	*			*	*	*		*	3	L
Diplodia pinea	*	*	*	*	*	*		*	3	M
Dothistroma pini	*		*					*[3]	3	L
Fusarium moniliforme var. *subglutinans*	*			*	*	*		*	3	L
Ganoderma applanatum	*					*	*	*	3	L
Ganoderma mastoporum	*					*	*		1	L
Ischnoderma rosulata	*					*	*		1	L
Junghuhnia vincta	*					*	*	*	3	L
Leptographium procerum	*					*		*	3	L
Leptographium truncatum	*	*				*		*[3]	2	M
Lophodermium pinastri	*		*					*	3	L
Melampsora larici-populina	*		*					*	3[4]	M
Nectria cinnabarina	*			*	*	*		*	3	L
Ophiostoma huntii	*					*		*	3	L
Ophiostoma ips	*					*		*	3	L
Ophiostoma piceae	*	*				*		*	3	L
Ophiostoma pilifera	*					*	*	*	3	L
Peniophora sacrata	*	*							1	L
Phaeocryptopus gaumannii		*	*					*	3	L
Phomopsis pseudotsugae	*	*		*	*	*		*	3	L
Pseudomonas sp.	*			*				*	3	L
Rhizosphaera kalkhoffi		*						*	3	L
Sclerophoma pithyophila	*	*						*	3	L
Stereum sanguinolentum	*	*				*		*	3	L

1 See Table 2-1 in chapter 2 for a description of categories
2 H = high, M = moderate, L = low
3 Questions about genetic variability or taxonomic identification
4 Recently discovered in Washington

Figure 2-1. *Pest Risk Assessment Form*

Scientific name of host(s): ....

Distribution: ....

Summary of natural history and basic biology of the pest:

....

....

....

....

Specific information relating to risk elements:

A. Probability of pest establishment..

1. **Pest with host at origin:** ....
2. **Entry potential:** ....
3. **Colonization potential:** ....
4. **Spread potential:** ....
   ....
5. **Control options:** ....
   ....
   ....

B. Consequences of establishment..

6. **Economic damage potential:** ....
   ....
7. **Environmental damage potential:** ....
8. **Perceived damage**
   (Social and political influences): ....

Estimated risk for pest: ....

Additional remarks: ....

Selected bibliography:

Summary of specific pest risk assessments

Each pest was evaluated to determine its risk to U.S. forest resources (figure 2-1). The assessments incorporate the risk elements discussed below. The probability of establishment is a function of the likelihood of the pest being in or on the logs, their potential for entry into U.S. ports, their potential for transmission and survival on U.S. hosts, and their potential for spread. Any of these potentials can be modified by mitigation measures. The consequence of establishment is the sum of monetary and non-monetary economic and environmental damage, plus other political or social influences.

Risk elements are underscored in the following list. The goal statements below each risk element asking for actual probability or impact are not attainable. Their function is to direct the known pest information into the risk assessment process. The estimated risk for a pest is an overall assessment based on known biological and technical information for each organism.

A. Probability of pest establishment

1. Pest with host at origin - risk potential

    - Determine probability of pest being on, with, or in the imported plant commodity at the time of exportation.
    - Determine if the pest shows a convincing temporal and spatial association with the imported commodity?

2. Entry potential - risk potential

    - Determine probability of pest surviving in transit.
    - Determine probability of pest being detected at port of entry under present quarantine procedures.

Examine the following characteristics: the pest's hitchhiking ability in commerce, ability to survive during transit, stage of life cycle during transit, and number of pest individuals expected on the imported commodity.

3. Colonization potential - risk potential

    - Determine probability of pest coming in contact with an adequate food resource.
    - Determine probability of the pest coming in contact with appreciable environmental resistance.
    - Determine probability of pest to reproduce in the new environment.

Characteristics of this element include: the pest coming in contact with an adequate food resource, encountering appreciable environmental resistance, and ability to reproduce in the new environment.

4. Spread potential - risk potential

- Determine the probability of a pest spreading beyond the colonized area.
- Estimate the range of probable spread.

Characteristics of this element include: ability for natural dispersal, ability to use human activity for dispersal, ability to readily develop races or strains, and the estimated range of probable spread.

B. Consequences of establishment

5. Economic damage potential - risk potential

- Determine economic impact if pest becomes established, including the cost of living with the pest.

Characteristics of this element include: economic importance of hosts, crop loss, effects to subsidiary industries, exports, control costs, and efficacy.

6. Environmental damage potential - risk potential

- Determine environmental impacts if pest becomes established.

Characteristics of this element include: ecosystem destabilization, reduction in biodiversity, reduction or elimination of keystone species, reduction or elimination of endangered or threatened species, and effects of control measures.

7. Perceived damage (social and political influences) - risk potential

- Determine impacts from social and/or political influences. Quality and amount of uncertainty should also be addressed.

Characteristics of this element include: esthetic damage, consumer concerns, and political repercussions.

Estimated risk for pest

The overall risk for each of the pests was estimated based on the assessment and the implementation of required mitigation measures. The level of risk also incorporated the perceived consequences of the establishment of each organism in the United States. These are qualitative and subjective estimates based on the best information available. The seven risk values were combined into a final pest risk potential, which represents the overall risk of the pest (Orr and Cohen 1991).

Risk assessments of specific organisms

Scientific name of pest: *Kalotermes brouni* Froggatt (Kalotermitidae)

Other name: New Zealand drywood termite

Scientific name of host(s): Hardwoods and softwoods

Distribution: New Zealand

Summary of natural history and basic biology of the pest: Nests of this drywood termite are found in dead, but sound wood (Milligan 1984). Dead trees and logs can be suitable for nest establishment. Nests have also been recorded in living *Pinus radiata* heartwood (Zondag 1959). These pests can use dry, suppressed or broken branches that have been previously infested by longhorn beetles to gain entry into the tree. The success of drywood termites in living trees depends on dead branch stubs remaining so dry that they are not rapidly broken down by rot fungi. In conifers, resin reactions of living sapwood can effectively deter this termite. The adults swarm in late summer or autumn and the span of the various life stages is unknown. The development of a new colony is a slow process, however. When colonies are found, they are normally in the heartwood of old trees. The practices of pruning branches at 5 to 7 years of age and the extensive use of young *P. radiata* trees (28 to 32 years of age) for logs would make this termite an unlikely pest.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Low***
   The termites are rarely found in plantation-grown *Pinus radiata*. The galleries are loosely packed with frass so that the required methyl bromide treatment in New Zealand would effectively control any colonies.

2. **Entry potential:** ***Moderate***
   The insects are located deep in the wood, so visual inspection would fail to detect infested logs.

3. **Colonization potential:** ***Low***
   The beginning of a colony is a slow process, but dead trees or logs may be available for infestation near ports or mills. The adults fly only for several hundred feet, so the spread is slow when compared to other insects.

4. **Spread potential:** ***Moderate***
   Termites, including drywood termites, spread slowly (50 to 1,000 feet per year) because they are poor flyers and only about 1 percent of those that fly eventually establish a new colony. People would spread them more rapidly by physically moving infested wood.

B. Consequences of establishment

5. **Economic damage potential: *Low***
This termite will attack untreated wood. The damage can be serious if conditions are damp, with poor ventilation or water leaks, and even the presence of small nests can cause structural weakness. The damage is difficult to detect and could go undetected for long periods of time. In personal communication, Peter Gadgil (Leader of the Forest Health Unit at the Forest Research Institute, Rotorua, NZ), states that "even in this country of wooden houses, such reports of infestations by drywood termites are rare." Termite damage in New Zealand often is associated with house borer beetles. If this termite became established in the United States, estimated losses would be from $75,000 to $500,000 per year (see chapter 5, Evaluation of Economic Effects). If introduced into the United States, this termite would be added to the 43 species already found here.

6. **Environmental damage potential: *Low***
K. brouni would not cause large outbreaks or kill trees. It would compete with native pests that degrade and decompose.

7. **Perceived damage (social and political influences): *Low***
This pest would not cause aesthetic damage in the forest. Damage to wood in use could cause consumer concerns, adding to concerns about other termite species. Controls for termites are available but can be expensive.

Estimated risk for pest: *Low*

Selected bibliography:

Bain, J; Jenkin, M.J., 1983. *Kalotermes banksiae, Glyptotermes brevicornis* and other termites (Isoptera) in New Zealand. New Zealand Entomologist 7: 365-71.

Kelsey, J.M., 1944. The identification of termites in New Zealand. New Zealand Journal of Science and Technology 25B: 231-60.

Kelsey, J.M., 1946. Insects attacking milled timber, poles and posts in New Zealand. New Zealand Journal of Science and Technology 28B: 65-100.

Milligan, R.H. 1984. New Zealand drywood termite. New Zealand Forest Service Forestry Research Institute Forest Pest Leaflet 59.

Zondag, R., 1959. Attack by *Calotermes brouni* Frogg. on living *Pinus radiata*. New Zealand Entomologist 2: 15-17.

Scientific name of pest: *Leptographium truncatum* (Wingf. & Marasas) Wingf.

Scientific name of host(s): *Pinus radiata, P. strobus, P. taeda*

Distribution: New Zealand, South Africa, Canada

Summary of natural history and basic biology of the pest: *Leptographium truncatum* is a reported pathogen of *Pinus radiata* and *P. strobus* in New Zealand (Wingfield and Marasas 1983). Inoculation tests and observations indicate that it is not highly pathogenic and may be opportunistic (Wingfield *et al.* 1988). This fungus has not been reported in the United States, but it has been reported on roots of dying red pine *(P. resinosa)* in Ontario, Canada (Harrington 1988). Recent information strongly suggests that this fungus is conspecific with *L. lundbergii* Lagerb. and Melin (Wingfield and Gibbs 1991). These authors suggest that *L. lundbergii* occurs throughout the boreal region and may be present in the United States.

This fungus is probably vectored by insects in the family Scolytidae. It has been isolated from *Hylastes ater* and *Hylurgus ligniperda* (Wingfield *et al.* 1988). These insects primarily attack injured or stressed trees.

Leptographium truncatum has been found infrequently on *P. radiata*, primarily along roadsides and on moist sites (Wingfield *et al.* 1988). This fungus differs from *L. wageneri*, which causes black stain root disease in the United States, by invading both tracheids and rays. It did not cause seedling mortality in inoculation studies.

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

1. **Pest with host at origin:** ***Low***
   Leptographium truncatum has been infrequently identified on stressed and weakened trees of *Pinus radiata* and eastern white pine (*P. strobus*) in New Zealand. *Leptographium lundbergii* is a common blue-stain fungus found in *Pinus* and *Picea* (Harrington 1988). Vectors have not been clearly identified, but these fungi are usually carried by bark beetles and possibly other insects found in beetle galleries (Harrington 1988). *Leptographium truncatum* has been isolated from *Hylastes ater* and *Hylurgus ligniperda* in New Zealand (Wingfield *et al.* 1988).

   There are no known effective control methods for this fungus in logs. The T312 fumigation schedule (USDA APHIS 1991) may be effective because these fungi are somewhat related to the oak wilt fungus, *Ceratocystis fagacearum* (Bretz) Hunt. Effectiveness of this treatment against *L. truncatum* should be evaluated, however. Complete bark removal would reduce the risk of transport of likely vectors, thereby reducing the opportunity for spread upon arrival in the United States. The lack of bark would also reduce the probability of potential native insect vectors attacking the logs and transmitting the fungus.

2. **Entry potential:** ***High***
   Entry potential is high. This group of fungi survives well in logs (more than a year with favorable temperatures and moisture regimes). It would be favored by the conditions expected to prevail during transport of the logs. Bark removal would not prevent survival in transit, and, in fact, mitigation would require a type of treatment that would kill hyphae occupying the entire sapwood cylinder of the logs. 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:** ***Moderate***
The probability of coming into contact with a North American host is high. The proximity of *Pinus radiata* to West Coast ports makes contact likely if vectors are present. The comparable climates of New Zealand and the Western United States, suggest that environmental conditions would be conducive to colonization by the fungus. Similar species of *Leptographium* present in the United States suggest that some of their vectors could function to transport *L. truncatum*. These potential vectors native to the United States could be more efficient at spreading the fungus.
4. **Spread potential:** ***High***
If established, this fungus has great potential to spread. 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 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. Also, spread of the fungus and associated insects can be increased substantially by human transport of harvested logs and firewood.

B. Consequences of establishment

5. **Economic damage potential:** ***Moderate***
Introduction of *Leptographium truncatum* might expose *P. radiata* to a new root disease in the United States. This would cause increased tree mortality in the native stands, ornamental plantings, and Christmas tree plantations. Most damage would be to weakened or damaged trees. It is possible that scolytids native to the United States could function as vectors if the New Zealand vectors are not transported. Other western pine hosts are not known, but are likely. Introduction to these other possible hosts could result in increased tree mortality in commercial forests. Loblolly pine *(Pinus taeda)* and eastern white pine *(P. strobus)* have been identified as hosts of *L. truncatum*. Exposure of these species in the Eastern United States could result in increased tree mortality in commercial forests and Christmas tree plantations. Mortality of ornamental plantings would require tree removals and the associated costs in an urban environment. The greatest loss would be in the native stands of *P. radiata*.

6. **Environmental damage potential:** ***Moderate***
Environmental damage associated with the introduction of *Leptographium truncatum* would depend on the number of new hosts that occur. The effect on the native *Pinus radiata* stands could be dramatic. Loss of cover could result in species shifts in the remaining acres of *P. radiata*.

7. **Perceived damage (social and political influences):** ***High***
Increased mortality in the native *Pinus radiata* stands would have highly significant social and political impacts because of the large population centers associated with these areas, the high environmental regard for them, and their limited distribution. Losses of even small amounts of this limited resource would probably be considered intolerable with the resulting political implications. Damage

by *Leptographium truncatum* appears to be associated with stress situations which includes offsite plantings.

Estimated risk for pest: ***Moderate***

Additional remarks: The lack of documented effective mitigation measures suggests that *Leptographium truncatum* would eventually enter the United States. Subsequent colonization is probable. Damage caused by colonization of *L. truncatum* is unknown. The taxonomy of this group of fungi is sufficiently uncertain that an evaluation of the relationship between New Zealand's *L. truncatum* and *L. lundbergii* should be done. The pathogenicity of *L. truncatum* on other *Pinus* species that are probable hosts should be evaluated to estimate the damage that might be expected.

Selected bibliography:

Harrington, T.C. 1988. *Leptographium* species, their distributions, hosts, and insect vectors. In: Cobb, F.W. Jr., Harrington, T.C. eds. Leptographium root diseases of conifers. St. Paul, MN: American Phytopathological Society Press: 1-40.

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Wingfield, M.J., and Gibbs, J.N. 1991. *Leptographium* and *Graphium* species associated with pine-infesting bark beetles in England. Mycology Research 95: 1257-1260.

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Wingfield, M.J.; Capretti, P.; MacKenzie, M. 1988. *Leptographium* spp. as root pathogens of conifers, an international perspective. In: Cobb, F.W., Harrington, T.C., Jr., eds. *Leptographium* root diseases of conifers. St. Paul, MN: American Phytopathological Society Press. p.113-128.

Scientific name of pests: *Platypus apicalis* White and *Platypus gracilis* Broun (Platypodidae)

Other name: Native pinhole borers

Scientific name of host(s): A wide range of hardwoods and softwoods, including *Pinus radiata* and *Pseudotsuga menziesii*. Attack on living *Nothofagus* can kill the trees.

Distribution: New Zealand

Summary of natural history and basic biology of the pests: These two beetles are mainly pests of native beeches (*Nothofagus*) in New Zealand (Milligan 1972, 1979). The damage, as their common names suggests, causes pinholes throughout the log. Apparently, they can complete a life cycle in felled *Pinus radiata* and Douglas-fir as well as stumps, logs, and branches in a moist environment. The beetles also attack rapidly growing eucalypts, but do not breed in them.

The beetles emerge during the warmer months, although some may emerge on warm winter days. The beetles are attracted to dying or freshly felled trees, an aggregating male attractant, and an attractant given off by rapidly growing eucalypts. Most of the early attacks are abortive, but a pathogenic fungus may survive in the process. *Sporothrix* sp., a blue stain fungus, has been isolated from beech trees that were infested by these beetles in New Zealand. The beetles' life cycle is 2 to 4 years.

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

1. **Pest with host at origin: *Low***
These beetles occur on *Pinus radiata* and Douglas-fir.

In an efficacy review of the control measures for potential pests of imported Soviet timber (USDA APHIS 1991), shot-hole borers (Platypodidae) were effectively eliminated from the logs treated with methyl bromide. These beetles keep their galleries relatively free of boring dust so methyl bromide could penetrate the log to kill them. The proposed mitigating dosage is higher when used in New Zealand than the dose reported in the reference cited above.

2. **Entry potential: *High***
The life cycle of these pinhole borers is2 years. All of the life stages could be present during shipment and they would have a good chance of surviving shipment. The attacks tend to be concentrated, so an infested log would have a high number of individuals.

3. **Colonization potential: *High***
If these pests escape methyl bromide fumigation, the colonization potential would be high. This is based upon the wide range of hosts the beetles attack, the availability of the hosts at the port of entry, and the strong flight characteristics of the beetles. They would have a higher potential of establishment in moist climates along the coasts of northern California, Oregon, and Washington.

4. **Spread potential: *High***
These beetles are good flyers, and they could spread 5 miles per year. In addition, they can be spread by the transport of infested logs and other dead wood materials. Because of the high number of host species, the beetles would probably find a suitable host within their flight capabilities, and their estimated spread potential is therefore high.

B. Consequences of establishment

5. **Economic damage potential: *Low***
These pests cause damage by the pinhole fungus-stained galleries they create. Attacks that are aborted also mar the wood, which decreases product value. In pulpwood, it would increase the pulping costs because of the gum pockets. In the economic analysis in this report, the estimated range of losses (present net value) would be from about $3 million to $119 million over 30 years. This value was calculated assuming no competition from other pinhole borers. In reality, the beetles will compete with other species, so the estimated loss will be lower than the calculated figure.

6. **Environmental damage potential: *Low***
These pests are mainly wood degraders that attack felled trees and logs. Because they are not known as tree killers, except of native beeches in New Zealand (*Nothofagus* spp.), they probably would not cause any environmental damage besides degrading wood products. The damage is estimated to be low.

7. **Perceived damage (social and political influences): *Low***
Because these pests degrade wood products, damage is not obvious to the public in a forest situation. The products with damage could be culled or marketed as unique products. For these reasons the perceived damage is estimated to be low.

Estimated risk for pest: ***Low.*** The risk for these pests is low because of the high effectiveness of methyl bromide against Platypodidae, the estimated low economic and environmental damage potential, and the estimated low perceived damage by the public.

Selected bibliography:

Coates, D., 1972. Defects in living silver beech caused by *Platypus and Psepholax*. New Zealand Forest Service Forest Research Institute Forest Entomology Report No. 32 (unpublished). Wellington, NZ.

Faulds, W., 1973. Discolouration associated with *Platypus* wounds in living *Nothofagus fusca*. New Zealand Journal of Forestry Science 3: 331-41.

Holloway, W.A., 1973. A study of *Platypus caviceps* in felled hard beech. New Zealand Forest Service Forest Research Institute Forest Entomology Report No. 39 (unpublished). Wellington, NZ.

Kershaw, D.J., 1969. The incidence of *Platypus* species in living silver beech at Rowallan Forest, Southland. New Zealand Forest Service Forest Research Institute Forest Entomology Report No. 24 (unpublished). Wellington, NZ.

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U.S. Department of Agriculture, Animal and Plant Health Inspection Service. 1991. An efficacy review of control measures for potential pests of imported soviet timber. Misc. Pub. No. 1496. Washington, D.C. 28 p.

Scientific name of pest: *Prionoplus reticularis* White (Cerambycidae)

Other name: Huhu beetle

Scientific name of host(s): *Pinus radiata, Pseudotsuga menziesii*, and other softwoods. Also occasionally attacks hardwood logs and stumps, e.g., *Eucalyptus* and *Acacia.*

Distribution: New Zealand

Summary of natural history and basic biology of the pest: Hosking (1978) has a good summary of this insect's activity in New Zealand. Edwards (1961) also has observations on the beetle's ecology and behavior. The following descriptions are adapted from these two publications.

The huhu beetle infests logs, stumps, dead parts of living trees, and green or kiln-dried lumber. In visiting a port site in New Zealand, huhu damage was evident on a small number of logs. Damage is normally associated with a log scar at the butt end of the log. These logs can normally be culled out for local use at the port site. This beetle occasionally attacks dead parts of living trees that could be anywhere on the bole. It would not be possible to detect some of these infestations by viewing the outside log surface.

The beetles fly from late spring to early autumn in New Zealand. The females are strong fliers and are attracted to light. They can, therefore, be attracted to logs stored at the port and lay eggs on debarked logs or sawn timber at the port site. The life cycle is 2 to 3 years. The adult beetle is about 2 inches long with the mature larva being 2 to 3 inches long. The resultant damage is therefore quite severe if an infestation is established.

Specific information relating to risk elements:

A. Probability of pest establishment

1. **Pest with host at origin:** ***Moderate***
   The beetles occur commonly on *Pinus radiata* and rarely on Douglas-fir. *Prionoplus reticularis* is not common in or on freshly fallen logs, except during the flight season as egg masses. The huhu beetle is common in older, partially decayed logs.

In visiting a port site in New Zealand, culled logs damaged by the huhu beetle were fairly common. If the damage is associated with the main bole of the tree, the pest's presence would probably go unnoticed. Huhu beetle damage, which usually occurs on butt-end logs, can often be seen and culled out at the port or in the woods.

Even with debarking, treating the surface of the logs with insecticide, and fumigation with methyl bromide, this pest still has a chance of infesting logs. The beetle penetrates throughout the wood and has tightly packed, frass-filled tunnels, so that fumigation would not be totally effective. Surface treatment of the logs with an insecticide would not kill the emerging adults because of the long residual time needed.

2. **Entry potential: *High***
The entry potential may be high because of its 2- to 3-year life cycle; larvae and pupae could be found in the inner wood all year long.

3. **Colonization potential: *High***
The adults are good flyers and with the wide range of tree species suitable for hosts, the beetles have a good colonization potential. The climate in the coast, and lower west-side conditions in the Pacific Northwest are similar to New Zealand, so little environmental resistance would be expected.

4. **Spread potential: *High***
Beetles would probably fly several miles to find suitable host material. The wide range of host material, *Pinus* and *Eucalyptus*, would also enhance their chance of surviving.

B. Consequences of establishment

5. **Economic damage potential: *Moderate***
Prionoplus reticularis is not a major pest in New Zealand, where its primary commercial damage is usually associated with logging wounds at the base of the tree. It could be a pest in the United States, causing damage to decked logs or untreated timber in damp conditions. The Pacific Northwest and coastal California would provide damp, moist conditions suitable for this pest. The net present value of losses over 30 years is estimated to be from about $2.5 million to over $40 million. There are no known control techniques for this beetle. The huhu beetle would be competing with other Prioninae cerambycids.

6. **Environmental damage potential: *Low***
This pest is a tree or log degrader and does not kill trees. The main damage would be in degrading the products from logs.

7. **Perceived damage (social and political influences):** ***Low***
   This insect would not cause esthetic damage or consumer concerns. The adult beetles are large, so large adult flights may be of concern to forest visitors.

Estimated risk for pest: ***Moderate.*** Even with debarking, treating the surface of the logs with insecticide, and fumigation with methyl bromide, this pest still has a chance of entering on infested logs. The beetles penetrate throughout the wood, so fumigation may not be totally effective. Surface treatment of the logs with an insecticide would not kill the emerging adults because of the long residual time needed.

Selected bibliography:

Edwards, J.S., 1961. Observations on the ecology and behaviour of the huhu beetle *Prionoplus reticularis* White (Col. Ceramb.). Transactions of the Royal Society of New Zealand 88: 733-41.

Hosking, G.P., 1978. *Prionoplus reticularis*. New Zealand Forest Service Forest Research Institute Forest Leaflet 35.

Scientific name of pest: *Sirex noctilio F.* (Siricidae)/ *Amylostereum areolatum* (Fr.) Boidin

Scientific name of host(s): *Pinus* spp., especially *P. radiata, Pseudotsuga menziesii, Larix, Picea,* and *Abies*

Distribution: Native in Eurasia, northern Africa; introduced in New Zealand, Australia, Brazil, Argentinia, and Uruguay

Summary of natural history and basic biology of the pest: *Sirex noctilio* is endemic to Eurasia and northern Africa, reaching its greatest density in the Mediterranean zone. *S. noctilio* is generally considered to be a secondary pest of trees following primary damage in its native range (Spradbery and Kirk 1978). It has become established in New Zealand (1900), Tasmania (1952), and the Australian mainland (1961), and recently in Brazil, Argentina and Uruguay. In Australia and South America it causes significant tree mortality and is considered a major pest (Taylor 1981; Bedding personal communication). In recent years in New Zealand, *S. noctilio* has not been considered a major pest species (Nuttall 1989).

Tree species attacked by *S. noctilio* in its native range are almost exclusively pines (e.g., *Pinus pinaster, P. sylvestris, P. nigra, P. pinea)*, but it also has been recorded in fir and spruce (Spradbery and Kirk 1978). *Sirex noctilio* has been reported in larch and Douglas-fir (Krombein *et al.* 1979), but these reports are very rare occurences, or they may be mistakes in identification. The other species of European siricids are only rarely associated with pines (Spradbery and Kirk 1978). In New Zealand and Australia, the main host is *Pinus radiata*, a native tree of California. Under stress condition *Pinus* spp. are very susceptible to attack by *S. noctilio.*

The fungus *Amylostereum areolatum* occurs in close association with woodwasps, *Sirex* spp. Talbot (1977) states "Specific species of *Sirex* carry only one species of *Amylostereum.* In the case of *A. areolatum*, it is only known to be carried be three species of *Sirex*, none of which are known from North America." These three species are *S. juvencus*, *S. noctilio*, and *S. nitobei* (Talbot 1977). The fungus is pathogenic in association with *Sirex*, mostly on *Pinus*.

Much of the research on *S. noctilio* has been conducted in Australia and New Zealand, so the following information relates to the situation in these countries. *Sirex noctilio* normally completes one generation per year in southeastern Australia, but a portion of a population may take 2 years in the cooler climates of Tasmania and New Zealand (Taylor, 1981). In Australia, adults emerge from early summer to early winter with peak emergence in late summer or early autumn. Males usually predominate, with sex ratios of 4:1 to 7:1 (Morgan and Stewart 1966, Neumann and Minko 1981). After an initial flight period usually less than 2 miles, but with the potential of 100 miles (Bedding and Akhurst personal communication), females are attracted to physiologically stressed trees. They drill their ovipositors into the outer sapwood to assess the suitability for oviposition. At this time, a symbiotic fungus *(Amylostereum areolatum)* and a toxic mucus are injected into the sapwood along with the eggs (up to three separate eggs at a drill site). The fungus and mucus act together to kill the tree and create a suitable environment for the development of larvae. Crown wilt does not occur until a cross section of wood in at least one part of the stem has been invaded and killed by the fungus, which causes an inconspicuous white sapwood rot. Fecundity ranges from 21 to 458 eggs, depending upon size of the female (Neumann and Minko 1981). The eggs usually hatch within 10 to 15 days, but some may overwinter in cooler climates. Unfertilized eggs develop into males, while fertilized eggs produce females. All larval instars feed on the fungus as they tunnel through the wood. Larval galleries may penetrate to the center of a tree. The number of instars varies from 6 to 12, and the larval stage generally takes 10 to 11 months. Mature larvae pupate close to the bark surface and adults emerge about 3 weeks later (Taylor 1981).

Specific information relating to risk elements:

A. Probability of pest establishment

1. Pest with host at origin: *Low*

Sirex noctilio and *Amylostereum areolatum* are established in New Zealand. Historically, *S. noctilio* has been reported as a pest in New Zealand. However, because of the establishment of biological control agents and improved stand management, the occurrence of these organisms in plantation forests has been reduced. Volatiles from cut trees can increase the *S. noctilio* population in an area, and oviposition may occur on cut trees (Madden 1971). Required fumigation of logs will be highly effective in killing early stages in recently cut logs (Harris 1963a; USDA APHIS 1991). Other life stages of *S. noctilio* deep in the wood are not effectively treated by fumigation. However, the quality of logs desired for importation will minimize the likelihood of these later stages being present in the logs at the time of export.Therefore, the probability for logs intended for export to be infested with *S. noctilio* and *Amylostereum areolatum* is low.

2. Entry potential: *High*

Survival of *S. noctilio* larvae in logs can be very high. Survival greatly depends on a suitable moisture content for fungal growth, e.g., above 20% ODW (oven-dried weight) (Talbot 1977). Because its life cycle is generally a year or longer, it could easily survive the transit period within logs and escape detection at the port of entry. Detection of either organism at the port of entry is unlikely.

3. **Colonization potential: *High***
S. noctilio has been transported to many parts of the world and has become established in pine plantations. A high probability is expected for pines within a 2-mile radius of ports of entry and/or destinations of the logs. Abundance of *Pinus* spp. in these areas would significantly increase the colonization potential. It is realistic to assume that other *Pinus* spp. in the United States would be susceptible to *S. noctilio.*

4. **Spread potential: *High***
If *S. noctilio* became established in Pacific Coast States, it is likely to spread throughout the Western United States, depending upon which pine species were suitable hosts. Most rapid spread would probably be through California, Arizona, New Mexico, Nevada, and Utah. Natural dispersal of *S. noctilio* has been estimated at 5 to 15 miles per year in Australia.

B. Consequences of establishment

5. **Economic damage potential: *High***
Sirex noctilio has the potential to cause significant mortality in overstocked pine plantations and unhealthy forest stands. In Australia, *S. noctilio* caused up to 80 percent tree mortality in *Pinus radiata* plantations over a 3-year period. In 1 year, *S. noctilio* killed 1.75 million trees in 141,000 acres of plantations aged 10 to 30 years (Haugen and Underdown 1990).

An economic assessment of the effects of *Sirex noctilio* and *Amylostereum areolatum* is presented in chapter 5. Based on the assumptions presented, the economic effect ranges from $24 million to $130 million.

An efficient biological control agent is available that can reduce and maintain *Sirex noctilio* populations below the economic damage threshold. A parasitic nematode, *Beddingia siricidicola* (Bedding) (formerly *Deladenus siricidicola*) can be mass-produced and inoculated into *S. noctilio* populations as they invade and colonize new territories (Bedding and Akhurst 1974). Minimum cost to establish the nematode is estimated at $3.50/acre in plantations (Haugen and Underdown 1990, Haugen *et al.* 1990), but a less intensive program could be implemented in natural stands. See appendix H for additional information.

Some increased economic loss would occur because of log degradation and decay caused by *Sirex noctilio* and *Amylostereum areolatum.* This would be a minor effect relative to the actual economic loss from tree mortality.

6. **Environmental damage potential: *High***
The effect of *Sirex noctilio* on the native forests of the Western United States could be significant. If *S. noctilio* became established and caused mortality in the

remaining native stands of *Pinus radiata*, a significant reduction in the genetic base of *P. radiata* could occur. In the Sierra Nevada mixed conifer type, changes in stand composition could occur with the selective mortality of pines due to an invasion of *S. noctilio*, depending upon the susceptibility of these pine species to attack. The potential damage to these stands would be increased during droughts or other climatic events that reduce tree vigor. Also, an increase in *S. noctilio*-associated tree mortality may increase the populations of other destructive insect populations, such as bark beetles, by increasing the available food resource. The establishment of *S. noctilio* in the forests of the Western United States would affect the populations of other insects. *S. noctilio* would be in competition with the native siricids, and because *S. noctilio* is more aggressive, it may reduce or eliminate native species. An expanding *S. noctilio* population would result in population increases of the native parasites of siricids (e.g., *Rhyssa* spp, *Megarhyssa nortoni, Schlettererius cinctipes,* and *Ibalia* spp.), which could further decrease the native siricid fauna. If *S. noctilio* became established and caused significant mortality, the impact could be severe in wilderness areas, cause deterioration in watersheds, and threaten key environments of endangered species. See chapter 4 for additional information.

7. **Perceived damage (social & political influences):** ***High***
Ornamental plantings of pines (especially *P. radiata*) would be at risk if *S. noctilio* became established, but this is a relatively minor impact compared to the potential damage in natural stands and plantations.

Estimated risk: ***Moderate/High***

Additional remarks: The risk from importing untreated *Pinus radiata* logs from anywhere in the world where a *Sirex noctilio* population is established is great.

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Chapter 3. Pest Risk Mitigation

Inventory of proposed New Zealand mitigation measures

The following procedures were used by New Zealand log exporters to reduce the pest risks associated with the logs carried on the M.V. *Balayan* and discharged at Sacramento in January 1992:

1. Visual inspection
2. Mechanical debarking
3. Fungicide application
4. Insecticide application
5. Methyl bromide fumigation (not used on M.V. Washington Star)

In the following sections, these procedures are discussed and the time frames for their use for future shipments of logs to the United States are shown in figure 3-1.

Visual inspection. Visual inspection of logs is an important component of the total mitigation procedures system. Logging, processing, and transportation methods proposed by New Zealand log exporters allow several opportunities for close inspection of individual logs prior to shipment. Additionally, log inventory management systems will be aimed at minimizing the time interval between stump and ship to prevent invasion by insects and fungi.

Plantation trees in New Zealand are handfelled using chainsaws, and this operation is closely monitored by forestry companies to ensure that trees are on the ground for as short a time as possible prior to extraction to landing areas. In general, companies currently aim to have all sawlog-quality logs on the landing within a few days of felling.

At the landing, each tree-length stem is visually examined by experienced "log makers" trained to look specifically for signs of dead wood, decay, or wood-boring insects. Current New Zealand practices exclude logs containing any such defect from the sawlog-quality classes and direct them to local pulp mills. All sawlog material comes from sound, live trees.

Lengths and diameters are measured by the log makers and stems are bucked to length prior to sorting. All sawlog rejects are directed to local mills. Logs destined for export are delivered directly to debarking stations. Although individual company practices and policies do vary, it is generally accepted that the total time from felling to debarking should not exceed 10 days.

It is significant that the buyers of sawlogs will either reject or substantially discount the value of sawlogs deemed not fresh or containing sapstain. This imposes a self-policing mechanism on log producers, and motivates companies to manage both woods operations and transportation scheduling closely to ensure speedy delivery.

Upon arrival of the logs at the export port, each log is again inspected by either the Ministry of Forestry or company staff prior to scaling. This procedure offers another opportunity to identify any logs showing signs of insect or fungal attack.

Mechanical debarking. Mechanical debarking will be carried out on all logs destined for shipment to the United States. This operation removes a minimum of 99 percent of the bark and most insects and diseases found on or in the bark. For example, foliage infected by *Dothistroma pini*, a fungal pathogen, may be lodged in crevices in the bark. In addition to eliminating "hitchhiking" pests and those associated with the bark, debarking makes any borer holes visible to the debarker operator, who inspects each log individually. Any log showing indications of insect attack or containing any unsound wood is also rejected for export at this time. At the time of debarking, insecticide and fungicide approved by the New Zealand Ministry of Forestry are sprayed onto each log, completely covering all surfaces.

Fungicides. Fungicides prevent sapstain, mold, and decay growth on logs awaiting fumigation and shipment. Fungicides are especially necessary if logs are to be held for extended periods on the wharf or in ships' holds for ocean shipment. Busan ©30WB, Cutrol ©375, and Antiblu © are fungicides currently used to treat debarked logs (appendix D).

Insecticides. Insecticides are applied to prevent reinfestation of the logs by insects. The insecticide used is Sumicidin 20WP (appendix D). The Ministry of Forestry recommends use of this insecticide, in combination with other listed mitigation measures, to ensure that insect-free logs are loaded at New Zealand ports.

An accepted standard regarding the timeframe for all activities discussed above is that all logs destined for export to the United States will be debarked and sprayed within 10 days of felling.

Fumigation. Fumigation of logs prior to export to the United States has been accepted by New Zealand exporters as a standard pest mitigation procedure. The New Zealand Ministry of Forestry recommends methyl bromide (appendix D) at 80 g/m^3 for 24 hours at a minimum temperature of 15 °C, which exceeds the current APHIS prescriptions (T404). All fumigation activities are undertaken by personnel approved by the Ministry of Forestry. Following fumigation, holds are to be sealed until arrival in the United States.

Days 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20. . . . . 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

tree
felling

[VI][1]
bucking,
sorting,
and transporting

[VI]
Scaling,
mechanical
debarking,
sorting, and
treating

[EQA][2]
on-wharf storage

[VI]
loading and
sorting

fumigation
and
ventilation

transport to the United States

1 [VI] visual inspection for pests by trained industry personnel

2 [EQA] denotes an Export Quality Assurance visual inspection to phytosanitary specifications by Ministry of Forestry Personnel (NZ Ministry of Forestry 1991b).

Figure 3-1. *Schedule of pest mitigation activities currently applied on each New Zealand log destined for the United States*

Mitigation considerations for log importation

The following discussion covers some items to be considered by APHIS in developing protocols to mitigate the risks associated with importing New Zealand logs into the United States.

Transportation considerations. There is some risk of introducing exotic pests in transporting logs from New Zealand to the United States. Risks during transportation include:

- Contamination of treated logs from holds of transportation vessels not properly sanitized after carrying infested forest products.

- Infestation of logs stored above deck by flying or wind-borne insects and fungal spores.

- Contamination from infested forest products loaded on top of hold-stored logs at subsequent ports-of-call.

- Growth of fungal bodies stimulated by the favorable environment within ship holds.

In reviewing the transportation mitigation actions, the team assumed that all logs are treated as specified in the Pest Risk Mitigation section (debarking, insecticide and fungicide applications, and in-hold fumigation). Suggested transportation mitigation procedures include

- Preloading examination of vessels by Ministry of Forestry personnel to ensure proper phytosanitary conditions.

- Transportation of all logs in ship holds or containers.

- Fumigation procedures that use the hold or containers as the fumigation chamber.

- Sealing of all holds containing logs, and appropriate documentation by Ministry of Forestry approved personnel.

- Maintaining seal integrity throughout the transportation process until documents are verified and holds opened at the destination port in the United States by USDA, APHIS inspectors, or their representatives.

The New Zealand Ministry of Forestry has legislative powers through the Forests Act of 1949 and the Forest Produce Import Export Regulations of 1989 to provide phytosanitary surveillance for logs exported from New Zealand and the vessels which carry them. Additionally, the Forest Disease Control Regulations of 1967 empower the Ministry to introduce measures anywhere in New Zealand to control or eradicate forest pests and diseases. The Ministry of Forestry will also provide inspections and certification when required by the exporter to ensure that the phytosanitary requirements of the importing country are met before logs leave New Zealand.

Assessment of mitigation efficacy. ***Mitigation of pests on or within bark:*** Debarking at the port of origin substantially reduces pests associated with the bark and cambium. Insecticidal and fungicide treatments of debarked logs can further reduce pest risk by preventing fungal invasion and reinfestation by insects attracted to the debarked logs. Fumigation with methyl bromide can provide added protection by penetrating for 4 to 5 inches into the log (Cross 1992). Fumigation is very effective against all stages of insects, mites, snails, slugs, and nematodes as well as some fungi. Methyl bromide has become the fumigant of choice in quarantine treatments.

Mitigation of pests in wood: Survival of pests deep within the wood following treatment with methyl bromide has not been studied extensively, especially for logs fumigated aboard ships. Yu *et al.* (1984) reported 100 percent mortality of wood-infesting insects following on-board fumigation with methyl bromide at 25 g/m^3 for 24 hours at 10 to 20 °C, or 37.5 g/m^3 for 16 hr at 10 to 20 °C. The Yu study included a lyctid *(Lyctus lineraris),* shot-hole borers (Platypodidae), five species of other beetles (Scolytidae), and several hitchhiking surface pests (table 3-2). Methyl bromide has also been documented as an effective eradication measure for termites (Spear 1970, Wylie and Yule 1977).

The following fumigation schedules, taken from Section VI of APHIS' Plant Protection and Quarantine (PPQ) Treatment Manual (USDA APHIS 1985), are typical. Schedule T312 (a) and (b) was based upon research by Liese and Ruetze (1985). Schedule T404 was based upon the work of Harris (1963 a,b).

T312 Treatment of Oak Logs and Lumber for Oak Wilt Disease

(a) Logs

(1) Fumigate with methyl bromide at normal atmospheric pressure

240 g/m^3 (240 oz/1,000 ft^3) for 72 h at 5 °C (41 °F) or above
(240 g minimum concentration for 1/2 to 2 h)
(200 g minimum concentration for 12 h)
(120 g minimum concentration for 24 h)

(2) After the 24-hour period, add additional fumigant to bring concentration up to 240 g.

(160 g minimum concentration for 36 h)
(120 g minimum concentration for 48 h)
(80 g minimum concentration for 72 h)

(3) Aerate for 48 h

(b) Lumber

(1) Fumigate with methyl bromide at normal atmospheric pressure

240 g/m^3 (240 oz/1,000 ft^3) for 48 h at 5 °C (41 °F) or above
(200 g minimum concentration for 1/2 h)
(160 g minimum concentration for 2 h)
(100 g minimum concentration for 12 h)

(40 g minimum concentration for 24 h)

(2) After the 24 h period, add additional fumigant to bring concentration up to 240 g.

(120 g minimum concentration for 36 h)
(80 g minimum concentration for 48 h)

(3) Aerate for 48 h

T404 Wood Products, Including Containers

(a) Borers (woodwasps, Cerambycids, *Dinoderus*)

(1) Methyl bromide at normal atmospheric pressure

Chamber or tarpaulin

48 g/m^3 (48 $oz/1,000\ ft^3$) for 16 h at 21 °C (70 °F) or above
(36 g minimum concentration for 1/2 to 2 h)
(30 g minimum concentration for 2 h)
(27 g minimum concentration for 4 h)
(25 g minimum concentration for 16 h)

80 g/m^3 (80 $oz/1,000\ ft^3$) for 16 h at 4.5 to 20.5 °C (40 to 69 °F) or above
(60 g minimum concentration for 1/2 h)
(51 g minimum concentration for 2 h)
(46 g minimum concentration for 4 h)
(42 g minimum concentration for 16 h)

A more detailed coverage of methyl bromide can be found in USDA APHIS (1991), chapter 9.

Steam/Hot Water Treatment. Raising the internal temperature of logs to levels sufficient to kill deep wood pests has been suggested as a treatment method. The use of either steam or hot water to kill pest organisms in wood was recently reviewed (USDA APHIS 1991). As with other treatment methods, efficacy data on these types of treatment are limited. It was suggested that raising the temperature to 120 °F (49 °C) for 24 to 48 hours may be satisfactory. Shorter exposure periods may be adequate if log temperatures are increased to 140 to 158 °F (60 to 70 °C). A review of measures tested for the importation of Siberian larch logs recommended that heat treatments be employed that raised the temperature of the center of the log to 160 °F (71.1 °C) for a minimum of 75 minutes (USDA Forest Service 1992a). No documentation on the efficacy of this treatment schedule is provided, however.

Table 3-2 summarizes the efficacy of different mitigation measures on the principal pests of concern associated with New Zealand logs.

Table 3-2. *Efficacy of Mitigation Measures on Pests of Concern*

	Debarking	Insecticide	Fungicide	Fumigation	Steam/hot water
I. Pests on outer surface	HE	HE	HE	HE	HE
II. Pests on or within bark					
Hylurgus ligniperda	ME	N	NA	HE	HE
Hylastes ater	ME	N	NA	HE	HE
III. Pests in the wood					
Prionoplus reticularis	N	N	NA	PE	PE
Sirex noctilio	N	N	NA	PE	PE
Platypus apicalis	N	N	NA	HE	HE
Platypus gracilis	N	N	NA	HE	HE
Kalotermes brouni	N	N	NA	HE	HE
IV. Pathogens					
Amylostereum areolatum	N	NA	N	PI	PE
Leptographium truncatum	N	NA	N	PE	PE

HE = Highly effective
ME = Moderately effective
N = Not effective
PE = Probably effective but needs research
PI = Probably ineffective but needs research
NA = Not applicable

Additional considerations for mitigation protocols

- Because this document is predicated on New Zealand's requiring mitigation activities as currently proposed by the New Zealand timber industry, this pest risk assessment is less valid if untreated logs and logs with bark are shipped to the United States.

- Additional information is needed to determine the efficacy of heat treatments on organism survival and to determine the appropriate treatment schedule.

- Consideration should be given to the time and place of fumigation, sealing, and inspection.

- Mitigation protocols in the United States may include log handling, log storage, milling practices, waste disposal, and APHIS monitoring at mills.

- APHIS should consider the need for additional mitigation measures before New Zealand logs are imported into the United States. Particular attention needs to be given to the organisms that occur deep in the wood,—*Sirex noctilio/Amylostereum areolatum* and *Prionoplus reticularis*.

Chapter 4. Evaluation of Ecological Effects

Evaluation of the potential ecological effects of exotic insects and pathogens on native forest ecosystems is extremely difficult. For example, the host range of a potential pest is often unknown for a new environment, and estimates of growth loss and tree mortality are generally based on extreme extrapolations.

If a potential pest becomes established, it may have significant effects (direct and indirect) on stand composition, wildlife populations (game and nongame), water and nutrient cycles, recreation, wilderness values, and fire hazards. Although these effects can be more significant than the direct loss of timber values, little data are available to quantify these impacts. However, in a risk assessment, it is appropriate to state, hypothesize, and speculate upon these effects.

In the following sections, the ecological effects are addressed for the 7 species considered in detail (chap. 2). In the first section, characteristics of the potential pests are given relating to their adaptability and aggressiveness to forest ecosytems in the United States. In the second section, ecological impacts are discussed for each species, assuming that large-scale infestations occur.

Adaptability and aggressiveness of potential introduced pests

***Kalotermes brouni* (New Zealand drywood termite):** This pest primarily attacks dead trees, but has been found in living *Pinus radiata.* It is not a tree-killing insect but normally acts as a beneficial organism because of its role in decomposing deadwood and reincorporating it into the soil. It would not be a likely pest and would not significantly change the forest ecology of an area if it were introduced.

***Leptographium truncatum* (root disease fungus):** The recorded hosts of this fungus are *Pinus strobus, P. radiata* and *P. taeda*. There is also a report of it occurring on Douglas-fir in New Zealand. It is probably vectored by *Hylastes ater* and *Hylurgus ligniperda,* but related United States insects may be able to act as vectors.The wide geographic separation of the three *Pinus* hosts will limit the opportunity for widespread dispersal of the fungus. However, if other U.S. tree species are hosts, the capability for spread would be greatly increased. In New Zealand, *L. truncatum* occurs on wounded trees that are under stress. Trees in the United States most likely to be attacked include ornamental trees and trees grown in Christmas tree plantations.

***Platypus apicalis* and *Platypus gracilis* (native pinhole borers):** These insects are found on a variety of tree species in New Zealand. They may kill some of the native beeches *(Nothofagus* spp.), but these trees do not occur in the United States except as ornamentals. For species that may be found in the United States, broods have been reared in *Pinus nigra, P. ponderosa, P. radiata, P. taeda, P. menziesii, Acer pseudoplatanus,* and *Salix babylonica.* Abortive attacks have occurred on various *Eucalyptus* species, *Populus trichocarpa,* and *Sequoia sempervirens.* It is expected that these pinhole borers will mainly be pests of pine logs. They also may affect rapidly growing eucalypts by causing gum defects. This may mar veneers and increase pulping costs of commercial operations.

***Prionoplus reticularis* (Huhu beetle):** The huhu beetle is native to New Zealand and is found in both native and exotic softwoods and hardwoods. It also may be found attacking decayed hardwood stumps such as *Eucalyptus* spp. It is commonly found in *Pinus radiata* and rarely found in Douglas-fir. It probably would attack most softwoods within a climate similar to New Zealand. It is not a tree-killing insect, but infests trees with logging wounds, fire-killed trees, and logs decked in the woods or at a storage site. The main damage would be in degrading the products from logs.

Sirex noctilio/Amylostereum areolatum: The beetle *S. noctilio* was reared almost exclusively from *Pinus* spp. during a study in Europe (Spradbery and Kirk 1978). It was also reared from *Abies* spp. (2 of 8 species) and *Picea* spp. (2 of 3 species), but few adults emerged.

Little information is available on the susceptibility of pine species to attack by *S. noctilio*, including most of the species from the United States. Two U.S. species, *Pinus radiata* and *P. taeda*, are known to be highly susceptible to outbreaks of *S. noctilio* in New Zealand, Australia, and Brazil. Plantations of *P. elliotii* occur in southern Queensland (Australia), but *S. noctilio* has not yet reached these plantations. Some workers have assumed that *P. elliotii* will be less susceptible than *P. radiata*.

In Europe, *S. noctilio* emerged from each of the six native *Pinus* spp. sampled (Spradbery and Kirk 1978). Therefore, it can be assumed that many of the pine species in the United States will be suitable hosts. However, a wide range of susceptibility to *S. noctilio* attack is expected for *Pinus* spp. For example, numerous stands of *P. pinaster* (cluster pine), a native of Portugal and Spain, were not infested during the major outbreak in *P. radiata* plantations in South Australia.

Too little is known about the susceptibility of the major *Pinus* spp. in the Western United States to *S. noctilio* attack to quantify the damage potential. A worst-case scenario might be 80 percent stand mortality as seen during outbreaks in the *P. radiata* plantations of New Zealand and Australia. In natural stands, a much lower mortality would be expected.

Amylostereum areolatum is found principally in *Pinus* spp. in close association with *Sirex noctilio*. Their symbiotic relationship can result in tree death. *Sirex*, and therefore *A. areolatum*, is found on trees under stress. Environmental conditions in which *P. radiata* successfully grows in the United States would not limit spread and growth of *Amylostereum*.

Ecological impacts of large-scale infestations

Many of the general ecological impacts of a large-scale pest infestation have been discussed previously (USDA Forest Service 1991). Most of the organisms considered in this assessment would not likely cause such widespread damage. A few of the pests, *Sirex noctilio* in particular, could have major effects on the existing ecological conditions in forests of the Western United States.

The introduction of an exotic pest to native *Pinus radiata* stands could have significant ecological effects because of their limited geographic range. Even relatively low levels of tree mortality could narrow the genetic base of *P. radiata*. Alterations in species composition and size classes could reduce habitat for threatened or endangered species that may be present, or result in some additional species becoming threatened.

***Kalotermes brouni* (New Zealand drywood termite):** *K. brouni* would not cause large outbreaks in a forest situation. It would fit in with the native forest ecology by degrading and decomposing deadwood and would compete with other similar decomposers.

Outside the forest environment, *K. brouni* probably would affect wood and wood products. Many termites are quite specific in their habitat requirements so it is unknown whether *K. brouni* would survive in the Western United States. Other species of termites in the United States have been known to cause considerable economic damage in localized environments.

***Leptographium truncatum* (root disease fungus):** The ecological effects of introducing *L. truncatum* depends on its anticipated virulence on *Pinus radiata* or other pine species. In New Zealand, it is not a highly virulent pathogen. If it follows this pattern in the United States, limited pockets of tree mortality in native stands and Christmas tree plantations would be expected. These pockets would develop slowly, and tree decline and mortality would be gradual. This slow opening of the canopy would allow for replacement species to colonize these pockets. This would reduce hydrologic and erosion problems from tree mortality. Tree mortality in these stands could adversely affect visual and recreation values.

If *L. truncatum* is more virulent in *Pinus radiata* in the United States than in New Zealand, or if native insects are more efficient vectors, the number of centers created, their size, and the amount of mortality would be significantly higher. Disease centers would likely be occupied by shrub and early seral stages with slow replacement by more shade-tolerant tree species. This could alter habitat for various fauna, possibly including some threatened or endangered species. Fire risk would be significantly increased and the number of catastrophic wildfires would increase.

There are no known suppression activities for *L. truncatum* or closely related fungi once they have become established. Therefore, if the fungus is introduced into the United States, there would be no means to stop its spread. Because its vectors are attracted to wounded and stressed trees, many *P. radiata* in native stands and in landscape situations would be susceptible to attack and infection.

***Platypus apicalis* and *P. gracilis* (native pinhole borers):** If introduced into the United States, these New Zealand pinhole borers probably would not kill trees. They can kill native beeches in New Zealand, but the genus *Nothofagus* is not represented in the United States. Pinhole borers can complete their cycle on pine, Douglas-fir, maple and some willow species. They have abortive attacks on a number of genera including eucalyptus, poplar, and sequoia. These insect species introduce a sapstain fungus during their attack and are probably most important as a degrader of *Pinus* spp. stockpiled or decked in the woods.

These species of pinhole borers are found only in the wetter forests of New Zealand. The climates in northern California, Oregon, and Washington west of the Cascade Mountains would be suitable for these two species. Introduced into California or the Northwest, these insects would probably have no significant ecological impact.

***Prionoplus reticularis* (Huhu beetle):** If introduced into the Western United States, the huhu beetle would probably compete with native beetles that attack *Pinus* spp. in the following conditions: dead and/or dying trees, trees with logging wounds, and stored logs. The beetle in New

Zealand occurs in all forests from the very wet to the very dry. These conditions would be similar to those found in California, Oregon, and Washington.

Based on its habits in New Zealand, the huhu beetle would not be a killer of trees or cause any dramatic outbreaks to occur in *Pinus* spp. It may, however, cause declining, windthrown, fire-killed, or wounded trees to degrade faster. The beetle is quite large, so the degradation of logs, especially those stored in the forest for a long period of time, could be significant. In the United States it would have to compete with native cerambycids, buprestids, and bark beetles for an ecological niche. Thus, if it became established in the United States, it probably would not have a significant impact on the ecology of western forests.

Sirex noctilio/Amylostereum areolatum. Tree mortality attributed to *S. noctilio* and *A. areolatum* has been recorded from 30 to 80 percent during severe and widespread outbreaks in the *Pinus radiata* plantations of New Zealand and Australia (Rawlings and Wilson 1949, McKimm and Walls 1980, Haugen and Underdown 1990). A number of factors appear to contribute to the susceptibility of a pine stand to attack by *S. noctilio* (Madden 1988). Tree stresses due to overstocking and drought are often suggested as the main factors. Other contributing factors include physical damage to trees (wind breakage, fire, wounding from thinning or pruning operations, lightning, hail, etc.).

Chapter 5. Evaluation of Economic Effects

This section presents the economic evaluations of potential infestations of pests from New Zealand if they become established in the United States. The evaluations of potential pest impacts are primarily limited to wood and wood products as the dominant resource affected by these pests and a dominant value of forests. The forests of the United States also have esthetic, recreation, fish, wildlife, and watershed values, but potential economic losses in these areas are not measured in this analysis.

The lumber and other solid-wood products industry is one of the top three manufacturing industries in most regions of the United States. Many areas rely on harvesting and processing of forest products for major contributions to local and regional economies. The employment and income of many people depend on forests and forest-related industries. In 1986 the value of harvested timber moved to the local delivery point was approximately $14.6 billion in 1990 dollars (USDA FS 1990a).

The economic evaluations were made using the following general guidelines:

1) Each pest was analyzed independently, and the economic losses were developed in isolation from potential losses caused by other introduced pests. A simple sum of the economic loss caused by an individual pest may not produce a valid estimate of the total loss from the introduction of all of the pests evaluated here for two reasons:

    a) Many of the same host trees may be attacked simultaneously by several introduced pests. It is impossible to estimate what proportion of the damage to a given tree should be attributed to a particular pest.

    b) Simultaneous attack on host types may also increase mortality rates and growth losses through the synergistic effect of multiple attacks. Totaling the economic costs of each pest group may underestimate the total economic costs from a simultaneous introduction of all of the pests considered in this analysis. The possibility of simultaneous attacks is limited because the pests are specific to different hosts and because some attack only dead wood and others only living trees.

2) Each pest or group of pests analyzed has separate and diverse assumptions about spread and damage caused as indicated in the following individual pest effects discussions.

3) The analysis of each pest where timber losses are measured considered all unreserved forests of all ownerships (both public and private) in the 11 Western States (Washington, Oregon, California, Idaho, Nevada, Arizona, New Mexico, Colorado, Utah, Montana, Wyoming) at risk. Reserved forest includes the approximately 7 million acres designated as critical habitat for the Northern spotted owl by the U.S. Department of the Interior, Fish and Wildlife Service. The 7 million acres that may be reserved for the Northern spotted owl reduces the quantity of wood available for damage, but also tends to increase the price of timber.

4) It is recognized that integrated pest management measures would be implemented should epidemics of introduced pests occur. Costs of such efforts are not considered in this analysis. Because of the limited experience with these pests in the United States, the mitigation measures would be based on crude estimates. Therefore, only the total potential losses have been estimated and no mitigation measures are assumed, except for drywood termites where a wide-spread termite control program currently exists.

Economic evaluations

1) Economic losses are a function of one or more of the following:

- Reduced growth rates (increased mortality) of timber trees.
- Reduced growth rates (increased mortality) of trees for non-timber purposes.
- Loss of exports from the United States because other nations would restrict imports from the United States due to fear that U.S. logs and timber would become infected.

2) Only those pests that are possible colonizers in the United States are considered for economic evaluation. It is assumed that each will be established by 1995 and all present value calculations are computed to the year 1995. This assessment estimates the potential for losses after a pest is established in the United States and begins to spread.

3) All computations are in constant 1990 dollars.

4) A 4-percent discount rate (real rate) is used to determine the present value of the stream of estimated losses. The 4-percent discount rate is the customary rate used by the USDA Forest Service in the evaluation of natural resources activities. A 10-percent rate is also shown to indicate the sensitivity to discount rates.

***Kalotermes brouni* (drywood termite)**: This termite will be added to the 43 species of termites in the contiguous United States. Termites in the United States are divided into three types: dampwood, drywood, and subterranean, but only 13 species have the potential for significant economic destruction (Moore 1979).

The economic evaluation of this drywood termite is based on the following information obtained through personal communication with Joe K. Mauldin, USDA Forest Service, Southern Forest Experiment Station, Gulfport, Mississippi.

a) Control of termites and repair of damage caused by them results in a total economic impact in the United States of approximately $1.5 billion per year.

b) Drywood termites cause about 5 percent ($75 million) of the total damage per year.

c) Termites, including drywood termites, spread slowly (50 to 1,000 feet per year) because they are poor flyers and only about 1 percent of the termites that fly eventually establish a new colony. People could increase the rate of spread by moving infested wood from one place to another.

d) 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 west coast. This damage estimate assumes continuation of wide-spread and effective termite control efforts in the United States. An added termite species does not cause major increases in damages.

In the best-case scenario the present value of losses of $75,000 per year starting in year 15 and continuing through year 30 is $463,000 at a 4-percent discount rate and $136,000 at 10 percent.

In the worst-case scenario the present value of losses of $500,000 per year starting in year 10 and continuing through year 30 is $4.590 million at 4 percent and is $1.641 million at 10 percent.

***Leptographium truncatum* (root disease fungus):** *Leptographium truncatum* is a fungus that is capable of infecting *Pinus radiata* in the United States. It is unknown whether other western conifer species could serve as hosts. About 14,000 acres of unreserved timberland of *P. radiata* occur in the United States (USDA Forest Service 1990b). Generally located along the north coast of California, *P. radiata* had a 1984 inventory of about 14 million cubic feet (79 million board feet. It has little commercial value and harvest is minimal. *P. radiata* is also used as an ornamental tree. Because *P. radiata* is not a commercial species, the economic evaluation is based on the removal of dead trees and their replacement with trees of other species. An average cost of $400 per tree for removal and replacement is assumed in the many locations where *P. radiata* occurs.

The following basic assumptions were used in the economic evaluation:

a) *Leptographium truncatum* will be distributed throughout the 14,000 acres within 3 years after colonization. Initial colonization is assumed to start in northern California.

b) The spread among dispersed *Pinus radiata* stands will be a contiguous block.

c) *L. truncatum* will be evaluated for a 30-year period.

d) *P. radiata* will not regenerate on the affected centers but will be replaced with other species.

e) *L. truncatum* kills only *P. radiata*, with all ages being affected.

f) In the best-case scenario, damage from *L. truncatum* will start in the fourth year, and spread and damage will be at a maximum annual rate by the sixth year.

- Two new centers will start per 2,470 acres per year (rounded to 12 new centers per year).
- Each new center develops in size to 0.1 acre in 10 years.
- Ttrees die at a rate of 0.75 per acre per year.
- A maximum of 10 trees die per center per year.

g) In the worst-case scenario of *L. truncatum*, its spread and damage will start in the fourth year.

- Ten new centers per 2,470 acres per year (rounded to a total of 60 new centers per year).
- Each center develops to 0.2 acre in 10 years.
- Trees die at a rate of 1.5 per acre per year.
- A maximum of 20 trees die per center per year.

h) Economic losses are based on the following assumptions:

1) Dead *P. radiata* will be removed and replaced with other species.

2) The cost of tree removal and replacement with larger trees of other species is $400 per tree. The cost reflects the frequent use of *P. radiata* for ornamental purposes.

3) Starting in year 4 the dead trees will be removed and replaced each year.

The present value (at a 4-percent discount rate) of removing and replacing dead trees over 30 years in the best-case scenario, is $7 million. At a discount rate of 10 percent, the present value declines to $2 million (table 5-1).

The present value (at a 4-percent discount rate) in the worst-case scenario is $69 million. If a 10-percent discount rate is used, the present value is reduced to $22 million.

Table 5-1. *Economic evaluation data for* Leptographium truncatum

	Best-case scenario			Worst-case scenario		
Calendar year	Total centers	Number trees killed	Replacement costs $mil	Total centers	Number trees killed	Replacement costs $mil
1995	0	0	0.000	0	0	0.000
1996	0	0	0.000	0	0	0.000
1997	0	0	0.000	0	0	0.000
1998	0	0	0.000	0	0	0.000
1999	2	20	0.008	2	40	0.016
2000	8	80	0.032	32	640	0.256
2001	20	200	0.080	92	1840	0.736
2002	32	320	0.128	152	3040	1.216
2003	44	440	0.176	212	4240	1.696
2004	56	560	0.224	272	5440	2.176
2005	68	680	0.272	332	6640	2.656
2006	80	800	0.320	392	7840	3.136
2007	92	920	0.368	452	9040	3.616
2008	104	1040	0.416	512	10240	4.096
2009	116	1160	0.464	572	11440	4.576
2010	128	1280	0.512	632	12640	5.056
2011	140	1400	0.560	692	13840	5.536
2012	152	1520	0.608	752	15040	6.016
2013	164	1640	0.656	812	16240	6.496
2014	176	1760	0.704	872	17440	6.976
2015	188	1880	0.752	932	18640	7.456
2016	200	2000	0.800	992	19840	7.936
2017	212	2120	0.848	1052	21040	8.416
2018	224	2240	0.896	1112	22240	8.896
2019	236	2360	0.944	1172	23440	9.376
2020	248	2480	0.992	1232	24640	9.856
2021	260	2600	1.040	1292	25840	10.336
2022	272	2720	1.088	1352	27040	10.816
2023	284	2840	1.136	1412	28240	11.296
2024	296	2960	1.184	1472	29440	11.776
2025	308	3080	1.232	1532	30640	12.256
	Present value at 4		7			69
	Present value at 10%		2			22

***Platypus* spp. (pinhole borers):** This section evaluates both *Platypus apicalis* and *Platypus gracilis* as having similar biological characteristics and being able to cause similar potential economic losses.

The two species of *Platypus* beetles have a potential range of all of North America, but in this study the estimates of their effects are limited to the 11 Western States. If the pest is introduced elsewhere in the United States, the economic effects would be similar.

The *Platypus* beetles attack live trees, including New Zealand beech (*Fagus*), eucalyptus (*Eucalyptus*), poplar (*Populus*), and redwood (*Sequoia*), and cause holes and resin stains. There is no mortality in these tree species and the frequency of attack is very low. Thus there is little economic loss and the attacks on these trees are not evaluated. (The only trees killed by these species of *Platypus* are trees native to New Zealand.)

The *Platypus* beetles attack dead trees and felled logs of Douglas-fir and all pine species of the Western United States, and reduce the quality of the felled logs by boring pinholes and staining wood. The potential effects have not been adjusted to reflect the existence of similar species in the United States that cause damage to the same logs.

The economic evaluation is based on the following assumptions:

a) *Platypus* beetles are established on the west coast in the United States by 1995 and able to start spreading.

b) *Platypus* beetles can spread by flying, about 5 miles per year, and can spread by the transport of infested logs and other dead wood materials.

c) *Platypus* beetles will spread to all areas with Douglas-fir and pine species within the 11 Western States, and will infect all of these areas by the year 2025.

d) In the worst-case scenario, 5 percent of all felled logs will be attacked and each attacked log will lose 10 percent of its economic value.

e) In the best-case scenario 0.5 percent of all felled logs will be attacked and each attacked log will lose 10 percent of its economic value.

In the worst-case scenario, the potential losses are $119 million at a 4-percent discount rate and $35 million at 10 percent.

In the best-case scenario, the potential losses are $12 million at a 4-percent discount rate, and $4 million at 10 percent (table 5-2).

Table 5-2. *Economic evaluation data for* Platypus spp.

Calendar year	Price/MBF	Volume harvested	Harvest share affected per year (%)	Value at risk million $	Best-case losses $mil	Worst-case losses $mil
1995	$0.00	13,975	0.0	0.00	0.00	0.00
1996	$174.80	13,889	1.0	24.28	0.01	0.12
1997	$182.25	13,802	2.0	50.31	0.03	0.25
1998	$189.70	13,715	3.0	78.05	0.04	0.39
1999	$197.15	13,628	4.0	107.47	0.05	0.54
2000	$204.60	13,542	5.0	138.53	0.07	0.69
2001	$212.03	13,737	6.0	174.77	0.09	0.87
2002	$219.16	13,933	7.0	213.76	0.11	1.07
2003	$226.89	14,129	8.0	256.46	0.13	1.28
2004	$234.32	14,325	9.0	302.10	0.15	1.51
2005	$241.75	14,521	10.0	351.05	0.18	1.76
2006	$249.18	14,717	14.5	531.75	0.27	2.66
2007	$256.61	14,913	19.0	727.10	0.36	3.64
2008	$264.04	15,109	23.5	937.51	0.47	4.69
2009	$271.47	15,305	28.0	1163.36	0.58	5.82
2010	$278.90	15,501	32.5	1405.05	0.70	7.03
2011	$283.90	15,575	37.0	1636.03	0.82	8.18
2012	$288.90	15,649	41.5	1876.19	0.94	9.38
2013	$293.90	15,723	46.0	2125.61	1.06	10.63
2014	$298.90	15,797	50.6	2389.13	1.19	11.95
2015	$303.90	15,871	55.0	2652.67	1.33	13.26
2016	$308.90	15,944	59.6	2935.43	1.47	14.68
2017	$313.90	16,018	64.0	3218.01	1.61	16.09
2018	$318.90	16,092	68.5	3515.28	1.76	17.58
2019	$323.90	16,166	73.0	3822.43	1.91	19.11
2020	$328.90	16,240	77.5	4139.54	2.07	20.70
2021	$330.45	16,269	82.0	4408.39	2.20	22.04
2022	$332.00	16,298	86.5	4680.46	2.34	23.40
2023	$333.55	16,327	91.0	4955.74	2.48	24.78
2024	$335.10	16,356	95.5	5234.26	2.62	26.17
2025	$336.65	16,385	100.0	5516.01	2.76	27.58
			Present value	at 4%	12	119
			Present value	at 10%	4	35

***Prionoplus reticularis* (huhu beetle):** The huhu beetle infests logs, dead parts of living trees, and untreated sawn lumber. The huhu beetle could be expected to spread throughout the cool, moist areas of the Pacific Northwest coast.

The evaluation of the huhu beetle is based on the following assumptions:

a) Huhu beetle will spread across the Douglas-fir subregion.

b) The huhu beetle can spread by flying up to 10 miles per year and also is transported on logs and other infested wood materials to a susceptible forested area.

c) Huhu beetle will establish along the coast and by 1995 start to move inland. The rate of movement will be relatively slow initially and will increase as the huhu population increases. For this analysis the spread rate is 1 percent per year in the Douglas-fir subregion for the first 10 years, and then 4.5 percent per year until all of the Douglas-fir subregion is affected by the year 2025.

d) The huhu beetle primarily attacks logs, stumps, and dead wood of living softwood species. It has no affect on living trees or dead hardwoods. It does not kill trees or reduce growth rates.

e) The huhu beetle does not affect kiln-dried, insecticide-treated, or preservative-treated sawn wood products. Some damage to non-treated sawn wood is possible but is not evaluated here.

f) Economic loss is caused by huhu attacks that damage felled softwood logs.

g) In the worst-case scenario:

- huhu beetle attacks 10 percent of felled logs
- 3 percent of value is lost per log

h) In the best-case scenario:

- huhu beetle attacks 2 percent of felled logs
- 3 percent of value is lost per log

The present value of losses in the 30-year evaluation period at a 4-percent discount rate in the worst-case scenario is $40 million. At a 10-percent discount the loss is reduced to $12 million (table 5-3).

In the best-case scenario the losses are $8 million at 4 percent and $2 million at 10 percent.

Table 5-3. *Economic evaluation data for* Prionoplus reticularis

Calendar year	Percent area affected	Acres affected (million)	Volume harvested MBF	Price/MBF (1990)	Value of harvest affected $mil	Best-case losses $mil	Worst-case losses $mil
1995	0.0	0	0	$0.00	$0.00	$0.00	$0.00
1996	1.0	197	8717	$271.71	$23.69	$0.01	$0.07
1997	2.0	394	8602	$266.08	$45.78	$0.03	$0.14
1998	3.0	591	8477	$258.40	$65.72	$0.04	$0.20
1999	4.0	788	8246	$244.22	$80.56	$0.05	$0.24
2000	5.0	985	8013	$234.94	$94.13	$0.06	$0.28
2001	6.0	1182	8573	$264.80	$136.20	$0.08	$0.41
2002	7.0	1379	8856	$287.49	$178.23	$0.11	$0.53
2003	8.0	1576	8340	$268.10	$178.88	$0.11	$0.54
2004	9.0	1773	8288	$264.31	$197.15	$0.12	$0.59
2005	10.0	1970	7978	$245.09	$195.55	$0.12	$0.59
2006	14.5	2855	8809	$289.13	$369.31	$0.22	$1.11
2007	19.0	3740	8754	$293.78	$488.63	$0.29	$1.47
2008	23.5	4625	8338	$275.50	$539.82	$0.32	$1.62
2009	28.0	5510	8237	$268.00	$618.10	$0.37	$1.85
2010	32.5	6395	8419	$283.88	$776.74	$0.47	$2.33
2011	37.0	7280	8649	$297.68	$952.66	$0.57	$2.86
2012	41.5	8165	8747	$307.96	$1,117.89	$0.67	$3.35
2013	46.0	9050	8735	$313.35	$1,259.10	$0.76	$3.78
2014	50.6	9935	8607	$311.16	$1,355.17	$0.81	$4.07
2015	55.0	10820	8544	$309.32	$1,453.61	$0.87	$4.36
2016	59.5	11705	8631	$313.63	$1,610.68	$0.97	$4.83
2017	64.0	12590	8674	$316.44	$1,756.79	$1.05	$5.27
2018	68.5	13475	8756	$321.10	$1,925.88	$1.16	$5.78
2019	73.0	14360	8836	$326.35	$2,105.01	$1.26	$6.32
2020	77.5	15245	8779	$331.91	$2,258.21	$1.35	$6.77
2021	82.0	16130	8779	$331.91	$2,389.33	$1.43	$7.17
2022	86.5	17015	8740	$331.74	$2,507.96	$1.50	$7.52
2023	91.0	17900	8730	$331.74	$2,635.41	$1.58	$7.91
2024	95.5	18785	8940	$330.55	$2,822.11	$1.69	$8.47
2025	100.0	19666	8940	$330.55	$2,955.09	$1.77	$8.87
				Present value at 4%		$8	$40
				Present value at 10%		$2	$12

***Sirex noctilio* (wood wasp) and the related fungus *Amylostereum areolatum*:** *Sirex noctilio* is believed to be the pest with the greatest potential to cause significant damage to the trees and forests of the United States. *Sirex noctilio* and its associated fungus, *Amylostereum areolatum*, kill trees, which reduces inventory and growing stock, and eventually changes the amount, location, and cost of wood harvested. *Sirex noctilio* will be evaluated by estimating the reduction in trees available for harvest.

The potential economic risk associated with the establishment of *S. noctilio* is estimated in a market context (using timber supply and demand relationships) for three regions of the National Forest System: the Pacific Northwest, Pacific Southwest, and the Rocky Mountain Regions. The derived demand and stumpage supply functions were taken from the 1989 Forest Service Resources Planning Act (RPA) Timber Assessment (USDA FS 1990b) as modified by an assumption that timber supply would be further reduced by an amount equivalent to the estimated withdrawal of land for northern spotted owl critical habitat.

The analysis involves shifting the stumpage supply functions by the amount of the change in softwood growing stock inventories resulting from reduced forest growth or removal of land from the available timberland base. This approach was adopted because inventory levels are one of the main determinants of stumpage supply. Changes in inventories available act to shift stumpage supply functions in the long term, while changes in prices help establish supply levels in the short term. The necessary changes in inventories were computed by shifting the supply function of the base inventory (without *S. noctilio*) to a *S. noctilio*-modified inventory. Economic impacts were computed by calculating the equilibrium price and quantity by decade and region. Then the modified equilibrium price and quantity were calculated following a reduction in the stumpage supply functions assumed to be induced by changes in inventories caused by the activities of *S. noctilio*. Basic economic impacts are slow to develop and depend on the extent that lower growth reduces inventories and hence timber supplies.

This analysis makes no explicit assumption about salvage except to the extent that some products (fuelwood) come from dead material. Much of the dead material remains in the forests, where it may contribute to non-commodity products.

A number of assumptions were required to complete this analysis of the economic impacts. For the worst-case scenario, the assumptions are:

a) Base line is the "final critical habitat run" for the U.S. Department of the Interior, Fish and Wildlife Service. That is, the withdrawals or reduction in harvest levels necessary for meeting the Endangered Species Act requirements for northern spotted owl are assumed to be in place.

b) No action is taken to control spread or affect of *S. noctilio* in the United States.

c) *S. noctilio* is established by 1995 and starts to spread in the year 2000 from two west coast locations.

d) *S. noctilio* will spread 12 miles across the landscape in the year 2000, 13 miles in 2001, and thereafter at 25 miles per year through year 2025, when 100 percent of the 11 Western States will have *S. noctilio* present. *Sirex noctilio* will not spread beyond the 11 Western States for purposes of this analysis. Spread is assumed to start on the west coast and progress eastward. The total land area of 11 Western States is 750,416,000 acres and the forested acres are assumed to be evenly distributed so that the spread is at a uniform rate (table 5-4).

e) *S. noctilio* will affect all pine trees (ponderosa, Jeffrey, sugar, western white, lodgepole, Monterey, and other pines are include; hemlock, redwood, cedar, Douglas-fir, true firs, Sitka spruce, Engelmann spruce, larch, and all hardwoods are excluded).

f) *S. noctilio* will cause 30-percent mortality during an entire attack cycle for unthinned, natural stands; 10 percent for young, thinned stands; and 3 percent for older thinned stands. For purposes of this analysis, 15 percent of all pines in areas infested by *S. noctilio* are assumed to die.

g) Impact of *S. noctilio* applies equally to all ownerships of all unreserved timber land.

h) The *S. noctilio* risk is based entirely on the changes in inventory and the subsequent effect on timber available for harvest. Neither positive nor negative influences of changes in the number of trees per acre are estimated.

i) The annual increment of loss applies to the weighted average growing stock of all pines in all 11 Western States. The mortality caused by *S. noctilio* is in addition to mortality from all other causes.

In the worst-case scenario the present value of the losses caused by *S. noctilio* is $130 million at 4 percent and $24 million at 10 percent.

In the best-case scenario the present value of the losses is estimated to be $10 million at 4 percent and $2 million at 10 percent. The best case is calculated as 8 percent of the worst case, based on a spread rate of only 2 miles per year, compared to the 25 mile-per-year rate of the worst case.

These impacts are lower than initial expectations because *S. noctilio* will have only a modest effect on the inventory in the West by the year 2025 and pines are a relatively small share of the total timber inventory. The delay to year 2000 before *S. noctilio* is assumed to affect timber also decreases the potential losses. Finally, the available timber is sufficient to compensate for the reduction in pine without a reduction in harvest for several years.

The impact is greatest on producers of forest products in the West who lose their potential gains. Consumers are less affected because production in unaffected regions offsets the loss of production in the West.

Table 5-4. *Economic evaluation data for worst-case scenario for* Sirex noctilio

Calendar year	Accumulated acres affected[1] (1,000 acres)	Accumulated percent of trees killed
2000	289	.0
2001	1,358	.0
2002	5,024	.1
2003	11,304	.2
2004	20,096	.4
2005	31,400	.6
2006	45,216	.9
2007	61,544	1.2
2008	80,384	1.6
2009	101,740	2.0
2010	125,600	2.5
2011	151,980	3.0
2012	180,860	3.6
2013	212,260	4.2
2014	246,180	4.9
2015	282,600	5.6
2016	321,540	6.4
2017	362,980	7.3
2018	406,940	8.1
2019	453,420	9.1
2020	502,400	10.0
2021	553,900	11.1
2022	607,900	12.2
2023	664,420	13.3
2024	723,460	14.5
2025	750,416	15.0

[1] 750,416,000 is the total land area in acres in 11 Western States (excludes Alaska and Hawaii).

Summary of economic analysis

The estimates of potential losses demonstrate that there is significant risk to North American forests from the introduction of pests from New Zealand. These worst-case losses are made without consideration of suppression of these pests. Related to the potential economic losses, but not evaluated here, are jobs lost, watersheds damaged, recreation areas spoiled, adverse impacts on fish and wildlife, and damage to the ecology of the area. Application of suppression procedures would be expected to result in losses equal to or less than the worst-case potential.

The pests evaluated are those within the log that could survive treatment and shipment, and that have host plants that permit the pests to become established near the port of entry. The monetary estimates of potential losses are limited to the losses of commercial timber values, except for the *Leptographium* estimate, which is valued to reflect the ornamental and esthetic uses of *Pinus radiata*. Other non-timber-related impacts on recreation, wildlife, and watershed are not quantified.

The total present value of potential losses of $364 million (worst-case scenario at 4 percent) is 2.5 percent of the total value of harvested timber of $14.6 billion in 1986 (1990 dollars) (table 5-5). Potential losses caused by these New Zealand pests are significantly less than the $2,600 million potential commercial timber losses estimated for the Asian gypsy moth in a worst-case scenario (USDA FS 1992B).

Table 5-5. Summary of potential impact of introduced pests

	Present value of potential losses[1] (millions of dollars)	
Pest	Best case	Worst case
Kalotermes brouni	1	5
Leptographium truncatum	7	69
Platypus spp.	12	119
Prionoplus recticularis	8	40
Sirex noctilio/ Amylostereum areolatum	24	131
TOTAL	52	364

[1] At 4 % discount rate

Chapter 6. Discussion and Summary

The Pest Risk Assessment Team screened over 300 pests that have been recorded on *Pinus radiata* and Douglas-fir in New Zealand for the past 30 years. From this list, 31 pests (11 fungi and 20 insects) were screened in greater detail for risk potential. Based on this analysis, 2 fungi and 5 insects were chosen as representative of those groups of organisms posing the greatest potential pest problem. All five of the insect species penetrate deep into the wood and *Kalotermes brouni* and *Platypus* spp. may be the only species killed by methyl bromide fumigation. Similarly, the two fungi occur in the wood and may not be affected by fumigation. They also have overland dispersal mechanisms that could permit spread to forest stands in the United States from the ports of entry. Efficacy data are lacking on the use of steam treatments or hot water immersion treatments to control these organisms.

Of the five insect species of concern, only *Sirex noctilio,* in association with the fungus it introduces into the tree (*Amylostereum areolatum*) is regarded as a tree killer. The other fungus of concern, *Leptographium truncatum*, is also vectored by insects. *L. truncatum* has been reported in Ontario, Canada. The taxonomy of the genus is uncertain, and questions have been raised as to whether *L. truncatum* is a valid species or if it is actually another species already present in the United States. The other four insects of concern are either wood degraders or pests of wood in use. These pests, although not regarded as tree killers, may still cause appreciable loss through their activities.

The primary pest of concern in this evaluation is *S. noctilio*. In the past, outbreaks have caused significant damage in New Zealand, Australia, and other countries. This pest is presently held in check by a parasitic nematode and proper stand management in New Zealand and Australia. This natural control agent has been and continues to be successfully introduced into plantations in New Zealand and Australia.

Current mitigation procedures followed by New Zealand exporters should be continued. These measures include rapid processing from felling to shipping, debarking, fungicide and insecticide treatment, visual examination, and fumigation. This pest risk assessment assumed continuation of these procedures, and therefore this assessment is less valid if these procedures are discontinued.

It is recommended that APHIS consider the need for additional mitigation measures before New Zealand logs are imported into the United States.