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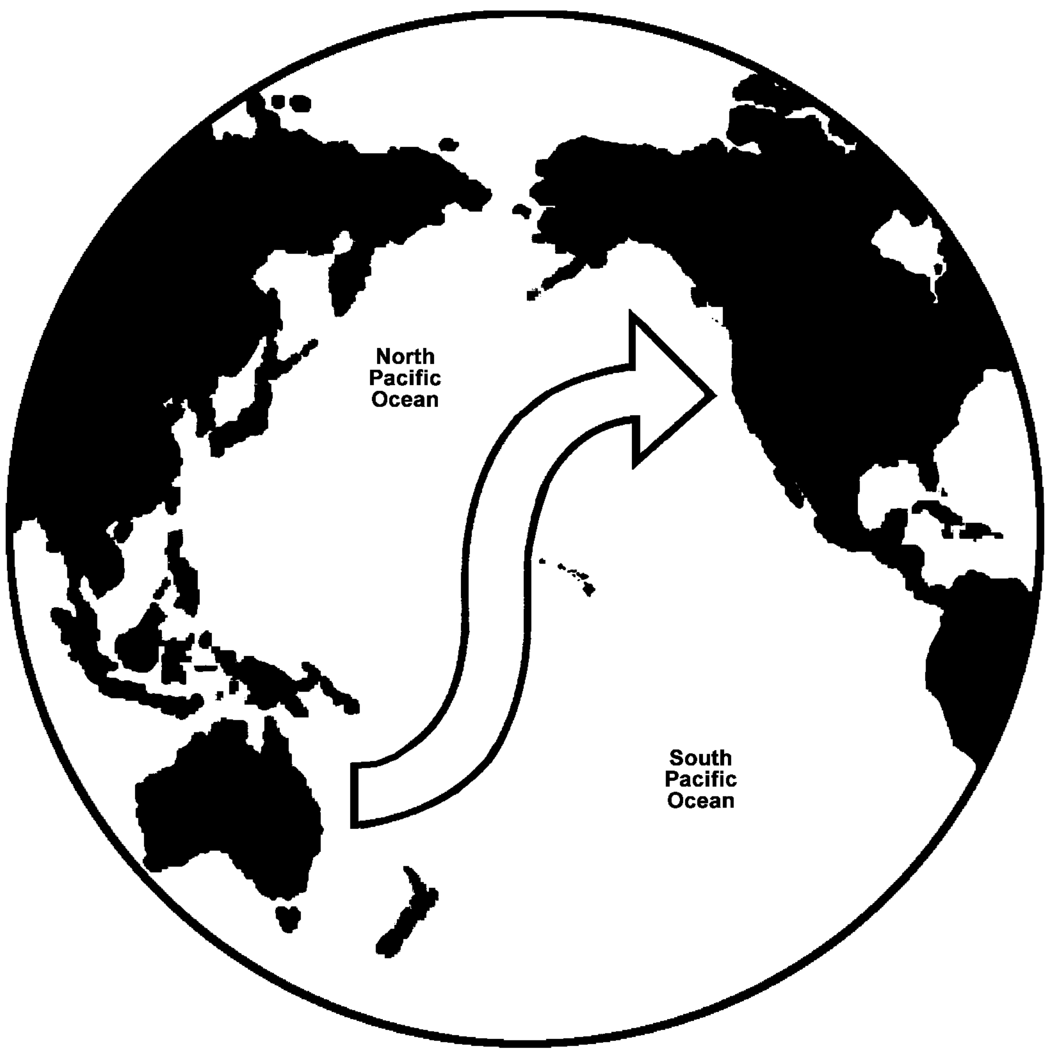
Forest Service

Forest Products Laboratory

General Technical Report FPL–GTR–137

Pest Risk Assessment of the Importation Into the United States of Unprocessed Logs and Chips of Eighteen Eucalypt Species From Australia



Abstract

The unmitigated pest risk potential for the importation of unprocessed logs and chips of 18 species of eucalypts (*Eucalyptus amygdalina*, *E. cloeziana*, *E. delegatensis*, *E. diversicolor*, *E. dunnii*, *E. globulus*, *E. grandis*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. pilularis*, *E. regnans*, *E. saligna*, *E. sieberi*, *E. viminalis*, *Corymbia calophylla*, *C. citriodora*, and *C. maculata*) from Australia into the United States was assessed by estimating the likelihood and consequences of introduction of representative insects and pathogens of concern. Twenty-two individual pest risk assessments were prepared, fifteen dealing with insects and seven with pathogens. The selected organisms were representative examples of insects and pathogens found on foliage, on the bark, in the bark, and in the wood of eucalypts.

Among the insects and pathogens assessed for logs as the commodity, high risk potentials were assigned to the following 14 organisms or groups of organisms: leaf beetles (*Chrysophtharta* and *Paropsis* species, including *C. agricola*, *C. bimaculata*, *P. atomaria*, *P charybdis*, *P. delittlei*), ambrosia beetles and pinworms (*Austroplatypus incompertus*; *Platypus australis*, *P. subgranosus*, *P. tuberculosus*; *Amasa truncatus*; *Ambrosiodmus compressus*; *Xyleborus perforans*; *Xylosandrus solidus*; *Atractocerus crassicornis*, *A. kreuslerae*, *Atractocerus* sp.), round-headed wood borers [*Callidiopsis scutellaris*; *Coptocercus rubripes*, *Coptocercus* sp.; *Epithora dorsalis*; *Hesthesis cingulata*; *Macrones rufus*; *Phlyctaenodes pustulosus*; *Phoracantha* (=*Tryphocaria*) *acanthocera*, *P.* (=*Tryphocaria*) *mastersi*, *P. odewahni*, *P. punctipennis*, *P.* (=*Tryphocaria*) *solida*, *P. tricuspis*; *Scolecobrotus westwoodi*; *Tessaromma undatum*; *Zygocera canosa*], ghost moths and carpenterworms [*Abantiades latipennis*; *Aenetus eximius*, *A. ligniveren*, *A. paradiseus*; *Zelotypia stacyi*; *Endoxyla cinereus* (=*Xyleutes boisduvali*), *Endoxyla* spp. (=*Xyleutes* spp.)], true powderpost beetles (*Lyctus brunneus*, *L. costatus*, *L. discedens*, *L. parallelocollis*; *Minthea rugicollis*), false powderpost or auger beetles (*Bostrychopsis jesuita*; *Mesoxylion collaris*; *Sinoxylon anale*; *Xylion cylindricus*; *Xylobosca bispinosa*; *Xylodeleis obsipa*, *Xylopsocus gibbicollis*; *Xylothrips religiosus*; *Xylotillus lindi*), dampwood termite (*Porotermes adamsoni*), giant termite (*Mastotermes darwiniensis*), drywood termites (*Neotermes insularis*; *Kalotermes rufinotum*, *K. banksiae*; *Ceratokalotermes spoliator*; *Glyptotermes tuberculatus*; *Bifiditermes condonensis*; *Cryptotermes primus*, *C. brevis*, *C. domesticus*, *C. dudleyi*, *C. cynocephalus*), subterranean termites (*Schedorhinotermes intermedius intermedius*, *S. i. actuosus*, *S. i. breinli*, *S. i. seclusus*, *S. reticulates*; *Heterotermes ferox*, *H. paradoxus*; *Coptotermes acinaciformis*, *C. frenchi*, *C. lacteus*, *C. raffrayi*; *Microcerotermes boreus*, *M. distinctus*, *M. implicadus*, *M. nervosus*, *M. turneri*; *Nasutitermes exitiosis*), Botryosphaeria canker pathogen (*Botryosphaeria ribis*), Cryphonectria eucalypti canker pathogen (*Cryphonectria eucalypti*), stain and vascular wilt fungi [*Ceratocystis eucalypti*, *C. moniliformis*, *C. moniliformopsis*, *Ophiostoma pluriannulatum* (or closely related species), *Ceratocystis* spp., *Ophiostoma* spp.; *Chalara* spp., *Graphium* spp., *Leptographium lundbergii* (anamorphic stages of Ophiostomataceae)], and the root-, sapwood-, and heart- rot fungi [*Phellinus gilvus*, *P. noxius*, *P. rimosus*, *P. robustus*, *P. wahlbergii*; *Inonotus albertinii*, *I. chondromyeluis*, *I. rheades*; *Hymenochaete* sp.; *Stereum hirsutum*; *Fistulina spiculifera; Ganoderma lucidum*; *Gymnopilus junonius* (= *G. spectabilus*, = *G. pampeanus*); *Omphalotus nidiformis*; *Perenniporia medulla-panis*; *Piptiporus australiensis*, *P. portentosus*]. A moderate pest risk potential was assigned to four organisms or groups of organisms, including the gumleaf skeletonizer moth (*Uraba lugens*), foliar disease fungi (*Aulographina eucalypti*, *Cryptosporiopsis eucalypti*, *Cylindrocladium* spp., *Phaeophleospora* spp., *Mycosphaerella* spp., *Quambalaria pitereka*), Seiridium canker fungi (*Seiridium eucalypti*, *S. papillatum*), and the Armillaria root rot fungi (*Armillaria fumosa*, *A. hinnulea*, *A. luteobubalina*, *A. novae-zealandiae*, *A. pallidula*). When chips were considered as the commodity, the risk potentials remained high for the true powderpost beetles, false (auger) powderpost beetles, *Cryphonectria eucalypti*, the stain and vascular wilt fungi, and the root-, sapwood-, and heart-rot fungi; dropped from high to moderate for the ambrosia beetles and pinworms and for *Botryosphaeria ribis*; and dropped from high to low for the leaf beetles, the round-headed wood borers, ghost moths and carpenterworms, the dampwood termite, the giant termite, drywood termites, and subterranean termites. The risk potential for the Seiridium canker fungi remained at moderate, while the risk potential for the gumleaf skeletonizer moth, the foliar disease fungi and the Armillaria root rot fungi dropped from moderate to low for the chip commodity. For those organisms of concern that are associated with logs and chips of Australian eucalypts, specific phytosanitary measures may be required to ensure the quarantine safety of proposed importations.

Keywords: pest risk assessment, *Eucalyptus*, *Corymbia*, eucalypt, Australia, log importation, chip importation

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Pest Risk Assessment of the Importation Into the United States of Unprocessed Logs and Chips of Eighteen Eucalypt Species From Australia

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South Australia: Charlma Phillips (Forestry SA)

Other individuals and organizations that provided valuable information are named in the Site Visit Reports in Appendix A.

Portions of this document were extracted from the Chilean Pest Risk Assessment (USDA Forest Service 1993), the Mexican Pest Risk Assessment (Tkacz and others 1998), and the South American Pest Risk Assessment (Kliejunas and others 2001).

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Executive Summary

Background and Objectives

Current regulations require that unprocessed hardwood logs from temperate areas of Australia are fumigated with methyl bromide or heat-treated to eliminate pests. Logs must be stored and handled to exclude access by pests after treatment [Title 7, CFR part 319.40-5(d), 319.40-6(a)]. Chips are required to be of tropical origin from healthy, plantation-grown tropical species or must be fumigated with methyl bromide, heat-treated, or heat-treated with moisture reduction [Title 7, CFR part 319.40-6(c)(2)]. The USDA Animal and Plant Health Inspection Service (APHIS) received requests from forest industry companies interested in exporting eucalypt (*Eucalyptus*, *Corymbia*) chips from Australia and from importers in the United States. APHIS requested that the USDA Forest Service prepare a pest risk assessment. The objectives of the risk assessment were to identify potential pests of 18 species of eucalypts (*Eucalyptus amygdalina*, *E. cloeziana*, *E. delegatensis*, *E. diversicolor*, *E. dunnii*, *E. globulus*, *E. grandis*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. pilularis*, *E. regnans*, *E. saligna*, *E. sieberi*, *E. viminalis*, *Corymbia calophylla*, *C. citriodora*, *and C. maculata*) in Australia, estimate the likelihood of their entry on Australian logs and chips into the United States, and evaluate the economic, environmental, and social consequences of such an introduction.

Risk Assessment Team

A USDA Forest Service Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET) conducted the assessment. The team was chartered by the Chief of the Forest Service to provide a permanent source of technical assistance to APHIS in conducting pest risk assessments. WIPRAMET members and APHIS representatives traveled to Australia in September 2001. The team met with local agricultural, quarantine, and forestry officials, and with entomologists, pathologists, and forest industry representatives to gather information. Sub-teams toured harvest areas, inspected processing plants and ports, and viewed pest problems in eucalypt plantations and forests in six states. The pest risk assessment document prepared by the team also takes into consideration comments by individuals who provided critical reviews of an earlier draft.

Pest Risk Assessment

The team compiled lists of insects and microorganisms known to be associated with 18 Australian species of eucalypts. From these lists, insects and pathogens that have the greatest risk potential as pests on imported logs or chips were identified. Twenty-two Individual Pest Risk Assessments (IPRAs) were prepared, 15 dealing with insects and 7 dealing with pathogens. The objective was to include in the IPRAs representative examples of insects and pathogens found on foliage, on the bark, in the bark, and in the wood. By necessity, this pest risk assessment focuses on those insects and pathogens for which biological information is available. However, by developing IPRAs for known organisms that inhabit a variety of different niches on logs, effective mitigation measures can subsequently be identified by APHIS to eliminate the recognized pests. It is assumed that any similar unknown organisms that inhabit the same niches would also be eliminated.

Conclusions

Numerous potential pest organisms found on eucalypts in Australia have a high probability of being inadvertently introduced into the United States on unprocessed logs and chips. The potential mechanisms of log or chip infestation by pests are complex. Differences in harvesting practices, such as debarking, can influence the risk potential for pests that are hitchhikers or pests that invade the inner bark. Reducing debarked logs to chips will impact the survival and subsequent risk of importation of certain pests. Most insects would be adversely impacted by chipping, and of those for which IPRAs were done, many would be rated at moderate or low risk of surviving chipping and subsequent transport. Other organisms such as stain and vascular wilt fungi may not be affected by chipping or could be negatively affected (Armillaria root rot fungi for example). Differences among Australian states in the occurrence and extent of certain pest organisms are noted in the individual pest risk assessments. These differences may influence the risk potential for certain organisms from specific states.

Among the insects and pathogens assessed for logs as the commodity, high risk potentials were assigned to the following 14 organisms or groups of organisms: leaf beetles (*Chrysophtharta* and *Paropsis* species, including *C. agricola*, *C. bimaculata*, *P. atomaria*, *P charybdis*, *P. delittlei*), ambrosia beetles and pinworms (*Austroplatypus incompertus*; *Platypus australis*, *P. subgranosus*, *P. tuberculosus*; *Amasa truncatus*; *Ambrosiodmus compressus*; *Xyleborus perforans*; *Xylosandrus solidus*; *Atractocerus crassicornis*, *A. kreuslerae*, *Atractocerus* sp.), round-headed wood borers [*Callidiopsis scutellaris*; *Coptocercus rubripes*, *Coptocercus* sp.; *Epithora dorsalis*; *Hesthesis cingulata*; *Macrones rufus*; *Phlyctaenodes pustulosus*; *Phoracantha* (=*Tryphocaria*) *acanthocera*, *P.* (=*Tryphocaria*) *mastersi*, *P. odewahni*, *P. punctipennis*, *P.* (=*Tryphocaria*) *solida*, *P. tricuspis*; *Scolecobrotus westwoodi*; *Tessaromma undatum*; *Zygocera canosa*], ghost moths and carpenterworms [*Abantiades latipennis*; *Aenetus eximius*, *A. ligniveren*, *A. paradiseus*; *Zelotypia stacyi*; *Endoxyla cinereus* (=*Xyleutes boisduvali*), *Endoxyla* spp. (=*Xyleutes* spp.)], true powderpost beetles (*Lyctus brunneus*, *L. costatus*, *L. discedens*, *L. parallelocollis*; *Minthea rugicollis*), false powderpost or auger beetles (*Bostrychopsis jesuita*; *Mesoxylion collaris*; *Sinoxylon anale*; *Xylion cylindricus*; *Xylobosca bispinosa*; *Xylodeleis obsipa*; *Xylopsocus gibbicollis*; *Xylothrips religiosus*;

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A moderate pest risk potential was assigned to four organisms or groups of organisms, including the gumleaf skeletonizer moth (*Uraba lugens*), foliar disease fungi (*Aulographina eucalypti*; *Cryptosporiopsis eucalypti*; *Cylindrocladium* spp.; *Phaeophleospora* spp.; *Mycosphaerella* spp.; *Quambalaria pitereka*), Seiridium canker fungi (*Seiridium eucalypti*, *S. papillatum*), and the Armillaria root rot fungi (*Armillaria fumosa*, *A. hinnulea*, *A. luteobubalina*, *A. novae-zealandiae*, *A. pallidula*).

When chips were considered as the commodity, the risk potentials remained high for the true powderpost beetles, the false (auger) powderpost beetles, *Cryphonectria eucalypti*, the stain and vascular wilt fungi, and the root-, sapwood-, and heart-rot fungi; dropped from high to moderate for the ambrosia beetles and pinworms and for *Botryosphaeria ribis*; and dropped from high to low for the leaf beetles, the round-headed wood borers, ghost moths and carpenterworms, the dampwood termite, the giant termite, drywood termites, and subterranean termites. The risk potential for the Seiridium canker fungi remained at moderate, while the risk potential for the gumleaf skeletonizer moth, the foliar disease fungi and the Armillaria root rot fungi dropped from moderate to low for the chip commodity.

Several factors suggest that eucalypt logs or chips destined for export from Australia may be relatively free of most damaging organisms. There is an excellent working knowledge of forest insects and pathogens and the ability to recognize problem situations when they occur. Commercial eucalypt plantations are generally well managed for maximum production and closely monitored to detect and control damaging pests. However, eucalypts from plantations and from natural Australian forests, depending on location, management intensity, and other factors, may have insects and microorganisms that could be of concern if introduced into the United States.

For those organisms of concern that are associated with the 18 species of Australian eucalypts considered in this pest risk assessment, specific phytosanitary measures may be required to ensure the quarantine safety of proposed importations. Detailed examination and selection of appropriate phytosanitary measures to mitigate pest risk is the responsibility of APHIS and is beyond the scope of this assessment.

Chapter 1. Introduction

Background

There is an increasing interest in importing large volumes of unmanufactured wood articles into the United States from abroad. The United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) is the government agency charged with preventing the introduction of exotic pests on plant material brought into the United States via international commerce. The USDA Forest Service (FS) has provided assistance to APHIS in conducting pest risk assessments of the importation of logs from Russia (USDA Forest Service 1991), New Zealand (USDA Forest Service 1992), Chile (USDA Forest Service 1993), Mexico (Tkacz and others 1998), and South America (Kliejunas and others 2001) according to a memorandum of understanding between the two agencies signed in February 1992.

In September 1995, the Chief of the Forest Service chartered the Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET) made up of FS employees to provide a permanent source of technical assistance to APHIS in conducting pest risk assessments of exotic pests that may move with logs. In November 2000, APHIS requested that WIPRAMET conduct a pest risk assessment of plantation-grown *Eucalyptus globulus* and *E. nitens* from Australia, and *E. amygdalina*, *E. delegatensis*, *E. globulus*, *E. obliqua*, *E. regnans*, and *E. viminalis* from natural stands in Tasmania only, to evaluate the risks associated with the importation of logs and chips into the United States. Following site visits to Australia by team members, the scope of the risk assessment was expanded to include 11 additional species of eucalypts of potential export significance. In addition, the original distinction between plantation grown eucalypts and eucalypts in natural forests was dropped. The final scope then became to conduct a pest risk assessment of 18 species of eucalypts in Australia.

Statement of Purpose

The specific objectives of this risk assessment are to

- identify the potential pest organisms that may be introduced with imported unprocessed eucalypt logs and chips (*E. amygdalina*, *E. cloeziana*, *E. delegatensis*, *E. diversicolor*, *E. dunnii*, *E. globulus*, *E. grandis*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. pilularis*, *E. regnans*, *E. saligna*, *E. sieberi*, *E. viminalis, Corymbia calophylla, C. citriodora*, and *C. maculata*) from Australia (the baseline for this pest risk assessment is raw, unprocessed logs of the 18 listed species, with subsequent consideration of the effect of chipping on potential pest organisms),
- assess the potential for introduction (entry and establishment) in the United States of selected representative Australian pests of the 18 species of eucalypts,
- estimate the potential economic and environmental impacts these pests may have on forest resources and urban trees if established in the United States.

Scope of Assessment

This risk assessment estimates the likelihood that exotic pests will be introduced into the United States as a direct result of the importation of unprocessed eucalypt (*E. amygdalina*, *E. cloeziana*, *E. delegatensis*, *E. diversicolor*, *E. dunnii*, *E. globulus*, *E. grandis*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. pilularis*, *E. regnans*, *E. saligna*, *E. sieberi*, *E. viminalis, Corymbia calophylla, C. citriodora*, and *C. maculata*) logs and chips from Australia. The team and APHIS made site visits to Queensland, New South Wales, Tasmania, South Australia, Victoria, and Western Australia (App. A), where the preponderance of eucalypt plantations and eucalypt natural forests in Australia occur (Ch. 2). Pests addressed in this report are phytophagous insects and plant pathogens. Major emphasis is placed on pests with the potential to be transported on, in, or with unprocessed eucalypt logs and chips destined for export from Australia to the United States. This assessment also estimates the economic and environmental impact of the more potentially destructive organisms if introduced into the United States.

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

Pest Risk Assessment Process

International plant protection organizations [for example, North American Plant Protection Organization (NAPPO) and the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization of the United Nations (FAO)] provide guidance for conducting pest risk analyses. Further guidance pertinent to U.S. wood importation is contained in Title 7, CFR 319.40-11. This risk assessment conforms to the standards for plant pest risk assessments as described therein. The general process is as follows:

1. Collect Commodity Information

- Evaluate permit applications and other sources for information describing the regulated article and the origin, processing, treatment, and handling of the regulated article, namely eucalypt logs and chips from Australia.
- Evaluate data from United States and foreign countries on the history of plant pest interceptions or introductions associated with eucalypt logs and chips from Australia.

2. Catalog Pests of Concern

- Determine what plant pests or potential plant pests are associated with eucalypt logs and chips in Australia. A plant pest that meets one of the following categories is a quarantine pest according to Title 7, CFR 319.40-11 and will be further evaluated:

  Category 1—Nonindigenous plant pest not present in the United States

  Category 2—Nonindigenous plant pest, present in the United States and capable of further dissemination in the United States

  Category 3—Nonindigenous plant pest that is present in the United States and has reached probable limits of its ecological range, but differs genetically (for example, biotypes, pathovars, strains) from the plant pest in the United States in a way that demonstrates a potential for greater damage in the United States

  Category 4—Native species of the United States that has reached probable limits of its ecological range, but differs genetically from the plant pest in the United States in a way that demonstrates a potential for greater damage in the United States

  Category 5—Nonindigenous or native plant pest capable of vectoring another plant pest that meets one of the above criteria

In addition to these criteria for quarantine pests as specified in the log import regulations, WIPRAMET determined that a broader definition of genetic variation was needed for Category 4. The definition of this category was expanded to include native species that have reached the probable limits of their range but *may* differ in their capacity for causing damage, based on the genetic variability exhibited by the species (Category 4a). There are uncertainties and unknowns about the genetic variability and damage potential of many pest organisms in forest ecosystems. Because of these unanswered questions, the team was cautious in its assessments and included additional pests of concern not considered under the requirements of the log import regulations.
For Category 2, the team added native organisms with limited distributions within the United States but capable of further dissemination (Category 2a). Some of these organisms may occupy a limited distribution only because they have not been afforded the opportunity to exploit additional environments.

3. Determine Which Pests of Concern to Assess

- Arrange pests of concern identified using cataloging criteria by location on host (such as, foliage–branches, bark–cambium, sapwood, heartwood).
- Evaluate the plant pests in each location on the host according to pest risk, based on the available biological information and demonstrated or potential plant pest importance.
- Conduct IPRAs for the pests of concern. Identify any quarantine plant pests for which plant pest risk assessments have been previously performed in accordance with 7 CFR 319.40-11 and determine their applicability to the proposed importation from Australia. Pests with similar biology and that attack similar plant parts were evaluated in the same IPRA because they would react similarly to the same mitigation measures. The lack of biological information on any given insect or pathogen should not be equated with low risk (USDA Forest Service 1993). By necessity, pest risk assessments focus on those organisms for which biological information is available. By developing detailed assessments for known pests that inhabit different locations on imported logs (namely, on the surface of the bark, within the bark, and deep within the wood), effective mitigation measures can subsequently be developed to eliminate the known organisms and any similar unknown ones that inhabit the same niches.

4. Evaluate Likelihood of Introduction and Consequences of Introduction for each IPRA

- Assign a risk value (high, moderate, or low) for each of seven elements.

Risk value is based on available biological information and subjective judgment of the assessment team. The seven elements and the rating criteria used to determine risk value for each element are listed in the following sections. The seven elements are described in Orr and others (1993). The individual rating criteria were developed by the team preparing the draft solid wood packing material pest risk assessment (USDA Animal Plant Health Inspection Service and Forest Service 2000) to facilitate the assignment of low, moderate, or high risk to each of the seven elements. Those rating criteria were used by WIPRAMET in a previous pest risk assessment (Kliejunas and others 2001), and here in a slightly modified form, in an attempt to make the assignment of a high, moderate, or low risk rating more consistent, objective, and transparent.

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

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

Source: Orr and others 1993.

Each specific element in the pest risk assessment is assigned a certainty code (Table 1) as described in Orr and others (1993). The seven elements have different critical components, the combination of which is used to determine rating levels. Rating criteria serve as guidelines for assigning values of high, moderate, or low pest risk for the seven elements that make up the determination of pest risk potential. If scientific information is lacking for a criterion for a particular organism, an evaluation of the criterion's appropriateness may be made based upon characteristics of closely related organisms. Organism complexes such as an insect vector and associated pathogen are to be rated as a unit; therefore, the term organism as used herein pertains to the complex of concern. The risk value for an element may be modified based upon knowledge of important biological characteristics not addressed by the criteria following each element. The seven elements are broken into two parts, likelihood of introduction and consequences of introduction.

Likelihood of Introduction

In this section, the elements pertain to estimating the likelihood that the pest will enter, colonize, and spread in the United States. Exotic organisms are considered established once they have formed a self-sustaining, free-living population at a given location (U.S. Congress Office of Technology Assessment 1993).

Element 1. Pest with host-commodity at origin potential—Likelihood of the plant pest being on, with, or in eucalypt logs and/or chips at the time of importation. The affiliation of the pest with the host or commodity, both temporally and spatially, is critical to this element.

High risk = Criterion a applies, or five or more of criteria b through h apply.

Moderate risk = Criterion a does not apply, and two to four of criteria b through h apply.

Low risk = Criterion a does not apply, and one or none of criteria b through h applies.

Rating criteria:

a. Organism has been repeatedly intercepted at ports of entry in association with host materials.

b. Organism has capability for large-scale population increases.

c. Populations of organism are widely distributed throughout range of host(s).

d. Organism has multiple or overlapping generations per year or an extended period (several months or more) of colonization activity, thereby having capability to infest or infect new host material throughout at least one quarter of a year.

e. One or more stages of the organism may typically survive in the plant host for an extended period of time.

f. Organism has active, directed host searching capability or is vectored by such an organism. Colonization activity may be directed by attraction to host volatiles, pheromones, or lights. Organism may be generally associated with recently cut or damaged host material.

g. Organism has wide host range, or primary plant hosts are widely distributed in several regions of the world.

h. Organism is unlikely to be dislodged from host or destroyed during standard harvesting and handling operations.

Element 2. Entry potential—Likelihood of the plant pest surviving in transit and entering the United States undetected. Important components of this element include the pest's ability to survive transport, which includes such things as the life stage and number of individuals expected to be associated with the logs, chips, or transport vehicles.

High risk = Criterion a applies, or two or more of criteria b through d apply.

Moderate risk = Criterion a does not apply, and one of criteria b through d applies.

Low risk = None of the following four criteria applies.

Rating criteria:

a. Multiple interceptions of live specimens of organism have been made at ports of entry in association with host materials.

b. One or more stages of the organism are likely to survive in the plant host during transportation.

c. Organism is protected within host material or is unlikely to be dislodged from host or destroyed during standard handling and shipping operations.

d. Organism is difficult to detect (for example, concealment within host material, small size of organism, cryptic nature of organism, random distribution of organism in, on, or associated with host material).

Element 3. Colonization potential—Likelihood that the plant pest will successfully colonize once it has entered the United States. Some characteristics of this element include the number and life stage of the pest translocated, host specificity, and likelihood of encountering a suitable environment in which the pest can reproduce.

High risk = Criterion a applies, or criterion b and two or more of criteria c through e apply.

Moderate risk = Criterion a does not apply; criterion b applies, or two or more of criteria c through e apply.

Low risk = Criteria a and b do not apply; none or only one of criteria c through e applies.

Rating criteria:

a. Organism has successfully established in location(s) outside its native distribution.

b. Suitable climatic conditions and suitable host material coincide with ports of entry or major destinations.

c. Organism has demonstrated ability to utilize new hosts.

d. Organism has active, directed host searching capability or is vectored by an organism with directed host searching capability.

e. Organism has high inoculum potential or high likelihood of reproducing after entry.

Element 4. Spread potential—Likelihood of the plant pest spreading beyond any colonized area. Factors to consider include the pest's ability for natural dispersal, the pest's ability to use human activity for dispersal, the pest's ability to develop races or strains, the distribution and abundance of suitable hosts, and the estimated range of probable spread.

High risk = Five or more of the following eight criteria apply.

Moderate risk = Two to four of the following eight criteria apply.

Low risk = One or none of the following eight criteria applies.

Rating criteria:

a. Organism is capable of dispersing more than several kilometers per year through its own movement or by abiotic factors (such as wind, water, or vectors).

b. Organism has demonstrated ability for redistribution through human-assisted transport.

c. Organism has a high reproductive potential.

d. Potential hosts have contiguous distribution.

e. Newly established populations may go undetected for many years due to cryptic nature, concealed activity, slow development of damage symptoms, or misdiagnosis.

f. Eradication techniques are unknown, infeasible, or expected to be ineffective.

g. Organism has broad host range.

h. Organism has potential to be a more efficient vector of a native or introduced pest.

Consequences of Introduction

In this section, the elements pertain to estimating the potential consequences if the pest were to become established in the United States.

Element 5. Economic damage potential—Estimate of the potential economic impact if the pest were to become established. Factors to consider include economic importance of hosts, crop loss, effects on subsidiary industries, and availability of eradication or control methods.

High risk = Four or more of the following six criteria apply.

Moderate risk = Two or three of the following six criteria apply.

Low risk = One or none of the following six criteria applies.

Rating criteria:

a. Organism attacks hosts or products that have significant commercial value (such as timber, pulp, wood products, wooden structures, Christmas trees, fruit or nut trees, syrup-producing trees).

b. Organism directly causes tree mortality or predisposes host to mortality by other organisms.

c. Damage by organism causes a decrease in value of the host affected, for instance, by lowering its market price; increasing cost of production, maintenance, or mitigation; or reducing value of property where it is located.

d. Organism may cause loss of markets (foreign or domestic) due to presence of pests and quarantine-significant status.

e. Organism has demonstrated ability to develop more virulent strains or damaging biotypes.

f. No known control measures exist.

Element 6. Environmental damage potential—Estimate of the potential environmental impact if the pest were to become established in the United States. Factors to consider include potential for ecosystem destabilization, reduction in biodiversity, reduction or elimination of keystone species, reduction or elimination of endangered or threatened species, and nontarget effects of control measures.

High risk = Criterion a or b applies, or two or more of criteria c through f apply.

Moderate risk = One of criteria c through f applies, and neither criterion a nor b applies.

Low risk = None of the following six criteria applies.

Rating criteria:

a. Organism is expected to cause significant direct environmental effects, such as extensive ecological disruption or large-scale reduction of biodiversity.

b. Organism is expected to have direct impacts on species listed by Federal or state agencies as endangered, threatened, or candidate. An example would be feeding on a listed plant species.

c. Organism is expected to have indirect impacts on species listed by Federal or state agencies as endangered, threatened, or candidate. This may include disruption of sensitive or critical habitat.

d. Organism may attack host with limited natural distribution.

e. Introduction of the organism would probably result in control or eradication programs that may have potential adverse environmental effects.

f. Organism has demonstrated ability to develop more virulent strains or damaging biotypes.

Element 7. Social and political considerations—Estimate of the impact from social and/or political influences, including the potential for aesthetic damage, consumer concerns, and implications for domestic and international trade.

High risk = Two or more of the following four criteria apply.

Moderate risk = One of the following four criteria applies.

Low risk = None of the following four criteria applies.

Rating criteria:

a. Damage by organism would probably result in public concerns (aesthetic, recreational, concern about urban plantings).

b. Presence of organism would likely have domestic trade implications.

c. Presence of organism would likely interfere with or burden domestic interstate commerce, trade, or traffic.

d. Known effective control measures are likely to have limited acceptance.

5. Estimate Unmitigated Pest Risk Potential

The assessment team developed an estimate of the unmitigated plant pest risk for each individual pest risk assessment based on the compilation of the risk values for the seven risk elements. The method for compilation is presented in Orr and others (1993).

- Determine the likelihood of introduction: The overall risk rating for the likelihood of introduction acquires the same rank as the single element with the lowest rating.
- Determine the consequences of introduction: Table 2 presents a method for ascertaining consequences of introduction for a specific pest organism or group of organisms with similar habits, based on the individual ratings for economic and environmental damage potentials and social and political considerations.
- Determine the pest risk potential: The pest risk potential for each IPRA is determined based on the ratings for likelihood of introduction and consequences of introduction (Table 3).

For this assessment, the team considered eucalypt logs and eucalypt chips as two separate commodities, and a separate pest risk potential was estimated for each. Because the rating for element 1 (the likelihood of the pest being on, with, or in the commodity at the time of importation) and for element 2 (likelihood of the pest surviving in transit and entering the United States undetected) may change depending on whether the commodity is logs or chips, a separate rating for each of these two elements was estimated. The effects of any changes in rating for the two elements was then reflected by determining a pest risk potential for logs and a pest risk potential for chips.

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

Economic damage potential	Environmental damage potential	Social and political considerations	Consequences of introduction
H	L, M, or H	L, M, or H	H
L, M, or H	H	L, M, or H	H
M	M	L, M, or H	M
M	L	L, M, or H	M
L	M	L, M, or H	M
L	L	M or H	M
L	L	L	L

[a] L, low; M, moderate; H, high.
Source: Orr and others 1993.

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

Likelihood of introduction [b]	Consequences of introduction	Pest risk potential
H	H	H
M	H	H
L	H	M or L [c]
H	M	H
M	M	M
L	M	M or L [c]
H	L	M
M	L	M
L	L	L

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

Source: Orr and others 1993.

Outreach

In an effort to gather information pertinent to the pest risk assessment, WIPRAMET contacted scientists and specialists in the fields of forestry, forest entomology, and forest pathology and in the timber industry throughout the United States, Australia, Canada, England, France, Indonesia, New Zealand, and the Republic of South Africa. A preliminary list of potential organisms of concern was compiled and mailed to 125 individuals for review. Suggested revisions to the list were incorporated into the final list prepared by WIPRAMET.

Site Visits

Site visits to the subject countries were an integral part of previous pest risk assessments. Teams of FS and APHIS specialists traveled to Russia (USDA Forest Service 1991), New Zealand (USDA Forest Service 1992), Chile (USDA Forest Service 1993), Mexico (Tkacz and others 1998), and South America (Kliejunas and others 2001) while working on pest risk assessments of those countries. Those site visits allowed the assessment teams to meet with local agricultural, quarantine, and forestry officials and entomologists, pathologists, and forest industry representatives to gather information on the proposed importation. The teams also visited harvest areas, inspected processing plants and ports, viewed pest problems in plantations and forests, and evaluated mitigation procedures. The site visits allowed assessment teams to gather information that is not readily available in the literature and to verify pest risk assessments.

For this pest risk assessment, eight members of WIPRAMET and two APHIS officials conducted a site visit to Australia from September 12 to September 28, 2001. The entire team met in Canberra with various Australian officials September 12 to 14. The team then split into three sub-teams or groups, with one group traveling to Queensland and New South Wales, the second group to Victoria and Western Australia, and the third group to Tasmania and South Australia. In addition to eucalypt plantations and eucalypt natural forests, the sub-teams also looked at *Pinus radiata* plantations in anticipation of a future pest risk assessment of radiata pine. The team reconvened in Canberra September 27 for a closeout session with Australian officials. (See App. A for trip reports.)

Resources at Risk

The commodity being assessed for its potential to introduce plant pests into the United States is unprocessed logs and woodchips of 18 Australian eucalypts. Therefore, the domestic resources at risk include, but may not be limited to, *Eucalyptus* and related species. The nature of the impacts of concern (for example, mortality or reduced yield) and the susceptible hosts (*Eucalyptus* or non-*Eucalyptus*) are pest specific and are addressed by the individual pest risk assessments.

Eucalypts (*Eucalyptus*, *Corymbia*, and *Angophora*) are members of the family Myrtaceae (Myrtles) and are native to Australia, Philippines, Papua New Guinea, and Indonesia. There are no members of the Myrtaceae native to the continental United States. Several species are native to Hawaii, with *Metrosideros polymorpha* (Gaud.) Rock (ohia-lehua) the most significant. Species of *Eucalyptus, Leptospermum,* and *Luma* (members of the Myrtaceae) have been introduced into the continental United States, and in certain areas, some species have naturalized. Numerous species of Myrtaceae have been introduced into Hawaii, some of which are agricultural crops [such as *Psidium guajava* L. (guava), and *Pimenta dioica* (L.) Merrill (allspice)]. Guava is also a minor horticultural crop in Florida.

Eucalyptus species were first introduced into the continental United States in the mid-1800s. The earliest introduction was of *E. globulus* into California in 1856 where it has since become naturalized (Skolmen and Ledig 1990). Since then, additional introductions of this and other *Eucalyptus* species have been made, principally into California, Florida, and Arizona. In Arizona, they were the most widely planted evergreen shade tree in the southern part of the state (Mariani and others 1978). The earliest plantings in Florida occurred in 1878 on Merritt Island (Geary and others 1983). During the 1960s, there was an effort by public agencies and private pulp and paper companies in Florida to expand plantings. This led to the development of a research cooperative, which planted nearly 6,500 hectares (16,000 acres) with 8.8 million seedlings of *E. grandis* between 1972 and 1982 in southwestern Florida (Meskimen 1983). Some test plantings have been made in other southeastern states, but freezing temperatures appear to limit the success of such plantings (Jahromi 1982). The species most commonly and widely planted are *E. globulus*, *E. grandis*, and *E. robusta*. The first record of *Eucalyptus* planted in Hawaii is from 1909, although earlier introductions probably occurred (Ziegner 1996). The planting of *Eucalyptus* in Hawaii has expanded in recent years in anticipation of a chip market.

Much of the planting has been for ornamental and landscape purposes, especially in coastal areas of California and in southern Florida. However, some commercial plantations have been attempted in both states. At the end of 1973, about 110,000 hectares (271,800 acres) of *Eucalyptus* had been planted in the United States, with 80,000 (197,700 acres) in California, 12,000 (29,700 acres) in Hawaii, and 18,000 (44,500 acres) in other states (Jacobs 1979). There was an estimated 38,900 hectares (96,000 acres) of *Eucalyptus* type in California in 1985, plus an additional 3,200 hectares (8,000 acres) of *Eucalyptus* in conifer type (Bolsinger 1988). Forest type is a classification of land based on the tree species forming a plurality of live tree stocking. Of this, about 24,700 hectares (61,000 acres) of *Eucalyptus* woodland (areas where timber species make up less than 10% of the stocking) had some evidence of harvesting. Estimates of the volume of *Eucalyptus* in California have been developed. In timberland situations (timber species make up more than 10% of the stocking), there was approximately 283,000 m^3 (10 million ft^3) in 1988.

In woodlands, this volume was 6.26 million m^3 (221 million ft^3). The majority of this is in the central coast area, San Joaquin Valley, and southern California (Bolsinger 1988). Much of this is in small woodlot situations, but in the early 1990s, 4,000 hectares (10,000 acres) of *E. camaldulensis* and *E. viminalis* were planted in the Sacramento Valley of northern California to provide a source of pulp (Flynn and Shield 1999). Other suggested uses for eucalypt trees include effluent remediation, storm water remediation, irrigation remediation, and energy production (Rockwood 1996).

A significant use of *Eucalyptus* in the United States is in the floriculture trade. Plants are grown for their foliage, which is used in arts and crafts and by the floral industry. Domestic production of cut cultivated greens in 1998 was 2.6 billion stems, of which 73% was a non-*Eucalyptus* species (leather leaf ferns) (Economic Research Service 1999). Domestic production of cut cultivated greens in 1998 involved 758 operations with approximately $130 million in sales, while floricultural production of *Eucalyptus* involved 119 operations, approximately 16.8 million bunches, and total sales of $17.8 million (approximately 14% of total cut cultivated green sales). California is the leading state in floricultural production of *Eucalyptus*, representing 85% of all operations with 97% total sales (National Agricultural Statistics Service 2001). An estimate of *E. pulverulenta* (the common species used in greens) in California in 1990 ranged from 400 to 1,200 hectares (1,000 to 3,000 acres) (Dahlsten and others 1998). Most of this was in small parcels.

Another use of the plant material is for the production of *Eucalyptus* oils that are used in medicines, flavorings, and cosmetics. This market provides about 1,814 to 2,722 metric tons (tonnes) (2,000 to 3,000 tons) per year worldwide. Lawrence (1993) listed *Eucalyptus* as the third top essential oil produced in the world with production of 3,382 metric tons (3,728 tons) and a value of US$29.8 million dollars. The major producers of cineole-rich oils, which are valued for their medicinal qualities, are China, Portugal, Spain, Chile, the Republic of South Africa, and Swaziland (Boland and others 1991). In the United States, however, there is currently no known production of these oils or production of *Eucalyptus* for these oils.

Some of the damaging organisms that could be introduced to the United States on eucalypts may not be limited to eucalypts. A thorough knowledge of which native or introduced species in the United States could be hosts is not available, but individual assessments may identify specific species. The native forests of the United States and the associated resources have been described in previous risk assessments (Tkacz and others 1998, USDA Forest Service 1991, USDA Forest Service 1992, USDA Forest Service 1993). This information may provide some general knowledge of the potential resources at risk in addition to eucalypts.

Chapter 2. Eucalypt Resources of Australia

Eucalypt Taxonomy

Eucalypts (*Eucalyptus*, *Corymbia, Angophora*) are a group of closely related hardwood evergreen forest trees native to Australia and its northern neighbors. The group contains approximately 500 named species and subspecies and numerous named hybrid varieties (Blakely 1965, Chippendale 1988). Only seven species of *Eucalyptus* occur naturally outside of Australia. Taxonomy of the three genera is unsettled. Hill and Johnson (1995) recognized the bloodwood and ghost gum groups of the genus *Eucalyptus* as a distinct genus, *Corymbia*. They created 33 new species and transferred 80 *Eucalyptus* species to the new genus. More recently the genera *Corymbia* and *Angophora* have been transferred back into the genus *Eucalyptus* (Brooker 2000). This risk assessment uses the classification of Hill and Johnson (1995), and the term eucalypt is used to include the genera *Eucalyptus*, *Corymbia*, and *Angophora*. See Appendix B for scientific authorities of *Eucalyptus*, *Corymbia*, and *Angophora* species discussed in this assessment. The genus *Eucalyptus* (the gums) and closely related genera *Corymbia* (the bloodwoods and ghost gums) and *Angophora* (the apples) are in the family Myrtaceae, a family of some 140 genera and 3,000 species found mainly in Australia, Central and South America, and Malaysia (Morley and Toelken 1983).

The taxonomic fluidity of the eucalypts is a result of the group's adaptability. Eucalypts have adapted to a wide range of environmental conditions and habitats, resulting in an extreme diversity of morphological characteristics and forms. Members of the group can be shrubs, mallees (having several stems from a common lignotuber), or trees. For example, *E. pauciflora* (snow gum) may have a shrubby habit at higher elevations, while *E. regnans* (mountain ash) often exceeds 100 m (328 ft) in height, making it the tallest hardwood in the world.

Natural Eucalypt Forests in Australia

The natural forests of Australia are distributed around the northern, eastern, southeastern, and southwestern coasts of the mainland and in various regions of Tasmania that generally receive more the 380 mm (15 in.) of rainfall per year (Fig. 1). The total area of Australian natural forest is about 156 million hectares (385.5 million acres), or about 21% of the continent (National Forest Inventory 1998). The most common natural forest types are those dominated by eucalypts (*Eucalyptus* and *Corymbia*), which make up 80% (about 124 million hectares, or 306.4 million acres) of the total area. Other forest types include Acacia (7.9%), Melaleuca (2.6%), Rainforest (2.3%), Mangrove (0.7%), and Other (6.6%) (National Forestry Inventory 1998). Areas of forest types by crown cover classes (Woodland, 20%–50% crown cover; Open Forest, 51%–80%; Closed Forest, 81%–100%) are presented in Table 4.

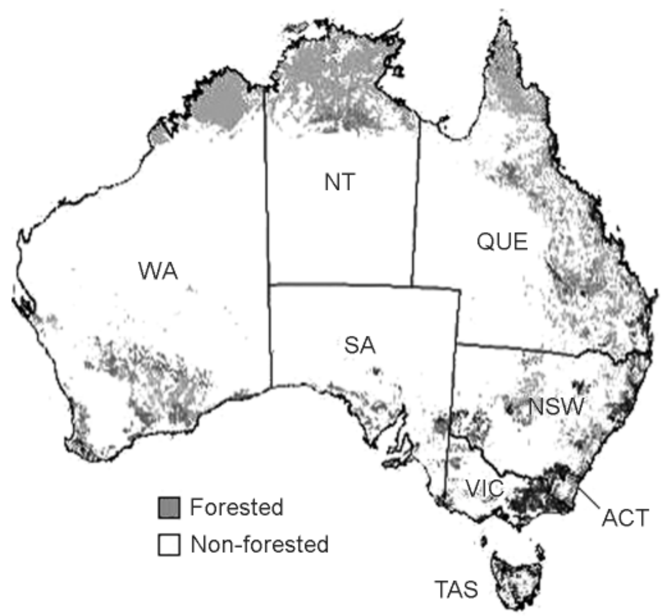

Figure 1—Locations of forested areas in Australia. (For a detailed color map, see http://www.affa.gov.au/image3/rural_science/nfi/forestinfo/fortype.jpg.)

Table 4—Area (thousands hectares) of native forest in Australia by forest type and crown cover

	Crown cover			
Forest type	Woodland (20%–50%)	Open (51%–80%)	Closed (81%–100%)	Total
Eucalypt	91,759	32,703	nil	124,463
Acacia	10,603	1,695	nil	12,299
Melaleuca	3,215	878	nil	4,093
Rainforest	nil	nil	3,583	3,583
Mangrove	nil	nil	1,045	1,045
Other	6,455	3,898	nil	10,354
Total[a]	112,032	39,174	4,628	155,835

[a]Column and row totals may not add up due to rounding.
Source: National Forest Inventory 1998.

The natural eucalypt forests are classified as tall open forests (wet sclerophyll forest), medium and low open forests (dry sclerophyll forest), woodland, or mallee. Tall open forests cover 5.5 million hectares (13.6 million acres), or about 4% of the total native forest area (National Forest Inventory 1998). Trees in these forests are generally 30 m (98.4 ft) or more in height and prefer good soil and plentiful rain. Their leaves form a thin canopy (foliage cover of 30% to 70%) that lets some sunlight through to the ferns and palms in the understory. The three broad groups of wet sclerophyll eucalypts are those of northern Queensland, southern Queensland and central New South Wales; those of Victoria, Tasmania, and the highlands of New South Wales; and those of southwest Western Australia (Ashton and Attiwill 1994). Common species include *E. cloeziana* (Gympie messmate), *E. grandis* (flooded gum), *E. dunnii* (Dunn's white gum), *E. saligna* (Sydney blue gum) and *E. pilularis* (blackbutt) in Queensland and New South Wales; *E. nitens* (shining gum) in New South Wales and Victoria; *E. regnans* (mountain ash), *E. viminalis* (ribbon gum), *E. globulus* (Tasmanian blue gum), and *E. obliqua* (messmate stringybark) in Victoria and Tasmania; *E. sieberi* (silvertop ash) and *E. delegatensis* (alpine ash) in New South Wales to Victoria and northeast Tasmania; and *E. diversicolor* (karri) in southwest Western Australia.

The tall open forests gradually grade into medium open forests (dry sclerophyll forests). The medium and low open forests cover 23.0 million hectares (56.8 million acres), or about 15% of Australia's total native forest area (National Forest Inventory 1998). These forests are found in drier areas, lack much of the structural complexity of their wetter counterparts, and the vegetation reaches 12 to 30 m (39.4 to 98.4 ft) in height. Most trees have thick leaves to reduce moisture loss. Most are well adapted to fire. The three major zones are subcoastal southeastern Australia from Adelaide to Brisbane; Tasmania; and southwestern Australia (Gill 1994). Common species include *E. rossii* (tableland scribbly gum), *E. macrorhyncha* (red stringybark), *E. ovata* (swamp gum), *C. maculata* (spotted gum), and *C. citriodora* (lemon-scented gum), in southeastern Australia; *E. amygdalina* (black peppermint) in Tasmania; and *E. marginata* (jarrah) and *C. calophylla* (marri) in southwestern Australia.

The open forests grade into woodland as rainfall decreases. Woodlands occupy 84.2 million hectares (208.1 million acres), or about 54% of the total native forest area (National Forest Inventory 1998). Woodlands are characterized by 10% to 30% foliage cover and ground vegetation composed mostly of grasses. About 80% of all eucalypts are woodland species. Some woodland species of eucalypts include *E. tetrodonta* (Darwin stringybark) and *E. papuana* (ghost gum) in northern Western Australia to Queensland; *E. drepanophylla* (narrow-leaved ironbark), *E. melanophloia* (silver-leaved ironbark), and *E. sideroxylon* (mugga) in Queensland and New South Wales; *E. melliodora* (yellow box) and *E. moluccana* (grey box) in New South Wales and Victoria; and *E. marginata* (jarrah), *E. wandoo* (wandoo), and *E. gomphocephala* (tuart) in southwest Western Australia.

The mallee forest type consists of low-growing eucalypts, generally 2 to 10 m (6.6 to 32.8 ft) tall, with multiple stems arising at ground level from a lignotuber (a large bulbous woody root). They occur primarily across the south of Australia in areas that generally receive 200 to 380 mm (7.9 to 15 in.) of rainfall per year. Mallee forests occupy 11.8 million hectares (29.2 million acres), or about 8% of Australia's native forests (National Forest Inventory 1998). Some mallee species are *E. diversifolia* (white mallee), *E. incrassata* (lerp mallee), and *E. viridis* (green mallee).

About 72% of the natural forests in Australia are on publicly owned lands. Tenure of Australia's 124 million hectares (306.4 million acres) of natural eucalypt forest is divided among five categories—conservation reserves (12% of the total), multiple-use forests (9%), leasehold land (41%), other crown land (11%), and private (27%). Conservation reserves are publicly owned forests reserved for conservation. National Parks and floral reserves are in this group, with no timber harvesting occurring. Multiple use forests are publicly owned forests set aside for timber production and other uses, including mining; state forest and timber reserve lands are included here. Leasehold land is publicly owned land leased from the crown; some timber harvesting occurs, but grazing is the primary use. Other crown land contains forests on publicly owned (crown) lands not covered by the previous three categories (such as Aboriginal reserves, defense lands, mining reserves). The fifth category, private or freehold, is land owned by private individuals and companies; various management uses include timber production (National Forest Inventory 1998).

About 28 million hectares (69.2 million acres) of the 124 million hectares (306.4 million acres) of eucalypt forest type is potentially productive forest (Australian Forestry Council 1989). Production of wood for industrial purposes is restricted to about 13 million hectares (32.1 million acres) by factors such as lack of accessibility and conservation reserves (Commonwealth of Australia 1997).

In most Australian states, the harvest of eucalypt sawlogs increased progressively from about 1930, peaked between 1955 and 1980, and is now declining. The volume harvested has remained fairly stable through the 1990s. In 1997 to 1998, 10.3 million m^3 (363.7 million ft^3) of native hardwoods (mainly eucalypts) was removed for timber and woodchips, and it is predicted that this level will be maintained until 2005 (Australian Bureau of Agricultural and Resource Economics 1999). By the year 2005, annual hardwood removals (mainly eucalypt) from Australia's native forests will be 10.1 million m^3, or 356.7 million ft^3 (Australian Bureau of Agricultural and Resource Economics 1999).

Table 5—Area of softwood and hardwood plantations in Australia by State and Territory, September 2000

State/Territory	Area (hectares) of plantation type: Soft-wood	Hard-wood	Mixed spp.[a]	Un-known	Total
Australian Capital Territory	14,585	194	0	0	14,779
New South Wales	270,672	44,626	2,678	923	318,898
Northern Territory	5,235	1,649	29	0	6,913
Queensland	178,620	9,435	2,660	192	190,907
South Australia	113,871	20,703	718	261	135,553
Tasmania	75,630	109,567	0	0	185,197
Victoria	215,110	101,453	2,035	35	318,633
Western Australia	98,441	214,993	430	0	313,864
Total[b]	972,164	502,620	8,549	1,411	1,484,743

[a]Mixed hardwood and softwood species, or mixed hardwood species.
[b]Column and row totals may not add exactly because of rounding.
Source: Wood and others 2001.

Plantations in Australia

Australia has approximately 1.5 million hectares (3.7 million acres) of plantations (Table 5), of which about 972,164 hectares (2.4 million acres) (65%) are softwood species and 502,620 hectares (1.2 million acres) (34%) are hardwood species, mostly eucalypts (Wood and others 2001). The area of plantations varies by state (Fig. 2). Although softwoods remain the majority of the total plantation area, the area of hardwoods is rapidly expanding (Fig. 3) (Wood and others 2001). Nearly 90% of plantings in 1999 were hardwood, increasing the proportion of hardwoods in the plantation estate to 29% compared with 25% in 1998. More than 80% of plantation wood is domestically processed. Plantation timber exceeds timber from native forests in volume and value, and represents about two thirds of all forest products.

Hardwood plantations are dominated by *Eucalyptus* species. Of the total area of hardwood species [502,620 hectares (1.2 million acres)], *E. globulus* constitutes 64% [311,344 hectares (769,348 acres)] and other eucalypts 19%. Tropical rainforest and other hardwood species (including *Acacia mangium* Willd., *Flindersia* spp., minor *Eucalyptus* and *Corymbia* spp.) make up the remaining 17%. In addition to *E. globulus*, the major eucalypt species planted are *E. nitens* [28,123 hectares (69,493 acres)], predominantly in Tasmania; *E. regnans* [12,276 hectares (30,335 acres)], predominantly in Victoria; *E. pilularis* and *E. grandis* [26,430 hectares (65,310 acres)], predominantly in New South Wales and Queensland; and *E. dunnii* [7,374 hectares (18,222 acres)], predominantly in New South Wales (Wood and others 2001).

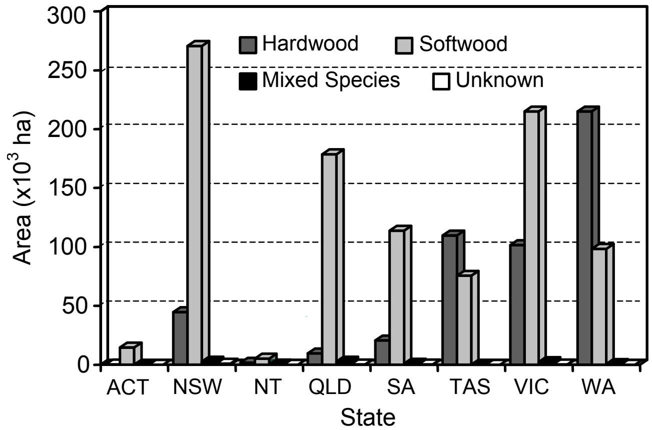

Figure 2—Plantation areas by State and type, September 2000. Source: Wood and others 2001.

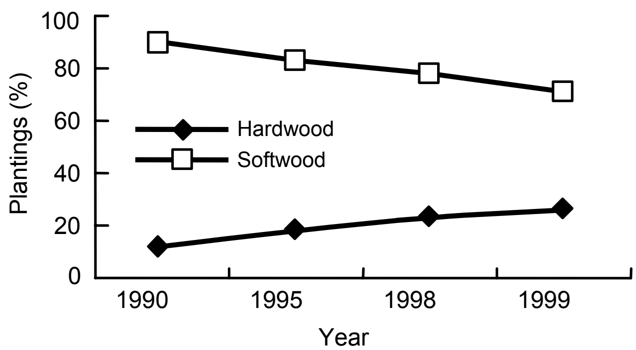

Figure 3—Trends in hardwood and softwood plantings in Australia, 1990-1999. Source: Wood and others 2001.

Eucalypt plantations are generally grown on short rotations (10 to 25 years) to provide a source of wood fiber for producing pulp and paper. Most of the current investment in eucalypts is being undertaken by the private sector for either domestic production of pulp and paper or woodchip exports. More recently, an interest has been developing in multi-product management due to the lower-than-expected returns in the pulpwood market. Higher value utilization, however, may require longer rotation periods and greater investments in management (for example, pruning and thinning) and research (utilization) (Flynn and Shield 1999).

The majority of Australian eucalypt plantations are in private ownership. About 65% of the plantation resource planted since 1990 has been on private lands. Gunns Ltd. is Australia's largest exporter of hardwood pulpwood chips, with Japan the primary market. Bunnings Forest Products, a subsidiary of Wesfarmers Limited, is probably second ranked in eucalypt plantations and is also a major exporter of eucalypt pulpwood chips to Japan. Boral Timber, a subsidiary of the building materials and energy company Boral

Limited, is another major exporter of eucalypt pulpwood chips and Australia's largest hardwood sawmill interest. Other major owners of eucalypt plantations in Australia are the Japanese pulp and paper companies Oji Paper, Nippon Paper Industries, and associated trading houses Itochu, Nissho-Iwa, and Mitsui & Co. These plantations are located in Western Australia, South Australia, and Victoria. More recently commenced Japanese projects are in southeast Queensland and northern Tasmania. At completion, Japanese eucalypt plantations in Australia could total 90,000 hectares (222,395 acres), with pulpwood for export to Japan as chips the exclusive utilization intention. The Korean pulp and paper company Hansol has a project to establish a 10,000-hectare (24,711-acre) estate in Western Australia for the same purpose (Flynn and Shield 1999).

Global Hardwood Pulp and Woodchip Market

Due to the substantial additional plantation areas in countries as diverse as Australia, China, Chile, Uruguay, and Brazil in recent decades, the world market has a surplus of hardwood pulpwood (Flynn and Shield 1999). Between 1993 and 1999, the reported annual volume of global trade in hardwood chips more than doubled. Delays in developing new pulp and paper projects in the 1990s have meant that vast areas of plantations are maturing with no established market in sight. Availability of eucalypt pulpwood, primarily *E. globulus*, is expected to surge in the coming decade, due to extensive planting in countries such as Australia and Chile. Eucalypt woodchips provide pulp that gives the paper certain qualities, such as smoothness, opacity, and ability to hold ink on the surface. These qualities are needed for fine writing and printing paper. Eucalypts with light colored woodchips (such as *E. globulus*) require less chemical bleaching. Even if plantation yields are less than forecast, there still appears to be an oversupply of hardwood fiber coming into the market in the next decade. This has forced growers to search for new outlets for their wood (Flynn and Shield 1999).

Australian Supply

Australia is predominantly an import market for forest products with the major exception of wood chips. The Australian Bureau of Agricultural and Resource Economics (ABARE) estimated that approximately 80% of Australian hardwood woodchips and 30% of softwood woodchips are exported. In 1997, exports of hardwood chips reached 2.5 million metric tons (2.7 tons). Woodchips, including softwood chips, have generally accounted for just over half the value of Australian forest product exports in the 1990s and reached a record $646 million in 1997–1998 (Australian Bureau of Agricultural and Resource Economics 1999). The major market for wood chips is Japan, which took about 95% of the 3.9 million tons of wood chips exported in 1998–1999 (Foreign Agriculture Service 1999). Most Australian wood exports are destined for nations in the Asia-Pacific region, with the major markets being Japan ($600 million), New Zealand ($316 million), and Asian countries (excluding Japan) ($312 million). Australia was the leading exporter of hardwood chips from 1989 to 1999 (Fig. 4) and the principal competitor to the United States in exporting non-conifer woodchips to Japan (United Nations Statistics Division). Australia's woodchip exports increased significantly from 1995–1996 through 1999–2000 (Fig. 5), with hardwood chips dominating (Australia Bureau of Agricultural and Resource Economics 2000).

Australia's pulpwood supplies are expected to increase rapidly and peak in 2009 (Flynn and Shield 1999). Exports of Australian forest products in 1999–2000 totaled $1,576 million; this included $121.2 million of round and sawn wood products, $135.5 million in wood based panels, $646 million of wood chips, and $556 million of paper and

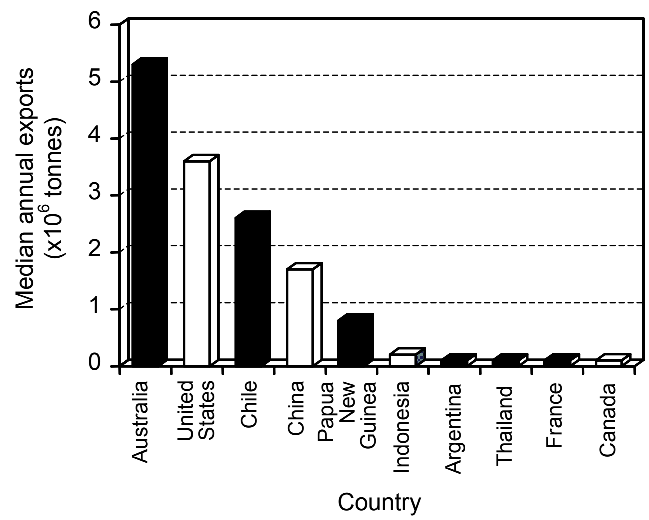

Figure 4—Top ten countries exporting hardwood chips, 1989 to 1999. Source: United Nations Statistics Division.

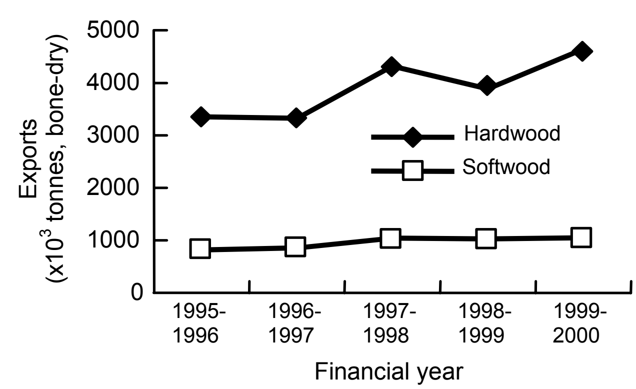

Figure 5—Export of Australian hardwood and softwood chips, 1995–1996 to 1999–2000. Source: Australian Bureau of Agricultural and Resource Economics 2000.

paper products. Chips are segregated by quality as measured by pulp yield. There are three classifications of chips with increasing quality: mixed hardwood (variety of species and sources), E50 (*Eucalyptus* primarily from natural forest), and E54 (*Eucalyptus* regrowth from natural forest and plantations). Natural forest chips of both mixed hardwood and E50 can contain *Eucalyptus, Nothofagus, Acacia, Atherosperma,* and other native hardwoods.

In October 1997, the Commonwealth and State governments and the Australian timber industry launched the "Plantations for Australia: 2020 Vision," which aims to increase the Australian area in plantations to 3 million hectares (7.4 million acres) by 2020. Achieving this objective will require an average planting of around 80,000 hectares (197,684 acres) per year. This goal is very ambitious, as the average annual planting during the peak plantation period of the 1970s and early to mid-1980s was 30,000 hectares (74,132 acres) (Foreign Agriculture Service 1999).

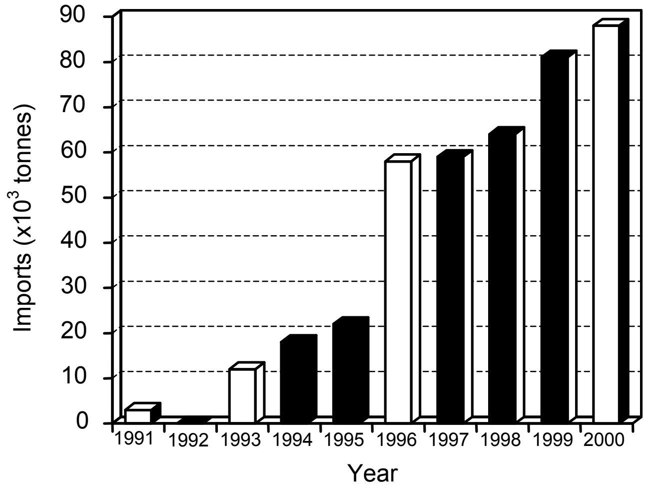

Figure 6—Import of hardwood chips into the United States, 1991–2000. Source: UN Statistics Division.

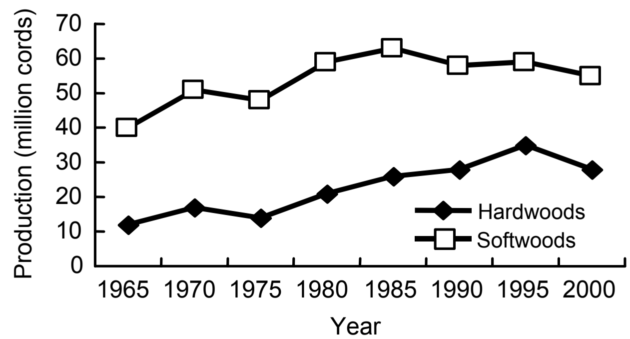

Figure 7—U.S. pulpwood production by type, 1965–1999. Source: Howard 2001.

Characteristics of the Proposed Importation

APHIS has received written and verbal indication of interest to import eucalypt chips from Australia to the United States. The commodity proposed for import into the United States is wood chips but could include unprocessed logs in the future. The chips would be expected to arrive by marine transport to any ports of entry in the United States. The amount of eucalypt commodities exported from Australia to the United States is unpredictable and will depend on, among other factors, market prices, and demand from other countries, especially Japan.

U.S. Demand for Hardwood Pulp Logs and Chips

Demand for hardwood chips in the United States has varied. Due to reduced availability of hardwood pulpwood from public lands and the present immaturity of private industrial hardwood plantation stock, U.S. imports of hardwood chips climbed steadily during 1991–2000 (Fig. 6) (UN Statistics Division). However, U.S. pulpmill closures have led to reduced interest in importing eucalypt woodchips (Neilson and Flynn 2000).

Factors suggesting continued U.S. demand for hardwood pulp and chips include a growing hardwood resource in northern U.S. states, which will increase the availability of low-value roundwood, and the increasing supply of eucalypt pulp on the international market (Luppold and others 2002).

Since peaking in 1995, total pulpwood production and pulp mill consumption have declined in the U.S. (Fig. 7) (Howard 2001). Total pulpwood consumption in U.S. mills of 86.7 million cords (314.2 million cubic meters) in 1999 was met by approximately 82.0 million cords (297.2 million cubic meters) of domestic production plus net imports. For the past several years, the U.S. paper industry has been characterized by overcapacity and low commodity prices. Declining prices have led to contraction in both softwood and hardwood pulp demand. Between 1992 and 1997, the number of pulp mill establishments [Standard Industrial Classification (SIC) 2611] declined by 13% (U.S. Census Bureau 2000). Eight of the Nation's 186 pulpmills shut down in 1999 (Howard 2001). Since then, further erosion in pulpwood demand has continued. From January 2001 to January 2002, the benchmark price for short-fiber hardwood (eucalyptus/birch) kraft pulp fell from US$703.61 to US$418.72 per metric ton, a 40% decline (http://www.paperage.com/foex_pulp2.html).

Location of U.S. Pulp Mills and Woodchip Port Facilities

The location of U.S. pulp mills and woodchip port facilities provides some indication of the most likely exposure routes associated with potential eucalypt pulpwood and woodchip imports. Pulp mills are located primarily in regions of the country where pulpwood is harvested. Traditionally, pulpwood production has been concentrated in the southern United States. In 1996, nine of the ten top pulpwood-producing states were in the southern region (Johnson 2001). As of 1999, the highest concentration of hardwood-utilizing pulp mills was in Alabama and Mississippi (Johnson and Steppleton 2001).

Woodchip export facilities are expected to have the infrastructure to accommodate imports as well. As of 1999, southern woodchip export facilities included Beaumont, Texas; Lake Charles, Louisiana; Reserve, Louisiana; Convent, Louisiana; Mobile, Alabama; Savannah, Georgia; Wilmington, South Carolina; and Morehead City, North Carolina (Neilson and Flynn 1999).

Although the Pacific Coastal region (California, Oregon, Washington, and Alaska) has a substantial pulp industry, most of the wood raw material is chips produced as byproduct from timber and lumber production. Oregon leads the Pacific Coastal region in pulpwood production (Johnson 2001). The extent to which Pacific Coastal pulp mills currently use or plan to use hardwoods is unknown. As of 1999, U.S. Pacific Coastal woodchip export facilities included Homer, Alaska; Port Angeles, Washington; Tacoma, Washington; Coos Bay, Oregon; Eureka, California; and Sacramento, California (Neilson and Flynn 1999).

Previous Interceptions of Quarantine Organisms

Because most of the eucalypt resource exported from Australia is shipped to Japan, inquiries were made with quarantine officials there. Japan requires quarantine inspection by MAFF (Ministry of Agriculture, Forestry and Fisheries of Japan) for both dry (logs and chips) and fresh (foliage) *Eucalyptus*, but only fresh imports require certification from AQIS (Australian Quarantine and Inspection Service). Mr. Murakami of the Yokohama PQ (Plant Quarantine) Station checked the fumigation records of *Eucalyptus* importation from Australia for the past 2 to 3 years. Although some shipments of fresh cut *Eucalyptus* were rejected because of harmful insects, there have been no interceptions from dry and other types (including wood chips) of *Eucalyptus.* Because dry shipments do not require phytosanitary certificates, it is possible that inspections are minimal and thus detection of insect contamination is rare. It is also possible that in fact no interceptions have been detected. Either way, it appears that insect infestation in dried wood chips is not a quarantine issue for Japan at this time.

Chapter 3. Insects and Pathogens Posing Risk

Introduction

The probability of pest introduction is determined by several related factors, including the likelihood of a pest traveling with and surviving on a shipment from the place of origin, the likelihood of a pest colonizing suitable hosts at the point of entry and during transport to processing sites, and the likelihood of subsequent pest spread to adjacent territories. Many insects and pathogens could be introduced on eucalypt logs or chips from Australia into the United States. Because it would be impractical to analyze the risk of all of them, some form of selection was necessary. Selection was based on the likelihood of the pest being on or in the logs or chips and on their potential risk to resources in the United States. The pest risk assessment team compiled and assessed pertinent data using the methodology outlined in Pest Risk Assessment Process in Chapter 1 and as used in previous pest risk assessments (Kliejunas and others 2001, Tkacz and others 1998, USDA Forest Service 1991, USDA Forest Service 1992, USDA Forest Service 1993).

Analysis Process

The general analysis process used is explained in Chapter 1. For this risk assessment, information was collected from an array of sources on the organisms associated with 18 species of Australian eucalypts that have the potential to be exported commercially to the United States. The 18 species within the scope of the assessment include seven species identified by U.S. companies as being of interest to them, as well as additional species that our Australian contacts believed could also be commercially available in the future. Lists of insects and pathogens that have been reported to inhabit the 18 species in Australia were compiled from the literature, from information provided by Australian forest entomologists and pathologists, from information received from reviewers of a preliminary list prepared by the team, and from information described in Chapter 1. These organisms were cataloged in one of the categories of quarantine pests defined in the log import regulations (Title 7, CFR 319.40-11). The team broadened some of the categories to include a broader definition of genetic variation (Table 6). The organisms were also identified as to the part of the plant they affect: nursery seedlings, on foliage or bark, in or under the bark, and in the wood. From these lists, organisms were selected for further analysis. Organisms were selected from each of the plant parts affected (except nursery seedlings). Organisms were selected because of the amount of damage they cause in Australia, the availability of information available on the organism, and the pathway they represent. For each organism selected, a thorough individual pest risk assessment was developed as described previously in Chapter 1, under Pest Risk Assessment Process.

Tables of Potential Insects and Pathogens of Concern

The species of insects and pathogens associated with 18 species of eucalypts in Australia and identified as potential pests of concern are presented in Tables 7 and 8. The lists include 286 insects and 115 pathogens. The lists of organisms in Tables 7 and 8 are not meant to be an all-definitive or all-inclusive but are a result of literature searches and

Table 6—Pest categories and descriptions

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

information provided by colleagues in Australia. For an organism to be listed in Table 7 or 8, it must have been identified with one of the 18 eucalypt hosts, either through the literature or through communication with Australian entomologists or pathologists. That host is listed in Table 7 or 8, as are any additional hosts known to harbor the insect or pathogen. Those insects or pathogens whose hosts are listed simply as "*Eucalyptus* spp." are ones suspected of being associated with our 18 species of eucalypts but whose specific hosts are not definitively known. Bold type is used in Tables 7 and 8 to highlight the insects or pathogens treated in Individual Pest Risk Assessments (IPRAs) and to highlight the 18 eucalypt species contained in the scope of the assessment. The tables represent a list of potential pests of concern and do not represent, or judge, quarantine status of any of the organisms listed.

Individual Pest Risk Assessments

Twenty-two IPRAs were prepared, 15 dealing with insects and 7 with pathogens. The objective was to include in the IPRAs representative examples of insects and pathogens found on the bark, in the bark, and in the wood that would have the greatest potential risk to forests and other tree resources of the United States. The team recognized that these might not be the only organisms associated with the 18 species of eucalypts in Australia. They are, however, representative of the diversity of insects and pathogens that inhabit logs and chips. By necessity, the IPRAs focus on those insects and pathogens for which biological information is available. The U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) will use the assessments of risks associated with known organisms that inhabit a variety of niches on logs and chips to identify effective mitigation measures to eliminate both the known organisms and any similar heretofore-unknown organisms that inhabit the same niches. Summary tables of the IPRA results can be found in Chapter 4.

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
***Abantiades latipennis* Tindale (Lepidoptera: Hepialidae)**	TAS, VIC, WA	***Eucalyptus globulus*, *E. obliqua*, *E. regnans***			X (roots)			1
Achaea janata (Linnaeus) (Lepidoptera: Geometridae)	NSW, NT, QLD, SA, VIC, WA	***Eucalyptus pilularis***, *Agathis robusta*, *Araucaria cunninghamii*, *Acacia* spp., *Ricinus communis*		X				2 (Hawaii)
Acrocercops calicella (Staint.) (Lepidoptera: Gracillariidae)	NSW, QLD	*Eucalyptus acmenioides*, *E. robusta*, ***E. saligna***		X				1
Acrocercops laciniella (Meyrick) (Lepidoptera: Gracillariidae)	NSW, QLD, TAS, (NZ)[c]	*Eucalyptus acmenioides*, *E. bridgesiana*, *E. dives*, ***E. globulus***, *E. macrorhyncha*, ***E. nitens***, ***E. obliqua***, ***E. pilularis***, ***E. regnans***, *E. rossii*, ***E. saligna***, ***E. viminalis***; *Angophora costata*, *A. floribunda*		X				1
***Aenetus eximius* (Scott) (Lepidoptera: Hepialidae)**	NSW, QLD, TAS, VIC	***Eucalyptus grandis*, *E. pilularis*, *E. saligna***				X	X	1
***Aenetus ligniveren* (Lewin) (Lepidoptera: Hepialidae)**	NSW, QLD, SA, TAS, VIC	***Eucalyptus delegatensis*, *E. globulus*, *E. grandis*, *E. obliqua*, *E. regnans*, *E. viminalis***, *Leptospermum*, *Melaleuca*, *Tristania*, other Myrtaceae, *Acacia*, *Ulmus*, *Dodonaea* (Sapindaceae), *Olearia* (Asteraceae), *Pomaderris* (Rhamnaceae), *Prostanthera* (Lamiaceae), *Malus pumila* (Rosaceae), *Rubus idaeus* (Rosaceae)				X	X	1
***Aenetus paradiseus* Tindale (Lepidoptera: Hepialidae)**	TAS	*Eucalyptus* spp.			X (saplings)			1
Agriophara spp. (Lepidoptera: Oechophoridae)	SA, TAS	*Eucalyptus* spp.		X				1
Agrotis intusa (Boisduval) (Lepidoptera: Noctuidae)	NSW, SA, TAS, VIC	*Eucalyptus* spp.	X					1
Agrotis sp. (Lepidoptera: Noctuidae)	TAS, WA	***Eucalyptus globulus***	X					1
***Amasa* (=*Xyleborus*) *truncatus* (Erichson) (Coleoptera: Scolytidae)**	NSW, QLD, TAS, (NZ)	*Eucalyptus acmenioides, E. camaldulensis, E. piperita, E. propinqua,* ***E. saligna****, Eucalyptus* spp**., *Corymbia citriodora, C. maculata*,** *Angophora intermedia*				X		1
***Ambrosiodmus* (=*Xyleborus*) *compressus* Lea (Coleoptera: Scolytidae)**	NSW, QLD, (NZ)	***Eucalyptus saligna***				X		1
Amorbus alternatus Dallas (Hemiptera: Coreidae)	SA	*Eucalyptus* spp.		X				1
Amorbus obscuricornis (Westwood) (Hemiptera: Coreidae)	TAS	***Eucalyptus globulus*, *E. obliqua*, *E. regnans***		X				1
Amorbus rubiginosus (Guerin-Meneville) (Hemiptera: Coreidae)	NSW, TAS	***Eucalyptus obliqua, E. piluaris, E. regans***		X				1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Anacephaleus minutus Evans (Homoptera: Cicadellidae)	WA	***Eucalyptus globulus***		X				1
Anilaria sp. (Coleoptera: Buprestidae)	WA	*Eucalyptus gomphocephala, E. marginata**,** E. microcorys,* ***Corymbia calophylla***			X	X		1
Anoplognathus boisduvali Boisduval (Coleoptera: Scarabaeidae)	QLD	*Eucalyptus camaldulensis,* ***E. grandis,*** *E. tereticornis*		X				1
Anoplognathus chloropyrus (Drapiez) (Coleoptera: Scarabaeidae)	NSW, QLD, VIC	*Eucalyptus botryoides,* ***E. dunnii,*** *E. fastigata,* ***E. globulus, E. grandis, E. obliqua, E. regnans, E. viminalis,*** *Eucalyptus* spp.		X				1
Anoplognathus hirsutus (Gyllenhal) (Coleoptera: Scarabaeidae)	VIC	*Eucalyptus botryoides, E. fastigata,* ***E. globulus, E. grandis, E. obliqua, E. regnans***		X				1
Anoplognathus montanus Macleay (Coleoptera: Scarabaeidae)	NSW	***Eucalyptus nitens***		X				1
Anoplognathus pallidicollis Blanchard (Coleoptera: Scarabaeidae)	QLD	*Eucalyptus camaldulensis,* ***E. grandis,*** *E. tereticornis*		X				1
Anoplognathus porosus Dalman (Coleoptera: Scarabaeidae)	NSW, QLD, VIC	***Eucalyptus dunnii, E. grandis,*** *E. tereticornis, Eucalyptus* spp.		X				1
Anoplognathus suturalis Boisduval (Coleoptera: Scarabaeidae)	TAS	***Eucalyptus ovata***		X				1
Apina callisto (Angas) (Lepidoptera: Noctuidae)	NSW, QLD, SA, TAS, VIC, WA	***Eucalyptus globulus***		X				1
Apiomorpha spp. (Homoptera: Eriococcidae)	TAS	*Eucalyptus* spp.		X				1
Aplopsis sp. nov. nr. *punctulata* (Blackburn) (Coleoptera: Scarabaeidae)	WA	***Eucalyptus globulus***		X				1
Aporocera bynoei (Saunders) (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Aporocera spp. (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Araiobelus acicularis (Pascoe) (Coleoptera: Belidae)	WA	***Eucalyptus globulus***		X				1
Ardozyga (=*Protolechia*) *stratifera* (Meyrick) (Lepidoptera: Gelechiidae)	WA	***Eucalyptus globulus***		X				1
Aterpus rubus Boheman (Coleoptera: Curculionidae)	TAS	*Eucalyptus* spp.			X (roots)			1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
***Atractocerus crassicornis* Clark (Coleoptera: Lymexylidae)**	WA	***Eucalyptus diversicolor***, *E. marginata, E. patens*			X	X	X	1
***Atractocerus kreuslerae* Pascoe (Coleoptera: Lymexylidae)**	NSW, QLD, SA, WA	*Eucalyptus astringens,* ***E. diversicolor****, E. gomphocephala, E. marginata, E. patens, E. rudis, E. wandoo,* ***Corymbia calophylla***			X	X	X	1
***Atractocerus* sp. (Coleoptera: Lymexylidae)**	TAS	***Eucalyptus obliqua***			X	X	X	1
***Austroplatypus incompertus* Schedl (Coleoptera: Platypodidae)**	NSW, VIC	*Eucalyptus baxteri, E. botryoides, E. consideniana,* ***E. delegatensis****, E. eugenioides, E. fastigata, E. globoidea, E. macrorhyncha, E. muelleriana,* ***E. obliqua, E. pilularis,*** *E. radiata, E. scabra,* ***E. sieberi,*** *Corymbia gummifera*				X	X	1
Autelobius sp. (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus***		X				1
Automolus spp. (Coleoptera: Scarabaeidae)	QLD	*Eucalyptus camaldulensis,* ***E. dunnii, E. grandis,*** *E. tereticornis,* ***Corymbia citriodora***		X				1
Bethelium sp. (Coleoptera: Cerambycidae)	WA	*Eucalyptus astringens,* ***E. diversicolor,*** *E. gomphocephala, E. marginata*				X		1
***Bifiditermes condonensis* (Hill) (Isoptera: Kalotermitidae)**	NSW, QLD, VIC, WA	*Eucalyptus* spp.				X	X	1
Blastopsylla occidentalis Taylor (Homoptera: Psyllidae)	NSW, QLD, SA, WA, (NZ)	*Eucalyptus camaldulensis, E. microtheca, Eucalyptus* spp.		X				2 (CA)
***Bostrychopsis jesuita* (Fabricius) (Coleoptera: Bostrichidae)**	NSW, NT, QLD, SA, VIC, WA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus,*** *E. marginata,* ***E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata,*** *Pinus pinaster, Melia azedarach, Grevillea robusta, Brachychiton populneus, Delonix regia*				X	X	1
Brachycaulus sp. (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Brunotartessus sp. (Homoptera: Cicadellidae)	WA	***Eucalyptus globulus***		X				1
Cadmus breweri Baly (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Cadmus crucicollis Boisduval (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				`1
Cadmus excrementarius Suffrian (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart- wood	Pest category[b]
Cadmus nothus Lea (Coleoptera: Chrysomelidae	WA	***Eucalyptus globulus***		X				1
***Callidiopsis scutellaris* (Fabricius) (Coleoptera: Cerambycidae)**	ACT, NSW, TAS, VIC, (NZ)	***Eucalyptus delegatensis, E. obliqua, E. viminalis***		X		X		1
Cardiaspina artifex (Schwartz) (Homoptera: Psyllidae)	QLD	***Eucalyptus grandis***		X				1
***Cardiaspina bilobata* Taylor (Homoptera: Psyllidae)**	VIC	***Eucalyptus regnans***		X				1
***Cardiaspina fiscella* Taylor (Homoptera: Psyllidae)**	NSW, QLD, VIC, WA, (NZ)	*Eucalyptus botryoides,* ***E. grandis,*** *E. robusta,* ***E. saligna***		X				1
***Cardiaspina maniformis* Taylor (Homoptera: Psyllidae)**	NSW, QLD	***Eucalyptus grandis***		X				1
***Cardiaspina retator* Taylor (Homoptera: Psyllidae)**	VIC	*Eucalyptus blakelyi, E. camaldulensis, E. tereticornis*		X				1
***Cardiaspina squamula* Taylor (Homoptera: Psyllidae)**	TAS, WA	***Eucalyptus viminalis***		X				1
Cardiaspina spp. (Homoptera: Psyllidae)	SA	***Eucalyptus globulus***		X				1
Catasarcus impressipennis (Boisduval) (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus,*** *E. gomphocephala*		X				1
***Ceratokalotermes spoliator* (Hill) (Isoptera: Kalotermitidae)**	NSW, QLD	*Eucalyptus spp.*				X	X	1
Chaetophyes compacta (Walker) (Homoptera: Machaerotidae)	NSW, QLD, TAS, VIC	*Eucalyptus spp.*		X				1
***Chrysophtharta agricola* (Chapuis) (Coleoptera: Chrysomelidae**)	TAS, VIC	*Eucalyptus dalrympleana,* ***E. delegatensis****, E. globoidea,* ***E. globulus, E. grandis, E. nitens, E. pilularis, E. viminalis***		X				1
Chrysophtharta amoena Clark (Coleoptera: Chrysomelidae)	WA	***Eucalyptus diversicolor,*** *E. gomphocephala*		X				1
***Chrysophtharta bimaculata* (Olivier) (Coleoptera: Chrysomelidae)**	TAS	*Eucalyptus coccifera,* ***E. delegatensis, E. globulus, E. nitens, E. obliqua, E. regnans***		X				1
Chrysophtharta cloelia Stal (Coleoptera: Chrysomelidae)	NSW, QLD	***Eucalyptus dunnii, E. globulus, E. grandis***		X				1
Chrysophtharta mentatrix (Blackburn) (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart- wood	Pest category[b]
Chrysophtharta nobilitata (Erichson) (Coleoptera: Chrysomelidae)	SA, TAS, WA	***Eucalyptus amygdalina, E. globulus,*** *E. tenuiramis,* ***E. viminalis***		X				1
Chrysophtharta obovata (Chapuis) (Coleoptera: Chrysomelidae)	SA	*Eucalyptus* spp.		X				1
Chrysophtharta variicollis (Chapuis) (Coleoptera: Chrysomelidae)	TAS, VIC, WA	***Eucalyptus globulus, E. nitens, E. ovata, E. viminalis***		X				1
Clania ignobilis (Walker) (Lepidoptera: Psychidae)	NSW, QLD, SA, TAS, VIC, WA	*Eucalyptus* spp., *Angophora* spp., *Callitris* spp., *Pinus* spp.		X				1
Colpochila spp. (Coleoptera: Scarabaeidae)	WA	***Eucalyptus globulus***		X				1
Colymbomorpha lineata Blanchard (Coleoptera: Scarabaeidae)	WA	***Eucalyptus globulus***		X				1
Coptocercus rubripes **(Boisduval) (Coleoptera: Cerambycidae)**	NSW, QLD, SA, TAS, WA, (NZ)	***Eucalyptus delegatensis, E. pilularis, E. obliqua,*** *E. odorata,* ***E. regnans, E. saligna, Corymbia maculata,*** *Angophora intermedia*				X		1
Coptocercus **sp. (Coleoptera: Cerambycidae)**	WA	***Eucalyptus diversicolor,*** *E. gomphocephala, E. marginata*				X		1
Coptotermes acinaciformis **(Froggatt) (Isoptera: Rhinotermitidae)**	NSW, NT, QLD, SA, VIC, WA, (NZ)	*Eucalyptus camaldulensis,* ***E. grandis, E. pilularis,*** *Eucalyptus* spp.				X	X	1
Coptotermes acinaciformis raffrayi **Wasmann (Froggatt) (Isoptera: Rhinotermitidae)**	WA	*Eucalyptus* spp.				X	X	1
Coptotermes frenchi **Hill (Isoptera: Rhinotermitidae)**	NSW, QLD, SA, VIC, (NZ)	***Eucalyptus pilularis***, *Eucalyptus* spp.				X	X	1
Coptotermes lacteus **Froggatt (Isoptera: Rhinotermitidae)**	NSW, QLD, VIC	*Eucalyptus* spp.				X	X	1
Creiis periculosa (Olliff) (Homoptera: Psyllidae)	WA	*Eucalyptus rudis, E. wandoo, Eucalyptus* spp.		X				1
Creiis sp. (Homoptera: Psyllidae)	QLD	***Eucalyptus dunnii,*** *Eucalyptus* spp.		X				1
Crossotarsus armipennis Lea (Coleoptera: Platypodidae)	NSW	***Corymbia maculata***				X		1
Crossotarsus externedentatus (Fairmaire) (Coleoptera: Platypodidae)	?	*Eucalyptus paniculata,* ***Corymbia maculata***				X		1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart- wood	Pest category[b]
***Cryptotermes brevis* (Walker) (Isoptera: Kalotermitidae)**	NSW, QLD	Seasoned hardwoods and softwoods				X	X	2 (FL, LA, HI)
***Cryptotermes cynocephalus* Light (Isoptera: Kalotermitidae)**	QLD	Seasoned hardwoods and softwoods				X	X	2 (HI)
***Cryptotermes domesticus* (Haviland) (Isoptera: Kalotermitidae)**	QLD	Seasoned hardwoods and softwoods				X	X	1
***Cryptotermes dudleyi* Banks (Isoptera: Kalotermitidae)**	QLD	Seasoned hardwoods and softwoods				X	X	1
Cryptotermes primus Hill (Isoptera: Kalotermitidae)	NSW, QLD	Seasoned hardwoods and softwoods				X	X	1
Crytocephalus iridipennis Chapuis (Coleoptera: Chrysomelidae)	QLD	***Eucalyptus pilularis***		X		X	X	2
Ctenarytaina eucalypti Maskell (Homoptera: Psyllidae)	NSW, SA, TAS, VIC, (WA, NZ)	*Eucalyptus acmenioides,* ***E. globulus, E. nitens,*** *E. phaeotricha, E. pulverulenta, E. tereticornis, E. umbra, Allocasuarina littoralis, Corymbia intermedia, C. trachyphloia, Lophostemon confertus, L. suaveolens, Syncarpia glomulifera*		X				2 (CA)
Ctenarytaina spatulata Taylor (Homoptera: Psyllidae)	NSW, SA, TAS, VIC, (NZ)	*Eucalyptus camaldulensis,* ***E. grandis,*** *E. leucoxylon,* ***E. ovata, E. saligna, E. viminalis***		X				2 (CA)
***Ctenomorphodes tessulatus* (Gray) (Phasmatodea: Phasmatidae)**	NSW, QLD	*Eucalyptus acmenioides,* ***E. delegatensis, E. grandis****, E. intermedia, E. paniculata,* ***E. pilularis,*** *E. propinqua, E. punctata, E. resinifera, E. tereticornis, E. triantha, E. umbra,* ***E. viminalis****, Corymbia gummifera,* ***C. maculata****, Syncarpia laurifolia, Casuarina torulosa, Acacia floribunda*		X				1
Culama australis Walker (Lepidoptera: Cossidae)	QLD	***Eucalyptus grandis***					X (saplings)	1
Culama sp. (Lepidoptera: Cossidae)	TAS	*Eucalyptus* spp.			X	X	X	1
Cyphagogus bipunctatus Senna (Coleoptera: Brenthidae)	NSW	***Eucalyptus saligna***				X		1
Deroptilinus granicollis Lea (Coleoptera: Anobiidae)	NSW, (NZ)	***Eucalyptus saligna***				X		1
***Didymuria violescens* (Leach) (Phasmatodea: Phasmatidae)**	NSW, QLD, VIC	*Eucalyptus bicostata, E. dalrympleana,* ***E. delegatensis****, E. dives,* ***E. grandis,*** *E. huberiana, E. laevopinea, E. maculosa, E. major, E. mannifera,* ***E. obliqua****, E. pauciflora,* ***E. pilularis,*** *E. radiata,* ***E. regnans****, E. robertsonii,* ***E. saligna, E. viminalis***		X				1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart- wood	Pest category[b]
Doratifera casta (Scott) (Lepidoptera: Limacodidae)	NSW, QLD	***Eucalyptus grandis, E. pilularis, E. saligna***		X				1
Doratifera oxleyi (Newman) (Lepidop-tera: Limacodidae)	NSW, SA, TAS, VIC	***Eucalyptus saligna, E. sieberi, Corymbia maculata***		X				1
Doratifera pinguis (Walker) (Lepidoptera: Limacodidae)	NSW, QLD, TAS	*Eucalyptus* spp.		X				1
Doratifera quadrigut-tata (Walker) (Lepidop-tera: Limacodidae)	NSW, QLD, VIC	*Eucalyptus* spp., *Tristaniopsis laurina, Lophostemon confertus, Rhizophora stylosa, Acacia* spp.		X				1
Doratifera vulnerans (Lewin) (Lepidoptera: Limacodidae)	NSW, SA, VIC, WA	*Eucalyptus camaldulensis, E. dives, E. marginata,* ***E. obliqua***		X				1
Dryophilodes subcyl-indricus Lea (Coleop-tera: Anobiidae)	VIC	*Eucalyptus baxteri,* ***E. delegaten-sis, E. regnans***	X (seeds)					1
Dryophilodes spp. (Coleoptera: Anobiidae)	TAS	***Eucalyptus globulus, E. obliqua***	X (seeds)					1
Ecnolagria grandis (Gyllenhal) (Coleop-tera: Tenebrionidae)	NSW, QLD, SA, TAS, VIC	*Eucalyptus* spp.		X				1
Edusella sp. (Coleop-tera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Emplesis sp. (Coleop-tera: Curculionidae)	WA	***Eucalyptus globulus***		X				1
***Endoxyla cinereus* (Tepper) (=*Xyleutes boisduvali* Roths-child) (Lepidoptera: Cossidae)**	NSW, QLD	*Eucalyptus camaldulensis,* ***E. cloeziana, E. globulus, E. grandis****, E. tereticornis*				X	X	1
***Endoxyla* spp. (=*Xyleutes* spp.) (Lepidoptera: Cossidae)**	TAS, VIC, WA	***Eucalyptus diversicolor, E. globulus, E. obliqua, E. saligna, E. regnans***				X	X	1
Epholcis bilobiceps (Fairmaire) (Coleop-tera: Scarabaeidae)	QLD	*Eucalyptus acmenioides, E. camaldulensis, E. drepanophylla,* ***E. grandis****, E. pellita,* ***E. pilularis,*** *E. robusta, E. urophylla*		X				1
Epicoma melanopsila (Wallengren) (Lepidop-tera : Notodontidae)	NSW, TAS, VIC	*Eucalyptus* spp., *Callistemon* spp., *Leptospermum* spp., *Kunzea* spp.		X				1
Epicoma tristis (Dono-van) (Lepidoptera: Notodontidae)	TAS	*Eucalyptus* spp.		X				1
***Epithora dorsalis* Macleay (Coleoptera: Cerambycidae)**	ACT, NSW, TAS	*Eucalyptus agglomerata, E. beyeri,* ***E. delegatensis, E. obliqua****, E. robertsonii,* ***E. saligna, E. viminalis, Corymbia maculata****, Angophora intermedia, Gmelina leichhardtii*				X	X	1
***Eriococcus cori-aceus* Maskell (Homoptera: Erio-coccidae)**	NSW, QLD, SA, TAS, VIC, WA, (NZ)	***Eucalyptus amygdalina****, E. camaldulensis,* ***E. globulus, E. grandis, E. nitens, E. pilularis, E. saligna,*** *E. tereticornis,* ***E. viminalis,*** *Eucalyptus* spp.		X				1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Eriococcus confusus **Maskell (Homoptera: Eriococcidae)**	NSW, SA, TAS, VIC	*Eucalyptus camaldulensis,* ***E. globulus,*** *E. mannifera,* ***E. nitens, E. viminalis***		X				1
Eriococcus irregularis Froggatt (Homoptera: Eriococcidae)	TAS	***Eucalyptus nitens***		X				1
Euander lacertosus (Erichson) (Hemiptera: Lygaeidae)	TAS	***Eucalyptus delegatensis, E. regnans***	X (seeds)					1
Eucalyptolyma maideni Froggatt (Homoptera: Psyllidae)	NSW, QLD, SA, (NZ)	***Corymbia citriodora, C. maculata***		X				2 (CA)
Euloxia meandraria Guenee (Lepidoptera: Geometridae)	TAS	***Eucalyptus amygdalina****,* *Leptospermum* sp.		X				1
Eurymela distincta Signoret (Homoptera: Eurymelidae)	ACT, NSW, QLD, TAS, VIC	*Eucalyptus aggregata, E. bridgesiana, E. botryoides,* ***E. globulus,*** *E. macarthurii,* ***E. viminalis,*** *Hakea sericea*		X				1
Eurymela fenestrata Lepeletier & Serville (Homoptera: Eurymelidae)	NSW, QLD, SA, TAS, VIC, WA	*Eucalyptus* spp.		X				1
Eurymeloides lineata Lepeletier & Serville (Homoptera: Eurymelidae)	NSW, QLD, SA, TAS, VIC, WA	***Eucalyptus viminalis***		X				1
Eurymelops latifasciata (Walker) (Homoptera: Eurymelidae)	WA	***Eucalyptus globulus***		X				1
Garrha spp. (Lepidoptera: Oecophoridae)	NSW, SA, TAS, VIC	*Eucalyptus* spp.		X				1
Gelonus tasmanicus (LeGuillou) (Hemiptera: Coreidae)	TAS	***Eucalyptus delegatensis, E. nitens, E. obliqua, E. regnans***		X				1
Glycaspsis baileyi **Moore (Homoptera: Psyllidae)**	NSW	*Eucalyptus resinifera, E. robertsoni,* ***E. saligna***		X				1
Glycaspsis brimblecombei **(Moore) (Homoptera: Psyllidae)**	NSW, QLD, NT, SA	*Eucalyptus camaldulensis,* ***E. diversicolor, E. globulus, E. nitens,*** *E. tereticornis,* ***E. viminalis, Corymbia citriodora***		X				2 (CA)
Glycaspis (*Synglycaspis*) *cameloides* Moore (Homoptera: Psyllidae)	SA	***Eucalyptus obliqua***		X				1
Glycaspis endasa Moore (Homoptera: Psyllidae)	NSW, VIC	*Eucalyptus dives,* ***E. obliqua,*** *E. radiata*		X				1
Glycaspis eucalypti (Dobson) (Homoptera: Psyllidae)	TAS	*Eucalyptus dalrympleana,* ***E. ovata, E. viminalis***		X				1
Glycaspis nigrocincta **(Froggatt) (Homoptera: Psyllidae)**	TAS	*Eucalyptus coccifera,* ***E. delegatensis***		X				1
Glycaspis particeps Moore (Homoptera: Psyllidae)	NSW, SA, VIC	*Eucalyptus baxteri****, E. obliqua***		X				1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart- wood	Pest category[b]
***Glyptotermes tuberculatus* Froggatt (Isoptera: Kalotermitidae)**	NSW, (NZ)	*Eucalyptus* spp.				X	X	1
Gonipterus scutellatus (Gyllenhal) (Coleoptera: Curculionidae)	NSW, QLD, SA, TAS, VIC, WA, (NZ)	***Eucalyptus amygdalina, E. delegatensis, E. globulus, E. nitens, E. obliqua, E. regnans, E. saligna, E. viminalis***		X				2 (CA)
Henicopsaltria eydouxii (Guerin-Meneville) (Homoptera: Cicadidae)	NSW, QLD	*Eucalyptus blakelyi,* ***Corymbia maculata***			X (roots)			1
***Hesthesis cingulata* (Kirby) (Coleoptera: Cerambycidae)**	NSW, QLD, SA, TAS, VIC	***Eucalyptus globulus, E. obliqua, E. pilularis***				X (saplings)		1
Heteronychus arator (Fabricius) (Coleoptera: Scarabaeidae)	NSW, QLD, SA, WA, (NZ)	***Eucalyptus diversicolor, E. globulus,*** *Pinus elliottii*	X	X				1
Heteronyx n. sp. var. *comans* Blkb. (Coleoptera: Scarabaeidae)	VIC	***Eucalyptus delegatensis, E. regnans***		X				1
Heteronyx crinitus Blkb. (Coleoptera: Scarabaeidae)	TAS, VIC	***Eucalyptus delegatensis, E. globulus, E. nitens, E. regnans, E. viminalis***		X				1
Heteronyx elongatus Blanchard (Coleoptera: Scarabaeidae)	SA, WA	***Eucalyptus globulus***	X	X				1
Heteronyx exectus Blackburn (Coleoptera: Scarabaeidae)	WA	***Eucalyptus globulus***		X				1
Heteronyx obesus (Coleoptera: Scarabaeidae)	SA	*Eucalyptus* spp.		X				1
Heteronyx proxima Burmeister (Coleoptera: Scarabaeidae)	WA	***Eucalyptus globulus***		X				1
Heteronyx pustulosus Blackburn (Coleoptera: Scarabaeidae)	WA	***Eucalyptus globulus***		X				1
Heteronyx striatipennis Blanch var. jabatus Blkb. (Coleoptera: Scarabaeidae)	VIC	***Eucalyptus delegatensis, E. regnans***		X				1
***Heterotermes ferox* (Froggatt) (Isoptera: Rhinotermitidae)**	ACT, NSW, NT, SA, VIC, WA	*Eucalyptus* spp., any hardwood or softwood				X	X	1
***Heterotermes paradoxus* (Froggatt) (Isoptera: Rhinotermitidae)**	NT, QLD, WA	*Eucalyptus* spp.				X	X	1
Hyalarcta huebneri (Westwood) (Lepidoptera: Psychidae)	NSW, QLD, SA, TAS, VIC, WA	*Eucalyptus* spp., *Pinus radiata*		X				1
Hyalarcta nigrescens (Doubleday) (Lepidoptera: Psychidae)	NSW, QLD, SA, VIC	*Eucalyptus* spp.		X				1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart- wood	Pest category[b]
Hyalinaspis semi-spherula Taylor (Homoptera: Psyllidae)	TAS	***Eucalyptus amygdalina***		X				1
Hypertropha tortrici-formis Guenee (Lepidoptera: Hyper-trophidae)	NSW, SA, TAS, VIC	***Eucalyptus delegatensis,*** *Angophora* sp.		X				1
***Kalotermes banksiae* Hill (Isoptera: Kalotermitidae)**	NSW, SA, VIC, (NZ)	*Eucalyptus* spp.				X	X	1
***Kalotermes rufino-tum* Hill (Isoptera: Kalotermitidae)**	NSW, QLD, VIC, (NZ)	*Eucalyptus* spp.				X	X	1
Lasiopsylla rotun-dipennis Froggatt (Homoptera: Psyllidae)	SA	*Eucalyptus* spp.		X				1
Lepidoscia arctiella (Walker) (Lepidoptera: Psychidae)	TAS	*Eucalyptus* spp., *Pinus radiata*		X				1
Limacodes longerans (Lepidoptera: Limacodidae)	SA	*Eucalyptus* spp.		X				1
Liparetrus discipennis Guerin-Meneville (Coleoptera: Scarabaeidae)	QLD, SA	*Eucalyptus camaldulensis,* ***E. cloeziana, E. globulus****,* *E. jensenii,* ***Corymbia maculata***		X				1
Liparetrus jenkensi Britton (Coleoptera: Scarabaeidae)	WA	***Eucalyptus globulus***		X				1
Lophyrotoma inter-rupta (Klug) (Hymen-optera: Pergidae)	NSW, QLD, SA, TAS, VIC	*Eucalyptus camaldulensis,* ***E. grandis,*** *E. leucoxylon var. rosea, E. melanophloia,* ***E. obliqua, E. ovata, E. viminalis,*** *Corymbia ficifolia*		X				1
***Lyctus brunneus* (Stephens) (Coleop-tera: Lyctidae)**	NSW, NT, QLD, SA, TAS, VIC, WA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corym-bia calophylla, C. citriodora, C. maculata***				X		2
***Lyctus costatus* Blackman (Coleop-tera: Lyctidae)**	SA, TAS	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corym-bia calophylla, C. citriodora, C. maculata***				X		1
***Lyctus discenens* (Stephens) (Coleop-tera: Lyctidae)**	NSW, QLD	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corym-bia calophylla, C. maculata***				X		1
***Lyctus parallelocollis* (Stephens) (Coleop-tera: Lyctidae)**	NSW, QLD, SA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corym-bia calophylla, C. citriodora, C. maculata***				X		

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Lyctus sp. (Coleoptera: Lyctidae)	WA	*Eucalyptus gomphocephala, E. wandoo,* ***Corymbia calophylla***				X		1
***Macrones rufus* Saunders (Coleoptera: Cerambycidae)**	NSW	*Eucalyptus polyanthemos,* ***E. saligna, E. viminalis***				X		1
Maskiella globosa Fuller (Homoptera: Diaspididae)	NSW, VIC, WA	*Eucalyptus blakelyi, E. microcarpa, Eucalyptus* spp.		X				1
***Mastotermes darwiniensis* Froggatt (Isoptera: Mastotermitidae)**	NT, QLD, WA	*Eucalyptus* spp., *Pinus caribaea*				X	X	1
Megastigmus spp. (Hymenoptera: Torymidae)	TAS, VIC	*Eucalyptus baxteri, E. crebra,* ***E. delegatensis****, E. drepanophylla,* ***E. globulus, E. obliqua, E. regnans****, Eucalyptus* spp.	X (seeds)					1
***Mesoxylion collaris* (Erichson) (Coleoptera: Bostrichidae)**	NSW, NT, TAS	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata***				X	X	1
Metura elongatus (Saunders) (Lepidoptera: Psychidae)	NSW, QLD, SA	*Eucalyptus* spp., *Pinus radiata*		X				1
***Microcerotermes boreus* Hill (Isoptera: Termitidae)**	NT, WA	*Eucalyptus* spp.				X	X	1
***Microcerotermes distinctus* Silvestri (Isoptera: Termitidae)**	NSW, QLD, SA, VIC, WA	*Eucalyptus* spp.				X	X	1
***Microcerotermes implicatus* Hill (Isoptera: Termitidae)**	NSW, QLD, VIC	*Eucalyptus* spp.				X	X	1
***Microcerotermes nervosus* Hill (Isoptera: Termitidae)**	NT, WA	*Eucalyptus* spp.				X	X	1
***Microcerotermes turneri* (Froggatt) (Isoptera: Termitidae)**	NSW, NT, QLD	*Eucalyptus* spp.				X	X	1
Minthea rugicollis (Walker) (Coleoptera: Lyctidae)	QLD, SA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata***				X		1
Mnesampela privata (Guenee) (Lepidoptera: Geometridae)	NSW, QLD, SA, TAS, VIC, WA	***Eucalyptus amygdalina,*** *E. bridgesiana, E. brookerana, E. camaldulensis, E. cordata, E. crenulata,* ***E. delegatensis, E. dunnii, E. globulus, E. grandis,*** *E. leucoxylon, E. maidenii, E. marginata,* ***E. nitens, E. obliqua,*** *E. perriniana, E. risdonii, E. rubida, E. smithii, E. tenuiramis,* ***E. viminalis, Corymbia calophylla***	X	X				1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Nascioides (=*Nascio*) *parryi* (Hope) (Coleoptera: Buprestidae)	NSW, QLD, TAS	*Eucalyptus phaeotricha*, ***E. viminalis***		X (Adults)		X (E. phaeo-tricha)		1
***Nasutitermes exitiosus* (Hill) (Isoptera: Termitidae)**	NT, WA	*Eucalyptus* spp.				X	X	1
***Neotermes insularis* (Walker) (Isoptera: Kalotermitidae)**	NSW, NT, QLD, SA, VIC, WA, (NZ)	*Eucalyptus* spp.				X	X	1
Nezara viridula (Linnaeus) (Hemiptera: Pentatomidae)	NSW, NT, QLD, SA, TAS, VIC, WA	***Eucalyptus globulus***		X				2 (VA, FL, LA, AL, MS, GA, CA, TX, HI)
Notomagdalis sp. (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus***		X				1
Nysius vinitor Bergroth (Hemiptera: Lygaeidae)	NSW, NT, QLD, SA, TAS, VIC, WA	***Eucalyptus globulus,*** *Pinus radiata*	X					1
Ogmograptis scribula Meyrick (Lepidoptera: Bucculatricidae)	NSW, VIC	***Eucalyptus saligna, E. regnans***, *E. rossii*			X			1
Opodiphthera eucalypti (Scott) (Lepidoptera: Saturniidae)	NSW, NT, QLD, SA, TAS, VIC, WA, (NZ)	*Eucalyptus* spp., *Tristaniopsis laurina, Lophostemon confertus, Schinus molle, Betula pendula, Liquidambar* sp., *Prunus* sp., *Pinus radiata*		X				1
Opodiphthera helena (White) (Lepidoptera: Saturniidae)	NSW, QLD, SA, TAS, VIC, WA	***Eucalyptus delegatensis, E. diversicolor, E. nitens, E. obliqua, E. regnans,*** *Schinus molle, Betula pendula, Liquidambar* sp., *Prunus domestica, Quercus robur, Ligustrum vulgare, Pinus radiata*		X				1
Orthorhinus cylindrirostris (Fabricius) (Coleoptera: Curculionidae)	NSW, QLD, SA, TAS, VIC	***Eucalyptus globulus***, *Eucalyptus* spp.		X	X			1
Otiorhynchus cribricollis Gyllenhal (Coleoptera: Curculionidae)	NSW, SA, WA	***Eucalyptus globulus***		X				1
Oxyops pictipennis (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus,*** *E. marginata*		X				1
Oxyops posticalia (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus***, *E. marginata*		X				1
Palaeotoma spp. (Lepidoptera: Tortricidae)	SA	*Eucalyptus* spp.		X				1
Pantomorus cervinus (Boheman) (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus***		X				1
Paralaea beggaria (Guenee) (=*Stathmorrhopa aphotista*) (Lepidoptera: Geometridae)	TAS, VIC	***Eucalyptus amygdalina, E. nitens, E. obliqua, E. ovata,*** *E. risdonii, E. tenuiramis,* ***E. viminalis***		X				1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Paroplites australis (Erichson) (Coleoptera: Cerambycidae)	NSW, QLD, TAS, VIC	***Eucalyptus pilularis***, *Banksia* spp., *Ulmus* sp., *Salix* sp., *Quercus* sp., *Allocasuarina stricta*			X	X		1
Paropsis aegrota Boisduval (Coleoptera: Chrysomelidae)	SA, TAS	***Eucalyptus amygdalina***, *E. coccifera*, *E. dalrympleana*, ***E. delegatensis, E. obliqua, E. ovata***, *E. pulchella*, ***E. regnans,*** *E. tenuiramis*, ***E. viminalis***		X				1
***Paropsis atomaria* Olivier (Coleoptera: Chrysomelidae)**	ACT, NSW, SA, VIC, WA	*Eucalyptus blakelyi*, *E. camaldulensis*, ***E. grandis***, *E. macarthurii*, *E. melliodora*, ***E. regnans***, *E. rudis*, ***E. viminalis***		X				1
***Paropsis charybdis* Stal (Coleoptera: Chrysomelidae)**	NSW, TAS, VIC, (NZ)	***Eucalyptus delegatensis, E. globulus, E. nitens,*** *E. macarthurii*, ***E. obliqua, E. ovata, E. regnans, E. viminalis***		X				1
Paropsis deboeri Selman (Coleoptera: Chrysomelidae)	TAS	***Eucalyptus nitens***		X				1
***Paropsis delittlei* Selman (Coleoptera: Chrysomelidae)**	TAS	***Eucalyptus delegatensis, E. globulus, E. nitens, E. obliqua, E. regnans***		X				1
Paropsis dilatata Erichson (Coleoptera: Chrysomelidae)	TAS	*Eucalyptus dalrympleana*, ***E. delegatensis, E. globulus,*** *E. nitida*, ***E. obliqua, E. ovata, E. regnans,*** *E. tenuiramis*		X				1
Paropsis geographica Baly (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Paropsis incarnata Erichson (Coleoptera: Chrysomelidae)	TAS	***Eucalyptus obliqua, E. ovata, E. viminalis***		X				1
Paropsis porosa Erichson (Coleoptera: Chrysomelidae)	TAS, VIC	***Eucalyptus amygdalina, E. globulus***, *E. gunnii*, ***E. nitens, E. obliqua, E. ovata,*** *E. pulchella*, ***E. regnans,*** *E. rubida*, ***E. viminalis***		X seedlings				1
Paropsis rubidipes Blackburn (Coleoptera: Chrysomelidae)	TAS	*Eucalyptus coccifera*, *E. dalrympleana*, ***E. delegatensis***, *E. nitida*, ***E. obliqua, E. ovata,*** *E. pauciflora*, *E. pulchella*						1
Paropsis tasmanica Baly (Coleoptera: Chrysomelidae)	TAS	***Eucalyptus amygdalina***, *E. dalrympleana*, ***E. delegatensis, E. obliqua, E. ovata***, *E. pauciflora*, ***E. regnans,*** *E. rubida*, ***E. viminalis***		X				1
Paropsis yilgarnensis Blackburn (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Paropsisterna nucea (Erichson) (Coleoptera: Chrysomelidae)	TAS	***Eucalyptus regnans***		X				1
Paropsisterna picta Chapuis (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Pelolorhinus cf. *angustatus* Fahraeus (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus***		X				1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
***Perga affinis affinis* Kirby (Hymenoptera: Pergidae)**	NSW, QLD, SA, VIC	*Eucalyptus bicostata, E. blakelyi, E. camaldulensis,* ***E. globulus, E. grandis,*** *E. maculosa, E. melliodora, E. occidentalis, E. sideroxylon,* ***E. viminalis***		X				1
***Perga affinis insularis* Riek (Hymenoptera: Pergidae)**	TAS	***Eucalyptus amygdalina, E.globulus, E. grandis, E. nitens, E. obliqua,*** *E. occidentalis,* ***E. ovata, E. viminalis***		X				1
***Perga dorsalis* Leach (Hymenoptera: Pergidae)**	NSW, QLD, SA, VIC	*Eucalyptus camaldulensis,* ***E. grandis,*** *E. occidentalis, Eucalyptus* spp.		X				1
Perga kirbyi Leach (Hymenoptera: Pergidae)	QLD, SA	*Eucalyptus camaldulensis,* ***Corymbia maculata***		X				1
***Perga schiodtei* Westwood (Hymenoptera: Pergidae)**	WA	***Eucalyptus globulus***		X				1
Pergagrapta bella (Newman) (Hymenoptera: Pergidae)	NSW, SA, TAS, VIC	***Eucalyptus amygdalina, E. viminalis***		X				1
Perthida glyphopa Common (Lepidoptera: Incurvariidae)	WA	***Eucalyptus grandis,*** *E. marginata, E. todtiana*		X				1
Perthida spp. (Lepidoptera: Incurvariidae)	NSW	*Eucalyptus camaldulensis,* ***E. saligna***		X				1
Phaulacridium vittatum (Sjostedt) (Orthoptera: Acrididae)	NSW, QLD, SA, TAS, VIC, WA	***Eucalyptus globulus, E. nitens****, Pinus radiata*	X	X				1
Phellopsylla spp. (Homoptera: Psyllidae)	SA	*Eucalyptus* spp.		X				1
***Phlyctaenodes pustulosus* Newman (Coleoptera: Cerambycidae)**	NSW, SA, TAS, VIC	***Eucalyptus amygdalina, E. obliqua, E. regnans****; Casuarina* sp.				X		1
***Phoracantha* (=*Tryphocaria*) *acanthocera* (Macleay) [=*Phoracantha* (*Tryphocaria*) *hamata*] (Coleoptera: Cerambycidae)**	NSW, QLD, SA, VIC, WA	*Eucalyptus acmenioides, E. camaldulensis,* ***E. diversicolor, E. globulus****, E. gomphocephala,* ***E. grandis,*** *E. jacksonii, E. marginata,* ***E. nitens,*** *E. paniculata, E. patens, E. propinqua, E. punctata, E. redunca* var. *elata,* ***E. regnans****, E. resinifera,* ***E. saligna,*** *E. wandoo, Eucalyptus* spp., ***Corymbia calophylla****, C. ficifolia,* ***C. maculata****, Angophora lanceolata, Agathis robusta, Araucaria cunninghamii*		X	X	X		1
Phoracantha (=*Tryphocaria*) *frenchi* (Blackburn) (Coleoptera: Cerambycidae)	NSW, QLD, SA, VIC	*E. alba,* ***E. globulus***				X	X	1
***Phoracantha* (=*Tryphocharia*) *mastersi* (Pascoe) (Coleoptera: Cerambycidae)**	NSW, QLD, SA, TAS, VIC	***Eucalyptus amygdalina, E. globulus, E. nitens, E. obliqua, E. pilularis, E. regnans, E. viminalis****, Eucalyptus* spp., ***Corymbia maculata****, Acacia* spp.				X	X	1

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***Phoracantha odewahni* Pascoe (Coleoptera: Cerambycidae)**	SA, VIC, WA	***Eucalyptus diversicolor,*** *E. wandoo, Eucalyptus* spp., ***Corymbia calophylla***				X	X	1
***Phoracantha punctipennis* (Blackburn) (Coleoptera: Cerambycidae)**	SA, WA	***Eucalyptus diversicolor****, E. wandoo,* ***Corymbia calophylla***				X	X	1
***Phoracantha recurva* Newman (Coleoptera: Cerambycidae)**	NSW, NT, QLD, SA, TAS, VIC, WA	*Eucalyptus camaldulensis,* ***E. globulus,*** *E. intermedia, E. melliodora, E. nova-anglica,* ***E. ovata,*** *E. rostrata,* ***E. saligna****, Eucalyptus* spp., ***Corymbia maculata***				X	X	2 (CA)
***Phoracantha semipunctata* (Fabricius) (Coleoptera: Cerambycidae)**	NSW, NT, QLD, SA, TAS, VIC, WA, (NZ)	*Eucalyptus acmenioides, E. botryoides, E. camaldulensis, E. cladoclayx,* ***E. cloeziana****, E. crebra, E. cypellocarpa, E. deanei,* ***E. delegatensis, E. diversicolor, E. dunnii,*** *E. fastigata,* ***E. globulus****, E. gomphocephala, E. gracilis,* ***E. grandis,*** *E. intermedia, E. leucoxylon, E. longifolia, E. microcorys, E. moluccana,* ***E. nitens, E. obliqua,*** *E. oleosa, E. oreades, E. paniculata, E. pauciflora, E. phaeotricha,* ***E. pilularis,*** *E. piperita, E. punctata, E. resinifera, E. robusta, E. rostrata,* ***E. saligna****, E. salubris, E. siderophloia, E. sideroxylon, E. tereticornis, E. trachyphloia, E. triantha,* ***E. viminalis****, Eucalyptus spp.,* ***Corymbia citriodora, C. maculata,*** *Angophora intermedia, Syncarpia laurifolia*				X		2 (CA)
***Phoracantha (=Tryphocaria) solida* (Blackburn) (Coleoptera: Cerambycidae)**	NSW, NT, QLD, SA, WA	*Eucalyptus camaldulensis,* ***E. grandis****, E. micrantha, E. microcorys, E. pellita, E. propinqua, E. resinifera,* ***E. saligna****, E. tereticornis, Angophora intermedia*				X		1
***Phoracantha tricuspis* Newman (Coleoptera: Cerambycidae)**	NSW, NT, QLD, SA, VIC	*Eucalyptus botryoides, E. melliodora, E. paniculata, E. robusta,* ***E. viminalis,*** *Eucalyptus* spp.				X	X	1
Phylacteophaga eucalypti Froggatt (Hymenoptera: Pergidae)	NSW, QLD, TAS, VIC	***Eucalyptus grandis, E. nitens***		X				1
Phylacteophaga eucalypti tasmanica Riek (Hymenoptera: Pergidae)	TAS	***Eucalyptus amygdalina, E. nitens, E. viminalis***		X				1
Phylacteophaga froggatti Riek (Hymenoptera: Pergidae)	NSW, QLD, SA, TAS, VIC, WA, (NZ)	*Eucalyptus blakelyi, E. brookerana, E. botryoides, E. camaldulensis,* ***E. dunnii, E. globulus, E. grandis, E. nitens, E. robusta, E. saligna, E. viminalis****, Eucalyptus* spp.		X				1
Platybrachys sp. (Homoptera: Eurybrachidae)	WA	***Eucalyptus globulus***		X				1

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***Platypus australis* Chapuis (Coleoptera: Platypodidae)**	NSW, QLD	***Eucalyptus saligna***				X		1
Platypus solidus Walker (Coleoptera: Platypodidae)	?	***Eucalyptus grandis***				X	X	1
***Platypus subgranosus* Schedl (Coleoptera: Platypodidae)**	QLD, TAS, VIC	***Eucalyptus delegatensis,*** *E. goniocalyx,* ***E. nitens, E. obliqua, E. regnans; E. saligna, Corymbia maculata****, Nothofagus cunninghamii, Pinus radiata*				X	X	1
***Platypus tuberculosus* Schedl (Coleoptera: Platypodidae)**	NSW, TAS, VIC	*Eucalyptus cypellocarpa,* ***E. nitens, E. ovata***				X	X	1
***Podacanthus wilkinsoni* Macleay (Phasmatodea: Phasmatidae)**	NSW, VIC	*Eucalyptus bicostata, E. dalrympleana,* ***E. delegatensis****, E. dives,* ***E. grandis****, E. huberiana, E. laevopinea, E. major, E. mannifera,* ***E. obliqua****, E. pauciflora,* ***E. pilularis,*** *E. radiata,* ***E. regnans,*** *E. robertsonii,* ***E. saligna,*** *E. stellulata,* ***E. viminalis***		X				1
Polyphrades oesalon Pascoe (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus***		X				1
***Porotermes adamsoni* (Froggatt) (Isoptera: Termopsidae)**	ACT, NSW QLD, SA, TAS, VIC	***Eucalyptus amygdalina, E. delegatensis, E. globulus, E. obliqua,*** *E. pulchella,* ***E. regnans,*** *E. robertsonii,* ***E. sieberi****, E. tenuiramis,* ***E. viminalis****, Eucalyptus* spp., *Pinus radiata, Araucaria cunninghamii, Ceratopetalum apetalum, Nothofagus cunninghamii*					X	1
Protolechia spp. (Lepidoptera: Gelechiidae)	SA, TAS	*Eucalyptus* spp.		X				1
Psaltoda moerens (Germar) (Homoptera: Cicadidae)	NSW, QLD, SA, TAS, VIC	***Eucalyptus grandis, E. obliqua, E. viminalis,*** *Angophora costata, Liquidambar styraciflua, Salix babylonica*		X				1
Pseudoperga lewisii (Westwood) (Hymenoptera: Pergidae)	NSW, QLD, SA, TAS, VIC	***Eucalyptus nitens, E. viminalis***		X				1
Rhachiodes dentifer Boheman (Coleoptera: Curculionidae)	TAS	***Eucalyptus delegatensis, E. globulus, E. nitens, E. obliqua,*** *Eucalyptus* spp.		X				1
Rhadinosomus lacordairei Pascoe (Coleoptera: Curculionidae)	TAS, WA	***Eucalyptus diversicolor, E. nitens***		X			X (seedlings)	1
Rhinaria sp. (Coleoptera: Curculionidae)	WA	***Eucalyptus globulus***		X				1
Rhinotia sp. (Coleoptera: Belidae)	WA	***Eucalyptus globulus***		X				1
Saccolaemus spp. (Coleoptera: Curculionidae)	SA	*Eucalyptus* spp.		X				1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Schedorhinotermes intermedius **(Brauer) (Isoptera: Rhinotermitidae)**	NSW, NT, QLD, SA, VIC, WA	*Eucalyptus* spp.; any hardwood or softwood				X	X	1
Schedorhinotermes reticulatus **(Froggatt) (Isoptera: Rhinotermitidae)**	NSW, QLD, VIC, WA	*Eucalyptus* spp.				X	X	1
Schedotrioza eucalypti (Froggatt) (Homoptera: Triozidae)	NSW	***Eucalyptus saligna***		X				1
Schedotrioza marginata Taylor (Homoptera: Triozidae)	SA	*Eucalyptus baxteri,* ***E. obliqua***		X				1
Schedotrioza multitudinea (Maskell) (Homoptera: Triozidae)	SA	***Eucalyptus obliqua***		X				1
Schedotrioza tasmaniensis (Froggatt) (Homoptera: Triozidae)	TAS	***Eucalyptus amygdalina***		X				1
Scolecobrotus westwoodi **Hope (Coleoptera: Cerambycidae)**	ACT, NSW, SA, TAS, VIC, WA	***Eucalyptus amygdalina****, E. corymbosa,* ***E. globulus****, E. gracilis, E. johnstonii, E. melliodora, Eucalyptus* spp.; *Corymbia gummifera, Amyema* sp.					X (saplings)	1
Sertorius australis (Fairmaire) (Homoptera: Membracidae)	SA	*Eucalyptus* spp.		X				1
Sinoxylon anale **(Lesne) (Coleoptera: Bostrichidae)**	NT, SA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata***				X	X	1
Siphanta acuta (Walker) (Homoptera: Flatidae)	NSW, NT, QLD, SA, TAS, VIC, WA, (NZ)	*Eucalyptus* spp.		X				1
Spondyliaspis plicatuloides (Froggatt) (Homoptera: Psyllidae)	SA	*Eucalyptus camaldulensis,* ***E. globulus, E. nitens,*** *E. leucoxylon,* ***E. saligna****, Eucalyptus* spp.		X				1
Strepsicrates macropetana Meyrick (Lepidoptera: Tortricidae)	NSW, QLD, SA, VIC, WA, (NZ)	*Eucalyptus* spp.		X				1
Strongylorhinus ochraceous Schonherr (Coleoptera: Curculionidae)	NSW, TAS, WA	***Eucalyptus globulus****, E. rudis, E. siderophloia*				X (branches)		1
Syarbis alcyone (Coleoptera: Curculionidae)	TAS	***Eucalyptus obliqua, E. sieberi***		X				1
Terrillus suturalis Blackburn (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Tessaromma sericans Newman (Coleoptera: Cerambycidae)	TAS	***Eucalyptus obliqua, E. sieberi, E. viminalis***				X		1
***Tessaromma undatum* Newman (Coleoptera: Cerambycidae)**	ACT, NSW, QLD, SA, VIC, (NZ)	*Eucalyptus camaldulensis, E. dalrympleana,* ***E. delegatensis, E. globulus, E. grandis,*** *E. macarthurii, E. melliodora,* ***E. obliqua,*** *E. polyanthemos,* ***E. saligna, E. sieberi, E. viminalis****, Acacia dealbata, Nothofagus moorei*				X		1
Thrydopteryx herrichii (Lepidoptera: Psychidae)	SA	*Eucalyptus* spp.		X				1
Tinea nectarea Meyrick (Lepidoptera: Tineidae)	NSW	***Eucalyptus grandis, E. pilularis, E. saligna***		X				1
Toxeutes arctuatus (Coleoptera: Cerambycidae)	TAS	*Eucalyptus* spp.						1
Toxeutes sp. (Coleoptera: Cerambycidae)	WA	***Eucalyptus diversicolor,*** *Pinus radiata*				X		1
Trachymela sloanei (Blackburn) (Coleoptera: Chrysomelidae)	? (NZ)	*Eucalyptus camaldulensis, Eucalyptus* spp.		X				2 (CA)
Trachymela tincticollis (Blackburn) (Coleoptera: Chrysomelidae)	WA	*Eucalyptus cornuta,* ***E. diversicolor, E. globulus****, E. gomphocephala,* ***E. grandis****, E. lehmannii, E. rudis,* ***Corymbia calophylla***		X				
Trachymela spp. (Coleoptera: Chrysomelidae)	WA	***Eucalyptus globulus***		X				1
Trocnada dorsigera Walker (Homoptera: Cicadellidae)	WA	***Eucalyptus globulus***		X				1
***Uraba lugens* Walker (Lepidoptera: Noctuidae)**	NSW, QLD, SA, TAS, VIC, WA, (NZ)	*Eucalyptus acmenioides, E. andreana, E. baueriana, E. bicostata, E. blakelyi, E. bridgesiana, E. camaldulensis, E. crebra, E. dalrympleana,* ***E. delegatensis****, E. dives, E. drepanophylla, E. eugenioides, E. fastigata,* ***E. globulus, E. grandis****, E. hemiphloia, E. intermedia, E. largiflorens, E. macrandra, E. macrorhyncha, E. marginata, E. melanophloia, E. melliodora, E. nichollii,* ***E. nitens, E. obliqua, E. ovata,*** *E. pauciflora, E. radiata, E. robertsonii, E. robusta,* ***E. saligna****, E. siderophloia, E. sideroxylon, E. stellulata, E. tereticornis, E. tessellaris,* ***E. viminalis, Corymbia calophylla, C. citriodora****, C. ficifolia,* ***C. maculata,*** *Angophora costata, A. subvelutina, Lophostemon confertus, Tristania suaveolens*		X	X (pupae)			1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart-wood	Pest category[b]
Uzucha humeralis Walker (Lepidoptera: Oecophoridae)	NSW, QLD	***Eucalyptus grandis, E. saligna***, *Eucalyptus* spp., *Angophora* spp., ***Corymbia maculata***			X	X	X	1
Valanga irregularis (Walker) (Orthoptera: Acrididae)	NSW, NT, QLD, WA	***Eucalyptus grandis***		X				1
***Xyleborus perforans* (Wollaston) (Coleoptera: Scolytidae)**	QLD	*Eucalyptus deglupta, E. drepanophylla,* ***E. grandis,*** *E. intermedia, E. seeana, E. tereticornis, Eucalyptus spp.,* ***Corymbia maculata,*** *C. variegata*				X		2 (Hawaii)
Xylion collaris Er. (Coleoptera: Bostrichidae)	NSW, TAS	***Eucalyptus obliqua, E. saligna, Corymbia maculata,*** *Banksia marginata*				X	X	1
***Xylion cylindricus* Macleay (Coleoptera: Bostrichidae)**	NSW, NT, QLD, TAS	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata***				X	X	1
***Xylobosca bispinosa* (Macleay) (Coleoptera: Bostrichidae)**	NSW, NT, QLD, TAS, WA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata,*** *Acacia pycnantha*				X	X	1
***Xylodeleis obsipa* Germar (Coleoptera: Bostrichidae)**	NSW, NT, QLD, WA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata***				X	X	1
***Xylopsocus gibbicollis* Macleay (Coleoptera: Bostrichidae)**	NSW, NT, QLD, TAS, WA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata***				X	X	1
Xylopsocus rubidus (Coleoptera: Bostrichidae)	WA	*Eucalyptus wandoo,* ***Corymbia calophylla***				X	X	1
***Xylosandrus (=Xyleborus) solidus* Eichhoff (Coleoptera: Scolytidae)**	NSW, QLD, TAS, (NZ)	***Eucalyptus saligna***				X		1
***Xylothrips religiosus* (Boisduval) (Coleoptera: Bostrichidae)**	NT, QLD, WA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, Corymbia calophylla, C. citriodora, C. maculata***				X	X	1

Table 7—Potential insects of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sapwood	Heart- wood	Pest category[b]
***Xylotillus lindi* (Blackburn) (Coleoptera: Bostrichidae)**	NSW, SA	***Eucalyptus amygdalina, E. cloeziana, E. delegatensis, E. dunnii, E. globulus, E. nitens, E. obliqua, E. ovata, E. regnans, E. saligna, E. viminalis, E. Corymbia calophylla, C. citriodora, C. maculata***				X	X	1
***Zelotypia stacyi* Scott (Lepidoptera: Hepialidae)**	NSW, QLD	***Eucalyptus grandis, E. saligna,*** *E. tereticornis*						1
***Zygocera canosa* (Erichson) (Coleoptera: Cerambycidae)**	TAS	***Eucalyptus amygdalina, E. obliqua***					X	1

[a]Insect species in bold type are treated in Individual Pest Risk Assessments; hosts in bold type are the 18 Australian eucalypt species being considered in this risk assessment.
[b]See Table 6 for pest category descriptions.
[c]Australian states or New Zealand in parentheses indicates state or country into which introductions of the pest have occurred.

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap- wood	Heart- wood	Pest category[b]
Amyema cambagei (Blakely) Danser (Santales, Loranthaceae)	ACT, NSW, QLD	*Eucalyptus* spp., *Acacia parramattensis*, *Allocasuarina littoralis*, *A. luehmannii*, *A. torulosa*, *Casuarina cristata*, *C. cunninghamiana*, *C. glauca*, *Callitris glaucophylla*, *Eremophila mitchellii*, *Melaleuca styphelioides*			X	X		1
Amyema miquelii (Lehm. ex Miq.) Tieghem (Santales, Loranthaceae)	ACT, NSW, NT, QLD, SA, VIC, WA	*Eucalyptus albens*, *E. aspera*, *E. baueriana*, *E. bicostata*, *E. bigalerita*, *E. blakelyi*, *E. bleeseri*, *E. botryoides*, *E. brachycalyx*, *E. bridgesiana*, *E. caleyi*, *E. camaldulensis*, *E. cambageana*, *E. cinerea*, *E. cladocalyx*, *E. concinna*, *E. conica*, *E. coolabah*, *E. crebra*, *E. dalrympleana*, *E. dealbata*, *E. dichromophloia*, *E. drepanophylla*, *E. drummondii*, *E. dumosa*, *E. dwyeri*, *E. eremicola*, *E. eugenioides*, *E. ewartiana*, *E. exserta*, *E. fasciculosa*, *E. fibrosa*, *E. flocktoniae*, *E. gamophylla*, *E. gillenii*, *E. gillii*, *E. glaucescens*, *E. gomphocephala*, *E. gongylocarpa*, *E. goniocalyx*, *E. gracilis*, *E. gummifera*, *E. intertexta*, *E. kingsmillii*, *E. kondininensis*, *E. laeliae*, *E. largiflorens*, *E. leptophylla*, *E. leucophloia*, *E. leucoxylon*, *E. longifolia*, *E. loxophleba*, *E. macrorhyncha*, *E. mannifera*, *E. melanophloia*, *E. melliodora*, *E. microcarpa*, *E. microcorys*, *E. microtheca*, *E. miniata*, *E. moluccana*, *E. nortonii*, *E. odontocarpa*, *E. odorata*, *Eucalyptus oldfieldii*, *E. oleosa*, *E. oxymitra*, *E. pachyphylla*, *E. papuana*, *E. patens*, *E. pileata*, ***E. pilularis***, *E. pimpiniana*, *E. platyphylla*, *E. polyanthemos*, *E. populnea*, *E. porosa*, *E. prava*, *E. pruinosa*, *E. punctata*, *E. pyriformis*, *E. racemosa*, *E. resinifera*, *E. rossii*, *E. rubida*, *E. rudis*, ***E. saligna***, *E. salmonophloia*, *E. scoparia*, *E. sessilis*, *E. siderophloia*, *E. sideroxylon*, *E. socialis*, *E. sparsifolia*, *E. spathulata*, *E. tectifica*, *E. tereticornis*, *E. tessellaris*, *E. tetrodonta*, *E. todtiana*, *E. transcontinentalis*, *E. umbra*, ***E. viminalis***, *E. viridis*, *E. wandoo*, *E. youngiana*, *E. yumbarrana*, ***Corymbia calophylla***, ***C. maculata***, *Acacia aneura*, *A. dealbata*, *A. farnesiana*, *A. mearnsii*, *A. victoriae*, *Allocasuarina verticillata*, *Amyema cambagei*, *Amyema miquelii*, *Angophora floribunda*, *Brachychiton* sp., *Callitris endlicheri*, *Canthium* sp., *Casuarina* sp., *Exocarpos cupressiformis*, *Melaleuca cardiophylla*, *Muellerina eucalyptoides*, *Petalostigma pubescens*, *Planchonia careya*			X	X		1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Pest category[b]
Amyema pendulum (Sieber ex Sprengel) Tieghem (Santales, Loranthaceae)	ACT, NSW, QLD, SA, VIC	*Eucalyptus agglomerata*, *E. albens*, *E. amplifolia*, *E. andrewsii*, *E. bancroftii*, *E. baueriana*, *E. baxteri*, *E. blakelyi*, *E. blaxlandii*, *E. bosistoana*, *E. bridgesiana*, *E. camaldulensis*, *E. capitellata*, *E. cephalocarpa*, *E. cinerea*, *E. cosmophylla*, *E. dalrympleana*, ***E. delegatensis***, *E. diversifolia*, *E. dives*, *E. eugenioides*, *E. fasciculosa*, *E. goniocalyx*, *E. gummifera*, *E. haemastoma*, *E. laevopinea*, *E. leucoxylon*, *E. macrorhyncha*, *E. mannifera*, *E. melliodora*, *E. micranthera*, *E. moorei*, *E. muellerana*, *E. nortonii*, *E. nova-anglica*, ***E. obliqua***, ***E. ovata***, **E. *pilularis***, *E. piperita*, *E. polyanthemos*, *E. propinqua*, *E. racemosa*, *E. radiata*, *E. rossii*, *E. seeana*, *E. siderophloia*, *E. sideroxylon*, ***E. sieberi***, *E. sparsifolia*, *E. stellulata*, *E. tereticornis*, ***E. viminalis***, *E. willisii*, *Acacia baileyana*, *A. dealbata*, *A. decurrens*, *A. fimbriata*, *A. irrorata*, *A. linifolia*, *A. mearnsii*, *A. melanoxylon*, *A. obliquinervia*, *A. paradoxa*, *A. parramattensis*, *A. pycnantha*, *A. retinervis*, *A. silvestris*, *Allocasuarina torulosa*, *Allocasuarina verticillata*, *Amyema cambagei*, *Amyema gaudichaudii*, *Angophora floribunda*, *Casuarina* sp., *Crataegus monogyna*, *Muellerina eucalyptoides*, *Siphonodon australis*			X	X		1
Anthostomella eucalypti H.Y. Yip (Xylariales, Xylariaceae)	TAS, VIC	*Eucalyptus camaldulensis*, ***E. globulus***		X				1
***Armillaria fumosa* Kile & Watling (Agaricales, Marasmiaceae)**	Australia	***Eucalyptus amygdalina***, *E. drepanophylla*, ***E. obliqua***, ***E. ovata***, ***E. pilularis***, *E. propinqua*, *E. punctata*, *E. rubida*, *E. signata*, broad host range			X	X	X	1
***Armillaria hinnulea* Kile & Watling (Agaricales, Marasmiaceae)**	Australia	***Eucalyptus delegatensis***, ***E. obliqua***, ***E. regnans***, broad host range			X	X	X	1
***Armillaria luteobubalina* Watling & Kile (Agaricales, Marasmiaceae)**	Australia	*Eucalyptus gummifera*, *E. camaldulensis*, *E. cladocalyx*, *E. cypellocarpa*, ***E. diversicolor***, *E. dives*, *E. erythrocorys*, *E. forrestiana*, ***E. globulus* subsp. *bicostata***, *E. gomphocephala*, *E. leucoxylon*, *E. macrorhyncha*, *E. marginata*, *E. megacarpa*, *E. melliodora*, *E. nicholii,* ***E. nitens***, ***E. obliqua***, ***E. ovata***, *E. patens*, *E. radiata*, *E. rubida*, *E. rudis*, ***E. viminalis***, *E. wandoo*, ***Corymbia calophylla***, ***C. citriodora*,** *C. ficifolia*, broad host range			X	X	X	1
***Armillaria novae-zealandiae* (G. Stev.) Herink (Agaricales, Marasmiaceae)**	Australia	***Eucalyptus delegatensis***, ***E. obliqua***, ***E. regnans***			X	X	X	1
***Armillaria pallidula* Kile & Watling (Agaricales, Marasmiaceae)**	Australia	*Eucalyptus* spp., *Pinus* spp.			X	X	X	1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Pest category[b]
***Aulographina eucalypti* (Cooke & Massee) v.Arx & Müller [anamorph *Thyrinula eucalypti* (Cooke & Massee) H.J. Swart] (Dothidiomycetales, Asterinaceae)**	ACT, NSW, QLD, SA, TAS, VIC	*Eucalyptus agglomerata*, *E. andrewsii*, *E. approximans*, *E. baxteri*, *E. botryoides*, *E. bridgesiana*, *E. caesia*, *E. camaldulensis*, *E. cladocalyx*, *E. coccifera*, *E. consideniana*, *E. cosmophylla*, *E. cypellocarpa*, *E. dalrympleana*, ***E. delegatensis***, *E. dives*, *E. elata*, *E. fastigata*, *E. fraxinoides*, *E. gigantea*, *E. globoidea*, ***E. globulus***, ***E. globulus* subsp. *bicostata***, ***E. globulus* subsp. *globulus***, ***E. grandis***, *E. gregsoniana*, *E. johnstonii*, *E. lehmannii*, *E. macarthurii*, *E. macrorhyncha*, *E. marginata*, *E. microcorys*, *E. moluccana*, *E. muellerana*, *E. niphophila*, ***E. nitens***, *E. nitida*, ***E. obliqua***, *E. oreades*, *E. pauciflora*, *E. pauciflora* subsp. *niphophila*, *E. pauciflora* subsp. *pauciflora*, *E. pellita*, *E. perriniana*, ***E. pilularis***, *E. quadrangulata*, *E. radiata*, ***E. regnans***, *E. resinifera*, ***E. saligna***, ***E. sieberi***, *E. stellulata*, *E. tetragona*, ***E. viminalis***, *E. woodwardii*, *Eucalyptus* spp., ***Corymbia maculata***, *Angophora costata*		X				2 (Hawaii)
Aurantiosacculus eucalypti (Cooke & Massee) Dyko & B. Sutton [syn. *Protostegia eucalypti* Cooke & Massee] (anamorphic Ascomycete)	SA, VIC	*Eucalyptus baxteri*, *E. incrassata*, ***E. obliqua***, ***E. regnans***		X				1
Blastacervulus eucalypti H.J. Swart (anamorphic Ascomycete)	VIC	***Eucalyptus obliqua***		X				1
***Botryosphaeria ribis* (Tode.:Fr.) Grossenb. & Dugger [anamorph *Fusicoccum* sp.] (Dothidiales, Botryospheriaceae)**	ACT, WA	*Eucalyptus accedens*, *E. andrewsii*, *E. blakelyi*, *E. botryoides*, *E. caesia*, *E. camaldulensis*, *E. cladocalyx*, *E. coriacea*, *E. cypellocarpa*, *E. dalrympleana*, ***E. delegatensis***, ***E. diversicolor***, *E. elata*, *E. fastigata*, *E. gigantea*, *E. globoidea*, ***E. globulus***, ***E. grandis***, *E. hemiphloia*, *E. leucoxylon*, *E. macarthurii*, *E. maidenii*, *E. marginata*, *E. megacarpa*, *E. muelleriana*, ***E. nitens***, ***E. obliqua***, *E. oreades*, ***E. pilularis***, *E. quadrangulata*, *E. radiata*, ***E. regnans***, *E. resinifera*, ***E. saligna***, *E. urophylla*, ***E. viminalis***, *E. wandoo*, *Eucalyptus* spp., ***Corymbia calophylla***, 100+ genera including *Cercis* spp., *Citrus* spp., *Cornus* spp., *Liquidambar* spp., *Malus* spp., *Pinus* spp., *Platanus* spp., *Prunus* spp., *Tilia* spp., *Ulmus* spp.		X	X	X		4a
***Calonectria morganii* Crous, Alfenas & M.J. Wingfield [anamorph *Cylindrocladium scoparium* Morgan] (Hypocreales, Nectriaceae)**	NSW	***E. grandis***, *E. microcorys*, ***E. pilularis***, *E. pyrocarpa*	X	X				2 (Florida)

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Pest category[b]
***Calonectria reteaudii* (Bugn.) C. Booth [anamorph *Cylindrocladium reteaudii* (Bugn.) Boesew. = *Cylindrocladium quinqueseptatum* Boedijn & Reitsma] (Hypocreales, Nectriaceae)**	NT, QLD	*Eucalyptus alba*, *E. bigalerita*, *E. camaldulensis*, *E. clavigera*, *E. cloeziana*, *E. confluens*, *E. crebra*, *E. deglupta*, *E. drepanophylla*, *E. ferruginea*, ***E. globulus***, ***E. grandis***, *E. lirata*, *E. microcorys*, *E. nicholii*, *E. oligantha*, *E. paniculata*, *E. patellaris*, *E. phoenicea*, *E. pilularis*, *E. robusta*, ***E. saligna***, *E. sphaerocarpa*, *E. staigeriana*, *E. tereticornis*, *E. tessellaris*, *E. torelliana*, *E. umbrawarrensis*, *Eucalyptus* sp., ***Corymbia citriodora***, ***C. maculata***, numerous additional genera, including *Hevea*, clove	X	X				1
Catenophoropsis eucalypticola Nag Raj & W.B. Kendrick (anamorphic Ascomycete)	QLD	*Eucalyptus* spp. (Pathogen?)	X					1
***Ceratocystis eucalypti* Z.Q. Yuan & Kile (Microascales, Ceratocystidiaceae)**	TAS, VIC	*Eucalyptus globoidea*, ***E. regnans, E. sieberi***			X	X		1
***Ceratocystis moniliformis* (Hedgc.) C. Moreau (Microascales, Ceratocystidiaceae)**		*Eucalyptus* spp.			X	X		4a
***Ceratocystis moniliformopsis* Z.Q. Yuan & C. Mohammed (Microascales, Ceratocystidiaceae)**	TAS	***Eucalyptus obliqua***			X	X		1
Ceuthospora innumera Massee [teleomorph *Phacidium eucalypti* G.W. Beaton & Weste] (Helotiales, Phacidiaceae)	NSW, TAS, VIC	***Eucalyptus globulus, E. nitens, E. ovata, E. regnans,*** *Eucalyptus* spp.		X	X			1
Coniella fragariae (Oudem.) B. Sutton (syn. *Coniella pulchella* Höhn.) (anamorphic *Schizoparme*, Diaporthales, Melonconidaceae)	QLD	*Eucalyptus camaldulensis*, ***E. grandis***, *Eucalyptus* spp.		X	X			1
Coniothyrium ovatum H.J. Swart [syn. *Coniothyrium parvum* H.J. Swart] (anamorphic *Leptosphaeria*, Pleosporales, Leptosphaeriaceae)	VIC	*Eucalyptus dives, E. leucoxylon, E. macrorhyncha, E. melliodora,* ***E. obliqua***, ***E. regnans***		X				1
Cryphonectria cubensis (Bruner) Hodges (Diaporthales, Valsaceae)	WA	*Eucalyptus angulosa, E. botryoides, E. camaldulensis,* ***E. cloeziana, E. globulus, E. grandis,*** *E. longifolia, E. marginata, E. microcorys, E. paniculata, E. pilularis, E. propinqua, E. robusta,* ***E. saligna,*** *E. tereticornis, E. trabutii, E. urophylla,* ***Corymbia citriodora, C. maculata****, Syzygium aromaticum*			X	X		2 (Florida, Hawaii)

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Pest category[b]
Cryphonectria eucalypti **M. Venter & M.J. Wingfield (Diaporthales, Valsaceae)**	ACT, NSW, TAS, VIC, WA	***Eucalyptus amygdalina***, *E. blakelyi*, ***E. delegatensis***, ***E. diversicolor***, *E. globoidea*, ***E. globulus***, ***E. grandis***, ***E. grandis*** **x** ***camaldulensis***, ***E. grandis*** **x** ***urophylla***, *E. marginata*, ***E. nitens***, *E. nitida*, ***E. obliqua***, *E. pauciflora*, *E. pulchella*, ***E. regnans***, *E. rossii*, ***E. saligna***, ***E. sieberi***, *E. tenuiramis*, *E. urophylla*, ***E. viminalis***, *Eucalyptus* sp., ***Corymbia calophylla***, ***C. maculata***			X	X		1
Cryptosporiopsis eucalypti **Sankaran & B. Sutton (anamorphic** ***Pezicula*****, Helotiales, Dermataceae)**	Australia	*Eucalyptus camaldulensis, E. camphora, E. cinerea, E. cypellocarpa,* ***E. globulus, E. grandis,*** *E. microcorys, E. nicholii,* ***E. nitens,*** *E. nova-anglica, E. robusta, E. rostrata, E. tereticornis,* ***E. viminalis***		X				2 (Hawaii)
Cytospora australiae Speg. (anamorphic *Valsa*, Diaporthales, Valsaceae)	Australia	***Eucalyptus globulus***, ***E. grandis***, ***E. nitens***, ***E. viminalis***, *Eucalyptus* sp., *Corymbia ficifolia*		X	X	X		1
Cytospora eucalypticola Van der Westhuizen [teleomorph *Valsa ceratosperma* (Tode:Fr.) Maire] (Diaporthales, Valsaceae)	ACT, NSW, TAS, VIC, SA, WA	*Eucalyptus accedens*, ***E. amygdalina***, *E. bancroftii*, *E. camaldulensis*, *E. cladocalyx*, *E. cloeziana*, *E. coccifera*, *E. dalrympleana*, ***E. delegatensis***, ***E. diversicolor***, *E. dives*, *E. erythrocorys*, ***E. globulus***, ***E. grandis***, *E. macrorhyncha*, *E. marginata*, *E. megacarpa*, ***E. nitens***, *E. nitida*, ***E. obliqua***, ***E. ovata***, *E. pauciflora*, ***E. pilularis***, *E. pulchella*, *E. radiata*, ***E. regnans***, *E. resinifera*, *E. rossii*, *E. rubida*, ***E. saligna***, *E. stellulata*, *E. tereticornis*, *E. urophylla*, *E. uro-grandis*, ***E. viminalis***, *E. wandoo*, *Eucalyptus* sp., ***Corymbia calophylla***, ***C. maculata***, *Acer* spp., *Alnus* spp., *Betula* spp., *Liquidambar* spp., *Malus* spp., *Quercus* spp., numerous additional species			X	X		4a (*Valsa*-US wide)
Cytospora eucalyptina Speg. [teleomorph *Valsa ceratosperma* (Tode:Fr.) Maire] (Diaporthales, Valsaceae)	Australia	***Eucalyptus globulus, E. grandis, E. nitens,*** *E. torelliana,* ***E. viminalis,*** *Corymbia ficifolia, Acer* spp., *Alnus* spp., *Betula* spp., *Liquidambar* spp., *Malus* spp., *Quercus* spp., numerous additional species			X	X		4a (*Valsa*-US wide)
Decaisnella brittenii (Blakely) Barlow (Pyrenulales, Massariaceae)	NT, QLD	*Eucalyptus* sp., *Alstonia actinophylla, Barringtonia acutangala, B. asiatica, Buchanania obovata, Euroschinus falcata, Ficus benjamina, Lophostemon grandiflorus, L. lactifluus, L. suaveolens, Melaleuca acacioides, M. argentea, M. cajuputi, M. dealbata, M. leucadendra, M. saligna, M. viridiflora, Parinari nonda, Planchonia careya, Syzygium eucalyptoides, S. suborbiculare, Terminalia* sp., *Tristania* sp.			X	X		1
Dichostereum sp. (Russulales, Lachnocladiaceae)	TAS	***Eucalyptus obliqua, E. regnans***					X	4
Dicomera versiformis Z.Q. Yuan (anamorphic Dothidiales)	TAS	***Eucalyptus nitens***		X				1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap- wood	Heart- wood	Pest category[b]
Diplatia furcata Barlow (Santales, Loranthaceae)	NT, QLD	*Eucalyptus* spp., *Alectryon diversifolius, Asteromyrtus angustifolia, A. symphyocarpa, Baeckea* sp., *Callistemon viminalis, Canthium vaccinifolium, Dendrophthoe vitellina, Flindersia collina, Leptospermum neglectum, Melaleuca bracteata, M. cajuputi, M. leucadendra, M. linarifolia, M. quinquenervia, M. viridiflora, Neofabricia myrtifolia, Thryptomene oligandra*			X	X		1
Dothidea rugulosa Cooke (Dothidiales, Dothidiaceae)	VIC	*Eucalyptus* spp. (Pathogen?)		X				1
Dothiorella eucalypti (Berk. & Broome) Sacc. (*Dothiorella berengeriana* Sacc.) (anamorphic *Botryosphaeria*?, Dothidiales, Botryospheriaceae)	VIC	***Eucalyptus globulus***		X				2 (Florida)
Elsinoë eucalypti Hansford [anamorph *Sphaceloma* sp.] (Myriangiales, Elsinoaceae)	Australia	***Eucalyptus delegatensis***		X				1
Fairmaniella leprosa (Fairm.) Petrak & Syd. [syn. *Coniothyrium leprosum* Fairm., *Melanconium eucalypticola* Hansf.] (anamorphic *Leptosphaeria*, Pleosporales, Leptosphaeriaceae)	SA, TAS, VIC	***Eucalyptus delegatensis,*** *E. fasciculosa, E. fastigata,* ***E. globulus, E. obliqua,*** *E. polyanthemos*, ***E. regnans,*** *E. robusta, Eucalyptus* sp., ***Corymbia citriodora***		X				2 (CA, HI)
Favostroma crypticum B. Sutton & E.M. Davison (anamorphic Ascomycete)	WA	***Corymbia calophylla***			X			1
***Fistulina spiculifera* (M.C. Cooke) D. A. Reid (Agaricales, Fistulinaceae)**	NSW, WA	*Eucalyptus guilfoylei, E. jacksonii, E. marginata,* ***E. pilularis, E. saligna, Corymbia calophylla***					X	1
Gampsonema exile (Tassi) Nag Raj (anamorphic Ascomycete)	NSW	***Eucalyptus grandis****, E. paniculata, E. robusta,* ***E. saligna****, Eucalyptus* spp. (Pathogen?)		X				2 (Hawaii)
***Ganoderma lucidum* (M.C. Curtis) P. Karst. (Polyporales, Ganodermataceae)**	QLD	*Eucalyptus* spp**.**, ***Corymbia citriodora***					X	4
***Gymnopilus junonius* (Fr.) P.D. Orton (= *G. spectabilus* (Fr.:Fr.) A.H. Smith (Agaricales, Cortinariaceae)**	VIC	*Eucalyptus mannifera, E. robusta,* ***E. viminalis, Corymbia citriodora, C. maculata***					X	4
Harknessia eucalypti Cooke (anamorphic *Wuestneia*, Diaporthales, Melanconidaceae)	QLD, WA	***Eucalyptus globulus,*** *E. globulus* subsp. *maidenii,* ***E. grandis, E. nitens,*** *Eucalyptus* spp.		X				2 (CA)

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap- wood	Heart- wood	Pest category[b]
Harknessia fumaginea B. Sutton & Alcorn (anamorphic *Wuestneia*, Diaporthales, Melanconidaceae)	QLD	***Eucalyptus grandis***, ***E. pilularis***, ***E. saligna***, *Eucalyptus* spp. (Pathogen?)		X				1
Harknessia hawaiiensis F. Stevens & E. Young (anamorphic *Wuestneia*, Diaporthales, Melanconidaceae)	TAS	***Eucalyptus globulus***, ***E. grandis***, ***E. nitens***, ***E. obliqua***, *E. paniculata*, *E. punctata*, *E. robusta*, *E. tereticornis*		X				2 (Hawaii)
Harknessia tasmaniensis Z.Q. Yuan, T. Wardlaw & C. Mohammed (anamorphic *Wuestneia*, Diaporthales, Melanconidaceae)	TAS	***Eucalyptus globulus, E. nitens***		X				1
Harknessia victoriae B.C. Sutton & Pascoe (anamorphic *Wuestneia*, Diaporthales, Melanconidaceae)	TAS	***Eucalyptus nitens***		X				1
Hymenochaete spp. (Hymenochaetales, Hymenochaetaceae)	Australia	***Eucalyptus diversicolor,*** *Eucalyptus* spp.				X	X	4
Idiocercus australis (Cooke) H.J. Swart (anamorphic Ascomycete)	VIC	*Eucalyptus cladocalyx*, ***E. globulus***, *E. gracilis*, ***E. regnans***, *Eucalyptus* spp.		X				1
Illosporium obscurum Cooke & Massee (anamorphic Ascomycete)	VIC	***Eucalyptus globulus*** (Pathogen?)		X				1
***Inonotus albertinii* (Lloyd) P.K. Buchanan (Hymenochaetales, Hymenochaetaceae)**	SA	***Eucalyptus obliqua***					X	1
***Inonotus chondromyeluis* Pegler (Hymenochaetales, Hymenochaetaceae)**	NSW	***Eucalyptus saligna***					X	1
Inonotus rheades (Pers.) Bond. & Singer (Hymenochaetales, Hymenochaetaceae)	QLD, SA, VIC	***Eucalyptus obliqua***, *E. macrorhyncha*, *E. tereticornis*					X	2
Lentinus strigosus (Schw.:Fr.) Fr. (Polyporales, Polyporaceae)	Australia	*Eucalyptus* spp., broad host range					X	4a
***Leptographium lundbergii* Lagerberg & Melin (Microascales, Ceratocystidiaceae, anamorphic form)**	VIC	*E. gigantea*, *E. goniocalyx*, ***E. obliqua, E. regnans***, *Nothofagus cunninghamii*			X	X		4a

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Lysiana murrayi (F. Muell. & Tate) Tieghem (Santales, Loranthaceae)	QLD	*Eucalyptus* spp., *Acacia adsurgens*, *A. aneura*, *A. brachystachya*, *A. burkittii*, *A. coriacea*, *A. craspedocarpa*, *A. cyperophylla*, *A. farnesiana*, *A. kempeana*, *A. ramulosa*, *A. tetragonophylla*, *A. victoriae*, *Cassia desolata*, *Casuarina* sp., *Eremonophila freelingii*, *E. mitchellii*, *Gossypium australe*, *Melaleuca* sp., *Muehlenbeckia cunningamii*, *Pittosporum phylliraeoides*			X	X		1
Macrohilium eucalypti H.J. Swart (anamorphic Ascomycete)	VIC	***Eucalyptus delegatensis***, *E. polyanthemos*		X				1
Microsphaeropsis callista (Syd.) B. Sutton (anamorphic Ascomycete?)	NSW	*Eucalyptus haemastoma*, *E.* ***nitens***, *E. pauciflora*, ***E. viminalis***		X				2 (CA)
Microsphaeropsis conielloides B. Sutton (anamorphic Ascomycete?)	NSW	***Eucalyptus delegatensis***, ***E. obliqua***, *E. pauciflora*, ***E. regnans***, ***E. viminalis*** subsp. *viminalis*, *Eucalyptus* spp.		X				1
Microthyrium eucalypti Henn. (Microthyriales, Microthyriaceae)	Australia	***Eucalyptus delegatensis***, *E. diversifolia*, *E. fastigata*, *E. fraxinoides*, *E. johnstonii*, ***E. regnans***		X				1
Muellerina eucalyptoides (DC.) Barlow (Santales, Loranthaceae)	ACT, NSW, QLD, SA, VIC	*Eucalyptus acmenoides*, *E. agglomerata*, *E. amplifolia*, *E. andrewsii*, *E. bancroftii*, *E. baueriana*, *E. baxteri*, *E. blakelyi*, *E. bridgesiana*, *E. camaldulensis*, *E. crebra*, *E. cypellocarpa*, *E. dealbata*, *E. dwyeri*, *E. eugenioides*, *E. eximia*, *E. goniocalyx*, ***E. grandis***, *E. gummifera*, *E. haemastoma*, *E. intermedia*, *E. laevopinea*, *E. longifolia*, *E. mannifera*, *E. melanophloia*, *E. melliodora*, *E. moluccana*, *E. muelleriana*, *E. notabilis*, ***E. obliqua***, ***E. ovata***, *E. paniculata*, *E. parramattensis*, *E. parvula*, *E. pauciflora*, ***E. pilularis,*** *E. piperita*, *E. polyanthemos*, *E. prava*, *E. propinqua*, *E. punctata*, *E. racemosa*, *E. resinifera*, *E. rossii*, ***E. saligna***, *E. scoparia*, *E. siderophloia*, *E. sideroxylon*, ***E. sieberi***, *E. sparsifolia*, *E. squamosa*, *E. tereticornis*, *E. umbra*, ***E. viminalis***, *E. wardii*, *E. willisii*, ***Corymbia calophylla***, *C. ficifolia*, ***C. maculata***, *Acacia adunca*, *A. baileyana*, *A. binervata*, *A. decurrens*, *A. ferominens*, *A. floribunda*, *A. fulva*, *A. implexa*, *A. linifolia*, *A. mearnsii*, *A. melanoxylon*, *A. paradoxa*, *A. prominens*, *Angophora bakeri*, *A. costata*, *A. floribunda*, *A. hispida*, *A. subvelutina*, *Allocasuarina littoralis*, *Allocasuarina torulosa*, *Allocasuarina verticillata*, *Brachychiton populneus*, *Callitris endlicheri*, *Callistemon lanceolatus*, *Callistemon viminalis*, *Casuarina glauca*, *Chamaecytisus palmensis*, *Crataegus monogyna*, *Crataegus oxyacantha*, *Euonymus japonicus*, *Exocarpos cupressiformis*, *Kunzea ambigua*, *Kunzea ericoides*, *Leptospermum trinervium*, *L. laevigatum*, *L. polygalifolium*, *Lysiana exocarpi*, *Magnolia grandiflora*, *Melaleuca ericifolia*, *Melaleuca linariifolia*, *Melaleuca stypheliodes*, *Melia azedarach*, *Muellerina celastroides*, *Muellerina eucalyptoides*, *Nerium oleander*, *Photinia serrulata*, *Platanus orientalis*, *Prunus armeniaca*, *P. avium*, *P. domestica*, *P. persica*, *Pyrus communis*, *Quercus humilis*, *Q. robur*, *Schinus areira*, *Ulmus procera*			X	X		1

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Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap- wood	Heart- wood	Pest category[b]
***Mycosphaerella cryptica* (Cooke) Hansford [anamorphs *Colletogloeopsis nubilosum* (Ganap. & Corbin) Crous & M.J. Wingf., and *Asteromella* sp.] (Mycosphaerellales, Mycosphaerellaceae)**	NSW, QLD, SA, TAS, VIC	*Eucalyptus baxteri*, *E. blakelyi*, *E. bosistoana*, *E. botryoides*, *E. bridgesiana*, *E. brookeriana*, *E. camaldulensis*, *E. cladocalyx*, *E. cypellocarpa*, *E. dalrympleana*, ***E. delegatensis***, *E. dendromorpha*, ***E. diversicolor***, *E. dives*, *E. elata*, *E. fastigata*, *E. fraxinoides*, *E. globoidea*, ***E. globulus***, ***E. globulus* subsp. *bicostata***, ***E. globulus* subsp. *globulus***, ***E. globulus* subsp. *maidenii***, ***E. globulus* subsp. *pseudoglobulus***, *E. goniocalyx*, ***E. grandis***, ***E. gunnii***, *E. macarthurii*, *E. macrorhyncha*, *E. marginata*, ***E. nitens***, *E. nitida*, *E. nova-anglica*, ***E. obliqua***, ***E. ovata***, *E. patens*, *E. polyanthemos*, *E. quadrangulata*, *E. radiata*, ***E. regnans***, ***E. saligna***, ***E. sieberi***, *E. smithii*, *E. stuartiana*, *E. tereticornis*, ***E. viminalis***, *Eucalyptus* spp.		X	X			1
***Mycosphaerella delegatensis* R.F. Park & Keane [anamorph *Phaeophleospora delegatensis* (R.F. Park & Keane) Crous] (Mycosphaerellales, Mycosphaerellaceae)**	TAS, VIC	***Eucalyptus delegatensis, E. obliqua***		X				1
***Mycosphaerella eucalypti* (Wakef.) Hansf. (Mycosphaerellales, Mycosphaerellaceae)**	QLD	*Eucalyptus* sp. (Crous 1998 excludes from the genus, represents a distinct genus)		X				1
***Mycosphaerella marksii* Carnegie & Keane (Mycosphaerellales, Mycosphaerellaceae)**	QLD, VIC	*Eucalyptus botryoides*, *E. fraxinoides*, ***E. globulus***, ***E. grandis***,***E. nitens***, *E. quadrangulata*, ***E. saligna***		X				1
***Mycosphaerella nubilosa* (Cooke) Hansf. (Mycosphaerellales, Mycosphaerellaceae)**	QLD, SA, TAS, VIC	*Eucalyptus bridgesiana*, *E. cypellocarpa*, ***E. globulus***, *E. gunnii*, ***E. viminalis***		X				1
***Mycosphaerella suberosa* Crous, F.A. Ferreira, Alfenas & M.J. Wingfield (Mycosphaerellales, Mycosphaerellaceae)**	WA	***Eucalyptus dunnii***, ***E. globulus***, ***E. grandis***, *E. moluccana*, ***E. saligna***, ***E. viminalis***, *Eucalyptus* sp.		X				1
***Mycosphaerella suttoniae* Crous & M.J. Wingf. [anamorph *Phaeophleospora epicoccoides* (Cooke & Massee) Crous, F.A. Ferreira & B. Sutton]; [synonym *Kirramyces epicoccoides* (Cooke & Massee) J. Walker, B. Sutton & Pascoe] (Mycosphaerellales, Mycosphaerellaceae)**	ACT, NSW, QLD, TAS, VIC	*Eucalyptus amplifolia*, *E. camaldulensis*, *E. cladocalyx*, *E. crebra*, *E. dealbata*, ***E. delegatensis***, *E. drepanophylla*, ***E. dunnii***, *E. exserta*, ***E. globulus***, *E. globulus* subsp. *bicostata*, *E. globulus* subsp. *maidenii*, ***E. grandis***, *E. longifolia*, *E. macarthurii*, *E. major*, *E. microcorys*, ***E. nitens***, *E. nova-anglica*, *E. pellita*, *E. platypus*, *E. punctata*, *E. quadrangulata*, *E. radiata* subsp. *robertsonii*, *E. resinifera*, *E. robusta*, *E. rostrata*, ***E. saligna***, *E. sideroxylon*, *E. tereticornis*, *E. urophylla*, ***E. viminalis***, *Eucalyptus* sp., ***Corymbia citriodora***, ***C. maculata***		X				2 (Florida, Hawaii)

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***Mycosphaerella swartii* R.F. Park & Keane [anamorph *Sonderhenia eucalyptorum* (Hansf.) H.J. Swart & J. Walker] (Mycosphaerellales, Mycosphaerellaceae)**	SA, TAS, VIC	*Eucalyptus agglomerata*, ***E. amygdalina***, *E. baxteri*, *E. coccifera*, *E. dalrympleana*, ***E. delegatensis***, *E. dives*, *E. elata*, *E. fastigata*, *E. fraxinoides*, *E. globoidea*, *E. johnstonii*, *E. leucoxylon*, *E. nigra*, ***E. nitens***, ***E. obliqua***, *E. pauciflora*, *E. radiata*, ***E. regnans***, ***E. sieberi***, *Eucalyptus* sp.		X				1
***Mycosphaerella tasmaniensis* Crous & M.J. Wingf. [anamorph *Mycovellosiella tasmaniensis* Crous & M.J. Wingf.] (Mycosphaerellales, Mycosphaerellaceae)**	TAS	***Eucalyptus nitens***		X				1
***Mycosphaerella vespa* Carnegie & Keane (Mycosphaerellales, Mycosphaerellaceae)**	TAS, VIC	***Eucalyptus globulus***, ***E. viminalis***		X				1
***Mycosphaerella walkeri* R.F. Park & Keane [anamorph *Sonderhenia eucalypticola* (A.R. Davis) H. Swart & J. Walker] (Mycosphaerellales, Mycosphaerellaceae)**	NSW, TAS, VIC	*Eucalyptus cladocalyx*, *E. fraxinoides*, ***E. globulus,*** *E. gomphocephala*, ***E. nitens,*** ***E. obliqua,*** *E. polyanthemos*, ***E. viminalis,*** *Eucalyptus* sp.		X				2 (CA)
Nothostrasseria dendritica (Hansf.) H.J. Swart & Nag Raj (anamorphic Ascomycete)	NSW, SA, VIC	*Eucalyptus eximia*, ***E. obliqua,*** *E. odorata*, ***Corymbia maculata***		X				1
***Omphalotus nidiformis* (Berk.) O.K. Miller, Jr. (Agaricales, Marasmiaceae)**	VIC, WA	*Eucalyptus macrorhyncha*, ***E. obliqua, E. pilularis***, *E. radiata*, ***E. saligna, Corymbia maculata***					X	1
***Ophiostoma pluriannulatum* (Hedgc.) Syd. & P. Syd. (Ophiostomatales, Ophiostomataceae)**		*Eucalyptus* spp.			X	X		4a
Pachysacca eucalypti Syd. Emen. H.J. Swart (Dothidiales, Dothidiaceae)	SA, VIC	*Eucalyptus camaldulensis*, *E. diversifolia*, *E. rostrata*, ***E. viminalis***, *Eucalyptus* sp. (Pathogen?)		X				1
Pachysacca pusilla H.J. Swart (Dothidiales, Dothidiaceae)	VIC	*Eucalyptus botryoides*, *E. fastigata*, ***E. obliqua, E. regnans, E. viminalis***		X				1
Pachysacca samuelii (Hansf.) H.J. Swart (Dothidiales, Dothidiaceae)	TAS, SA, VIC	*Eucalyptus camaldulensis*, *E. cypellocarpa*, *E. dives*, *E. goniocalyx*, ***E. obliqua,*** *E. odorata*, ***E. ovata***, *E. radiata*, *E. rostrata*, ***E. sieberi***		X				1
***Perenniporia medulla-panis* (Jacq.:Fr.) Donk (Polyporales, Polyporaceae)**	TAS	***Eucalyptus obliqua, E. regnans***					X	1

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Pest category[b]
Pestalotiopsis neglecta Thüm. (anamorphic *Pestalosphaeria*, Xylariales, Amphisphaeriaceae)	TAS	***Eucalyptus globulus, E. grandis, E. nitens,*** *Acacia polyacantha, Atylosia scarabaeoides, Boehmeria platyphylla, Cajanus cajan, Carissa congesta, Citrus sinensis, Elaeis guineensis, Euonymus japonicus, Guettarda calyptrate, Kingiodendron pinnata, Manilkara zapota, Mimusops hexandra, Sarcomphalus acutifolius, Typha angustifolia*		X	X			1
Phaeophleospora eucalypti **(Cooke & Massee) Crous, F.A. Ferreira & B. Sutton [synonym *Kirramyces eucalypti* (Cooke & Massee) J. Walker, B. Sutton & Pascoe; *Septoria pulcherrima* Gadgil & M. Dick] (anamorphic Mycosphaerellales, Mycosphaerellaceae)**	ACT, NSW, QLD, TAS, VIC	*Eucalyptus aggregata, E. alba, E. albens,* ***E. amygdalina****, E. blakelyi, E. bosistoana, E. botryoides, E. bridgesiana, E. camaldulensis, E. camphora, E. cephalocarpa, E. cinerea, E. creba, E. cypellocarpa, E. dalrympleana,* ***E. delegatensis****, E. fastigata, E. gardneri,* ***E. globulus, E. globulus*** subsp. ***bicostata, E. globulus*** subsp. ***maidenii,*** *E. gomphocephala, E. goniantha, E. goniocalyx,* ***E. grandis****, E. gunnii, E. largiflorens, E. leucoxylon, E. leucoxylon* var. *rosea, E. longifolia, E. melliodora, E. moluccana,* ***E. nitens****, E. nutens,* ***E. obliqua****, E. occidentalis, E. oreades,* ***E. ovata,*** *E. paniculata, E. pauciflora, E. paulistana, E. perriniana, E. platypus, E. polyanthemos, E. populnea, E. pulchella, E. punctata,* ***E. regnans****, E. resinifera, E. robusta, E. rostrata, E. rubida, E. rudis, E.* ***saligna,*** *E. sideroxylon, E. stellulata, E. stenostoma, E. tereticornis, E. trabutii,* ***E. viminalis****, Eucalyptus* sp., *Corymbia ficifolia*		X	X			1
Phaeothyriolum microthyrioides (G. Winter) H.J. Swart (Microthyriales Microthyriaceae)	NSW, NT, QLD, SA, TAS, VIC	*Eucalyptus acmenoides*, ***E. amygdalina***, *E. amygdalina* var. *linearis*, *E. botryoides*, *E. camphora*, *E. cephalocarpa*, *E. dalrympleana*, ***E. delegatensis***, *E. diversifolia*, *E. dives*, *E. elata*, *E. eximia*, *E. fastigata*, ***E. globulus***, ***E. nitens***, ***E. obliqua***, ***E. ovata***, *E. pauciflora*, *E. polyanthemos*, *E. rubida*, ***E. sieberi***, *E. tetrodonta*, ***E. viminalis***, *Eucalyptus* sp., *Corymbia ficifolia*		X				1
Phellinus gilvus **(Schw.) Pat. (Hymenochaetales, Hymenochaetaceae)**	NSW, QLD, WA	*Eucalyptus crebra*, ***E. diversicolor***, *E. marginata*, ***Corymbia calophylla***				X	X	1
Phellinus noxius **(Corner) G.H. Cunn. (Hymenochaetales, Hymenochaetaceae)**	QLD	***Corymbia citriodora***, *C. ptychocarpa*				X	X	1
Phellinus rimosus **(Berk.) Pilat (Hymenochaetales, Hymenochaetaceae)**	WA	*Eucalyptus* spp., broad host range				X	X	1
Phellinus robustus (Karst.) Bourd. & Galz. (Hymenochaetales, Hymenochaetaceae)	QLD, TAS, SA, WA	***Eucalyptus globulus***, ***E. ovata***, ***E. viminalis***, *Eucalyptus* spp., broad host range				X	X	1
Phellinus wahlbergii **(Fr.) D.A. Reid (Hymenochaetales, Hymenochaetaceae)**	Australia	*Eucalyptus* spp., broad host range				X	X	1

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap- wood	Heart- wood	Pest category[b]
Phoma eucalyptidea Thüm (anamorphic *Leptosphaeria*, *Pleospora*, Pleosporales, Leptosphaeriaceae, Pleosporaceae)	TAS	***Eucalyptus globulus***, *E. pauciflora* (Pathogen?)		X				1
Phoma viminalis Cooke & Massee (anamorphic *Leptosphaeria*, *Pleospora*, Pleosporales, Leptosphaeriaceae, Pleosporaceae)	VIC	***Eucalyptus viminalis*** (Pathogen?)		X				1
Phytophthora cinnamomi Rands (Pythiales, Pythiaceae)	Australia	*Eucalyptus* spp., broad host range			X	X		4
Piggotia substellata Cooke (anamorphic Pleosporales, Venturiaceae)	VIC	***Eucalyptus regnans***		X				1
***Piptiporus australiensis* (Wakef.) G.H. Cunn. (Polyporales, Polyporaceae)**	NSW	*Eucalyptus botryoides*, *E. camaldulensis*, *E. robusta*, *Eucalyptus* spp., *Corymbia fastigata*					X	1
***Piptiporus portentosus* (Berk.) G.H. Cunn. [syn. *Laetiporus portentosus* (Berk.) Rachenb.] (Polyporales, Polyporaceae)**	Australia	*Eucalyptus* spp.					X	1
Plectosphaera eucalypti (Cooke & Massee) H.J. Swart (Phyllacorales, Phyllacoraceae)	TAS, VIC	***Eucalyptus globulus***, *E. goniocalyx*, *E. leucoxylon*, *E. mannifera*, *E. melliodora*, ***E. obliqua***, *E. pauciflora*, ***E. regnans***, ***E. viminalis***, *Eucalyptus* sp.		X				USA (?)
Pseudocercospora eucalyptorum Crous, M.J. Wingf., Marasas & B. Sutton (anamorphic *Mycosphaerella*, Mycosphaerellales, Mycosphaerellaceae)	QLD, SA	*Eucalyptus bridgesiana*, *E. cinerea*, *E. deanei*, *E. deglupta*, ***E. globulus***, *E. globulus* subsp. *maidenii*, *E. morrisii*, ***E. nitens***, *E. nova-anglica*, *E. pellita*, ***E. saligna***, ***E. viminalis***, *Eucalyptus* sp.		X				2 (Florida)
***Quambalaria pitereka* (J. Walker & Bertus) J.A. Simpson [*Sporothrix pitereka* (J. Walker & Bertus) U. Braun & Crous] (syn. *Ramularia pitereka* J. Walker & Bertus) (anamorphic Exobasidiales or Ustilaginales?)**	NSW, QLD, WA	***Corymbia calophylla***, *C. eximia*, *C. ficifolia*, ***C. maculata***		X	X	X		1
Rehmiodothis inaequalis (Cooke) H.J. Swart (Phyallachorales, Phyallachoraceae)	VIC	*Eucalyptus* spp.		X				1
Rhytisma eucalypti Henn. (Rhytimatales, Rhytismataceae)	Australia	*Eucalyptus diversifolia*, *Eucalyptus* spp.		X				1

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Pest category[b]
Seimatosporium brevilatum H.J. Swart & D.A. Griffiths (*Seimatosporium fusisporum* Swart & Griffiths) (anamorphic *Discostroma*, Xylariales, Amphisphaeriaceae)	NSW, VIC	***Eucalyptus delegatensis***, ***E. globulus***, *E. globulus* subsp. *pseudoglobulus*, ***E. nitens***, *E. polyanthemos*, ***E. regnans*** (Pathogenicity unknown)		X				1
Seimatosporium samuelii (Hansford) J. Walker & H.J. Swart (anamorphic *Discostroma*, Xylariales, Amphisphaeriaceae)	SA, TAS	***Eucalyptus delegatensis***, ***E. globulus***, ***E. obliqua***, ***E. viminalis***, *Eucalyptus* sp.		X				1
***Seiridium eucalypti* Nag Raj (anamorphic *Lepteutypa*, *Blogiascospora*, Xylariales, Amphisphaeriaceae)**	SA, TAS	***Eucalyptus amygdalina***, *E. botryoides*, *E. cypellocarpa*, ***E. delegatensis***, ***E. globulus***, ***E. grandis***, ***E. nitens***, ***E. obliqua***, ***E. regnans***, ***E. saligna***, *Eucalyptus* sp., ***Corymbia maculata***		X	X	X		1
***Seiridium papillatum* Z.Q. Yuan (anamorphic *Lepteutypa*, *Blogiascospora*, Xylariales, Amphisphaeriaceae)**	TAS	***Eucalyptus delegatensis***, ***E. globulus***, ***E. nitens***, *Eucalyptus* sp.			X			1
Stereum hirsutum (Willd.:Fr.) Gray (Russulales, Stereaceae)	WA	***E. diversicolor***, ***E. globulus***					X	4
Stigmina eucalypticola B. Sutton & Pascoe (anamorphic *Otthia*, *Acantharia*, Dothidiales, Pleosporales)	SA	*Eucalyptus oleosa*, *Eucalyptus* sp.		X				1
Trimmatostroma excentricum B. Sutton & Ganap. (anamorphic Ascomycete)	VIC	***Eucalyptus delegatensis***, ***E. globulus*** subsp. *globulus*, *E. pauciflora* subsp. *niphophila*, *E. perriniana*, ***E. regnans***, ***E. sieberi***, *Eucalyptus* sp.		X				1
Vermisporium biseptatum H.J. Swart & M.A. Williamson (anamorphic Ascomycete)	SA, VIC	*Eucalyptus baxteri, E. foecunda,* ***E. globulus,*** *E. macrorhyncha, E. melliodora,* ***E. regnans,*** *E. rostrata,* ***E. viminalis***		X				1
Vermisporium brevicentrum H.J. Swart & M.A. Williamson (anamorphic Ascomycete)	VIC	*Eucalyptus dumosa*, ***E. ovata***, ***E. viminalis***		X				1
Vermisporium cylindrosporum (H.J. Swart) Nag Raj [*Seimatosporium cylindrosporum* Swart] (anamorphic Ascomycete)	VIC	*Eucalyptus behriana*, *E. radiata*, ***E. regnans***, ***E. saligna***		X				1
Vermisporium eucalypti (McAlpine) Nag Raj (anamorphic Ascomycete)	VIC	*Eucalyptus camaldulensis,* ***E. globulus***, *E. melliodora*, ***E. nitens***, *E. smithii*, *Eucalyptus* sp., ***Corymbia maculata*** (Pathogen?)		X				1

Table 8—Potential pathogens of concern associated with eucalypts in Australia, including host range, location on host, and pest category[a]—con.

Species	State/ territory	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Pest category[b]
Vermisporium falcatum (B. Sutton) Nag Raj [*Seimatosporium falcatum* (Sutton) Shoemaker] (anamorphic Ascomycete)	NSW, QLD, TAS, VIC	*Eucalyptus crebra*, ***E. delegatensis***, *E. dives*, ***E. globulus***, ***E. nitens***,***E. obliqua***, *E. perriniana*, *E. radiata*, ***E. regnans***, *Eucalyptus* sp. (Pathogenicity unknown)		X				1
Vermisporium obtusum H.J. Swart & M.A. Williamson (anamorphic Ascomycete)	VIC	***Eucalyptus amygdalina***, *E. baxteri*, ***E. delegatensis***, *E. fraxinoides*, *E. macrorhyncha*, ***E. obliqua***, *E. pauciflora*, *E. radiata*, ***E. regnans***		X				1
Vermisporium orbiculare (Cooke) H.J. Swart & M.A. Williamson (anamorphic Ascomycete)	SA, VIC	*Eucalyptus macrorhyncha*, ***E. obliqua***		X				1
Vemisporium verrucisporum Nag Raj (anamorphic Ascomycete)	VIC	***Eucalyptus regnans***		X				1
Vermisporium walkeri H.J. Swart & M.A. Williamson (anamorphic Ascomycete)	VIC	*Eucalyptus baxteri*, *E. macrorhyncha*, ***E. obliqua***, *E. pauciflora*		X				1
Waydora typica (Rodway) B. Sutton (anamorphic Ascomycete)	TAS	***Eucalyptus globulus***, ***E. grandis***, *E. robusta*, ***E. saligna***, ***E. viminalis***, *Eucalyptus* sp. (Pathogen?)		X				2 (Florida)
Wuestneia epispora Yuan and Mohammed [anamorph *Harknessia* cf. *eucalypti* Cooke] (Diaporthales, Melanconidaceae)	QLD, TAS, WA	***Eucalyptus delegatensis***, *E. drepanophylla*, ***E. globulus***, *E. marginata*, ***E. nitens***, ***E. obliqua***, ***E. regnans***, *Eucalyptus* sp.			X			1

[a]Pathogen species in bold type are treated in Individual Pest Risk Assessments; hosts in bold type are the 18 Australian eucalypt species being considered in this risk assessment.
[b]See Table 6 for pest category descriptions.

Insect IPRAs

Pergid Sawflies

Assessor—Dennis Haugen

Scientific name of pest—*Perga* species, including *P. affinis affinis* Kirby, *P. affinis insularis* Rick, *P. dorsalis* Leach, and *P. schiodtei* Westwood (Hymenoptera: Pergidae)

Scientific names of hosts—many eucalypt species, including *Eucalyptus amygdalina*, *E. blakelyi*, *E. camaldulensis*, *E. globulus*, *E. grandis*, *E. melliodora*, *E. nitens*, *E. oblique*, and *E. viminalis*

Distribution—eastern Australia: *P. affinis affinis*, South Australia, Victoria, New South Wales, and southern Queensland; *P. affinis insularis*, Tasmania; *P. dorsalis*, coastal areas of South Australia, Victoria, and New South Wales; *P. schiodtei* recorded for Western Australia

Summary of natural history and basic biology of the pest—Adult pergid sawflies emerge in autumn. Adults live for less than 10 days, and they do not feed. Reproduction is parthenogenetic, and females emerge from pupation with a complement of mature eggs. Females are most often observed on lower foliage of host trees, where the eggs are laid. Females insert eggs into the leaf tissue along the midrib using a saw-like ovipositor. Females may lay 40 to 65 eggs per batch on a leaf. Egg incubation is about 30 days, and eggs hatch in synchrony. After the eggs hatch, larvae congregate in clusters on a leaf with their heads facing outwards during the day. At night, they move out to the leaf margins to feed and then reform the cluster before dawn. Larvae have six instars. By the third or fourth instars, larvae cluster on large branches or the main stem during the day, and large masses may form on heavily infested trees. During the night, the larvae disperse within the tree to feed on the foliage. When a tree is completely defoliated, the larvae will move en mass to a nearby tree. Larvae store eucalypt oils in the foregut, and they will regurgitate a drop when disturbed, thus the common name— “spitfires.” Larval development is usually completed by early spring. Larvae, still in a cluster, burrow into the litter or soil to form cocoons. Larvae molt into prepupae, and they spend the summer in the cocoons. Pupation occurs in late summer, the adults emerge in autumn. However, a proportion of the prepupae delay pupation for a year or up to 4 years (Macdonald and Ohmart 1993, Phillips 1996, Elliott and others 1998).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*Low* (RC) (Applicable risk criteria, from Ch. 1: c)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: c)

   No life stage of these sawflies should be associated with logs or chips. The eggs and larvae are found on the foliage. Late instar larvae use large branches and the bole as a resting place during the day, but the harvesting process would dislodge the mass of larvae or they would disperse at night in search of foliage. Pupae are found in the litter or soil and should not be found on logs or chips. Adults are highly mobile and strong fliers. However, they are short-lived (less than 10 days) with the primary goal of reproduction. They do not feed as adults. Even though pergid sawflies are common throughout eastern Australia, they are unlikely to be associated with eucalypt logs or chips.

2. Entry potential:
   Logs—*Low* (VC) (Applicable risk criteria, from Ch. 1: none)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: none)

   The only life stage of pergid sawflies that is likely to survive transport is the prepupal stage, which may last from a few months to a couple years. However, the cocoons are not found on logs but rather in soil or litter. Larvae are highly gregarious, and small clusters have a low survival rate. So, if even a few larvae were present on harvested logs, their survival during international transport would be very unlikely.

3. Colonization potential: *Moderate* (RC) (Applicable risk criteria, from Ch. 1: b, e)

   Reproduction of pergid sawflies is parthenogenetic, and females are able to oviposit immediately after emergence. These sawflies are only known to feed on eucalypts (Elliott and Bashford 1995). However, their range in Australia (from tropical Queensland to temperate Tasmania) demonstrates adaptability to a wide range of climates where eucalypts can grow. Thus, if even a small number of adult females were introduced into an area with eucalypts, establishment of a reproducing population would be likely.

4. Spread potential: *Moderate* (RC) (applicable risk criteria, from Ch. 1: a, c, f)

   The adults are strong fliers and are capable of long-distance flights. Flight behavior is to climb to heights sometimes exceeding 100 ft then disperse to tall trees (Carne 1962). Because reproduction is parthenogenetic, potential population growth and spread is increased, as most offspring are females. The flight behavior and parthenogenetic reproduction would reduce the chance of successful eradication.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RU)
(Applicable risk criteria, from Ch. 1: a, c)

In Australia, pergid sawflies have not been major pests in eucalypt plantations (Elliott and others 1998). Defoliation is usually on a small scale and populations show considerable fluctuations from year to year. Defoliation occurs in late winter and early spring, when it has the least impact on tree growth and health. A single defoliation probably has minimal impact on tree health (Carne 1969). Even repeated defoliations in successive years do not generally cause tree mortality. This insect could impact the eucalypt foliage industry, as most of the eggs are laid in foliage close to the ground with a preference for regrowth foliage and for small trees (Carne 1962, 1965). A board-spectrum insecticide probably would be effective in controlling outbreak populations in foliage beds.

Another pergid sawfly, *Lophyrotoma interrupta*, is found throughout eastern Australia. In three districts of southern Queensland, it is known as the cattlepoisoning sawfly. When cattle feed on the larval masses at the base of silver-leaved ironbarks (*Eucalyptus melanophloia*), they can develop severe liver necrosis, which is often fatal (Dadswell and others 1985). Cattle poisoning by *L. interrupta* has not been documented outside of Queensland, where this sawfly feeds on other host plants besides *E. melanophloia* (Elliott and others 1998). Host-plant and insect interactions have the potential to greatly influence pest status and economic damage, as shown by this example of *L. interrupta*.

6. Environmental damage potential: *Low* (MC)
(Applicable risk criteria, from Ch. 1: none)

Pergid sawflies are only known to feed on eucalypts, so they would not impact any native ecosystems in the United States. Very minimal environmental impacts from defoliation would be expected in eucalypt plantings, as the defoliations rarely result in tree mortality. If pergid sawflies became a major pest in the eucalypt foliage industry, increased insecticide sprays could result in nontarget environmental impacts.

7. Social and political considerations: *Low* (MC)
(Applicable risk criteria, from Ch. 1: none)

Pergid sawflies have the potential to become significant pests in urban environments on ornamental eucalypts. The defoliation could result in aesthetic damage. The massive clusters of larvae on the branches and boles would be a potential nuisance, and could result in human stress if they migrated into living spaces. It is unlikely that sawfly populations could reach levels to cause significant and widespread public nuisance (as has gypsy moth) in eastern urban environments.

C. Pest risk potential:

Logs—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)

Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)

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Reviewers' comments—"Section 3—the statement that these sawflies are not known to feed on any other plant genera besides *Eucalyptus* is not true; there is at least one *Perga* species that feeds on *Nothofagus* spp. in Chile." (Cameron)

"Under scientific names of host: *E. occidentalis* is also a notable host of *Perga* in Victoria." (Collett)

Response to comments—The *Perga* species in Australia (19 species) are known only to feed on eucalypts. Also the subfamily Perginae, which includes the genus *Perga*, is restricted to Australia and New Guinea. The subfamily Pergulinae occurs in South America. (Insects of Australia, 2d ed., 1991, CSIRO, Division of Entomology).

Leaf Beetles

Assessor—Dennis Haugen

Scientific names of pests—*Chrysophtharta* and *Paropsis* species, including *C. agricola* (Chapuis), *C. bimaculata* (Olivier), *P. atomaria* (Olivier), *P. charybdis* Stal, *P. delittlei* Selman. Australia has over 100 species of eucalypt-defoliating leaf beetles (Coleoptera: Chrysomelidae); Tasmania has 36 species (de Little 1983).

Scientific names of hosts—many eucalypt species, including *Eucalyptus amygdalina*, *E. delegatensis*, *E. globulus*, *E. nitens*, *E. obliqua*, *E. pilularis*, *E. regnans*, *E. viminalis*

Distribution—Australia wide: *C. agricola*—Tasmania, Victoria; *C. bimaculata*—Tasmania; *P. atomaria*—New South Wales, South Australia, Western Australia; *P. charybdis*—Tasmania, Victoria, New South Wales (introduced into New Zealand); *P. delittlei*—Tasmania

Summary of natural history and basic biology of the pest—The natural history of eucalypt-feeding leaf beetles is known for only a few species. However, those that have been studied have similar habits. Leaf beetles overwinter as pupae in the leaf litter, or as sexually immature adults in leaf litter, on tree bark, or in other sheltered areas. In spring, adults emerge and feed on new foliage, especially the small expanding leaves. Eggs are laid on newly expanding leaves or shoots, either singly or in batches (10 to 70 eggs/batch) (de Little 1979). Young larvae are gregarious if their species lays eggs in batches, while older larvae feed singly or in small groups. Larvae of species that lay eggs singly also feed singly for the entire larval period. Larval development is usually completed in four instars, which takes 3 to 4 weeks. Depending upon climate and species, leaf beetles generally have two or more generations per year, though some species may have only one generation per year, and other species may have five generations per year (Phillips 1996, Elliott and others 1998).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*Moderate* (RU) (Applicable risk criteria, from Ch. 1: c, e)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: c)

   Most life stages of these beetles are not associated with logs. Eggs and larvae are found only on foliage. Pupae are in the litter layer, and they are the most common overwintering stage. Adults feed on foliage. However, sexually immature adults may diapause and overwinter under loose bark, in bark crevices, or in other sheltered niches (Elliott and others 1998). Thus, adults may be occasional "hitchhikers" under the bark of logs. The frequency of this behavior is not known, so logs are rated *Moderate*, with reasonable uncertainty. No life stage of these leaf beetles is associated with chips.

2. Entry potential:
   Logs—*Moderate* (RU) (Applicable risk criteria, from Ch. 1: b)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: none)

   Adult beetles that may be under the bark of logs may be able to survive international transport. As sexually immature adults, they would need to survive in significant numbers so that when they emerged from diapause, they could find mates and suitable eucalypt foliage.

3. Colonization potential: *High* (VC) (Applicable risk criteria, from Ch. 1: a, b)

   Three species of Australian leaf beetles have become established overseas (de Little 1989). In New Zealand, *P. charybdis* was first recorded in 1916 and has spread throughout most of New Zealand (Styles 1970). It causes frequent and severe defoliation of *E. globulus*, *E. viminalis*, *E. nitens* and *E. macarthurii*. In Australia, this species usually has low populations, and significant defoliation is rare (Bain 1977). The second species found in New Zealand is *Trachymela sloanei* (Blackburn), which was first recorded in 1976 (Bain 1977). This species also was found established in California during 1998 (Paine and others 2000). In South Africa, *Trachymela tincticollis* (Blackburn) was detected near Cape Town in 1982, and it is a severe defoliator of coastal eucalypt plantations (Tribe 2000).

4. Spread potential: *Moderate* (RC) (applicable risk criteria, from Ch. 1: a, c)

   If colonization occurs, population spread is likely to be rapid through the eucalypt resource. Adult leaf beetles readily fly and appear capable of dispersing over substantial distances (Carne 1966). These beetles have a high reproductive potential. Fecundity has exceeded 600 eggs per female in some species (de Little 1983, Carne 1966), and batches frequently contain 30 to 70 eggs for species that lay eggs in batches. Spread would be limited by the geographic distribution of eucalypts, the only known host plant of these leaf beetles. In South Africa, *T. tincticollis* dispersed 1,330 km (826.4 miles) over 4 years, while *T. sloanei* advanced 30 to 40 km (18.6 to 24.9 miles) over 8 years in New Zealand (Tribe and Cillie 1997). *Paropsis charybdis* dispersed throughout the North Island of New Zealand at an average of 60 km (37.3 miles) per year. Observations suggested that *P. charybdis* adults have a dispersal period prior to overwintering (White 1973).

B. Consequences of introduction

5. Economic damage potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, c)

   Leaf beetles are pests of commercial native eucalypt forests in Australia, but their impacts on tree growth have been minor (Elliot and others 1998). In eucalypt plantations, leaf beetles are very serious pests due to the consumption of newly expanding foliage. The most damaging species in Tasmania is *C. bimaculata*, especially in *E. nitens* and *E. regnans* plantations. All ages of trees can be impacted, but damage is most prevalent to young trees that are 1 to 5 m (3.3 to 16.4 ft) in height. Growth loss due to typical defoliation by leaf beetles has been estimated at 40% over a 15-year rotation (Candy and others 1992, Elliott and others 1998). An introduced leaf beetle could impact the eucalypt foliage industry. The most significant factors in the level of damage that a leaf beetle species could cause are host plant preferences and the number of generations per year. In Australia, leaf beetles are one of the most serious insect pests of eucalypt plantations (Elliott and others 1998); thus, they are given a "*High*" rating in this assessment.

6. Environmental damage potential: *Low* (VC) (Applicable risk criteria, from Ch. 1: none)

   These leaf beetle species are only known to feed on eucalypts; so native ecosystems in the United States would not be directly impacted. Defoliation of eucalypt plantings would have minimal environmental impacts, and tree mortality is not expected even for heavy defoliation over consecutive growing seasons (Candy and others 1992). Integrated control programs in Australia use chemical insecticides on a limited basis to reduce undesirable environmental impacts. Research is continuing on the application of a biological insecticide and breeding for tree resistance (Elliott and others 1992, Elek 1997).

7. Social and political considerations: *Low* (MC) (Applicable risk criteria, from Ch. 1: none)

   Defoliation by an introduced leaf beetle species could result in aesthetic damage to ornamental plantings of eucalypts. However, this damage would probably be limited to small areas and infrequent. Development of a biological insecticide would allow for efficient and acceptable control of these limited outbreaks. A biological control program is likely to provide a long-term solution for an introduced leaf beetle species (Paine and others 2000).

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *Moderate*; Consequences of introduction = *High*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

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"Pest with host commodity at origin potential and Entry potential. In my experience with paropsines (*Paropsis* and *Trachymela*) I would rate the chances of adult leaf beetles surviving international transport under the bark of logs as quite high. These adults can be quite long-lived (up to a year, depending on the species) and often congregate in relatively high numbers under bark. The fact that Australian *Trachymela* spp. have become established in South Africa and California would tend to indicate that the insects can survive international transport." (Bain)

"The Australian chrysomelid, *Trachymela catenata* (Chapuis) is established in New Zealand. It was first found here in 1992 [Barrett, D.P., 1998: Aspects of the ecology of *Trachymela catenata* Chapuis (Coleoptera: Chrysomelidae) in New Zealand. MSc thesis, Massey University, New Zealand. 119 p. Kay, M., 1993: New *Trachymela* sp. Forest Health News, Forest Research Institute, Rotorua, New Zealand (M Dick, ed.) 2p.]." (Bain)

"The behavior of adult leaf beetles as described in the IPRA suggests this pest could be a 'hitchhiker' on both log and chip imports. Adults congregate and overwinter in large numbers in sheltered areas. Similar exotic insects (Hemiptera) have been detected recently in several western states, possibly the result of 'hitchhiking' (J. LaBonte, ODA, pers. comm.). Also, this insect has multiple generations per year. Given this information, the rating for pest-with-host-at-origin should be raised to Moderate. Also, since the beetles can survive a trip to New Zealand, overwintering adults should be able to survive the trip to the U.S. (criterion 'b' for entry-potential)." (Osterbauer and Johnson)

Response to comments—We concur with the reviewers' comments that ratings for Pest with Host-Commodity at Origin Potential and Entry Potential should be elevated for logs. Each has been assigned a "*Moderate*" rating. This has changed the overall pest risk potential of logs from "*Low*" to "*High*." The rating for chips remains at "*Low*," as the chipping process would destroy any adult beetles, and there is no evidence that adult beetles would be attracted to woodchip piles.

Trachymela species and *P. charybdis* from Australia are established in other countries, but we do not know the pathways or commodities associated with these introductions. These leaf beetle species are not common in Australia, while the species that are most common (*C. bimaculata* and *P. atomaria*) are not established in other countries. Australian leaf beetles that are established in other countries have a closer association with bark than does the native pest species. *Trachymela tincticollis* eggs are laid in bark crevices, larvae use bark crevices as shelter between foraging periods, and adults overwinter under bark curls (Tribe and Cillie 1997). In California, *T. sloanei* larvae and adults also use loose bark as hiding places (Paine and others 2000). In New Zealand, *P. charybdis* adults are the overwintering stage, and they are found in leaf litter or under loose eucalypt bark (Styles 1970). Thus, the risk of introduction of Australian leaf beetles on eucalypt logs is greater for some of the uncommon and unstudied species than for the most common native pest species.

Lerp Psyllids

Assessor—Dennis Haugen

Scientific namse of pests—*Cardiaspina* and *Glycaspis* species, including *C. albitextura* Taylor, *C. bilobata* Taylor, *C. fiscella* Taylor, *C. maniformis* Taylor, *C. retator* Taylor, *C. squamula* Taylor, *G. baileyi* Moore, *G. nigrocincta* Froggatt (Homoptera: Psyllidae: Spondyliaspidinae). This subfamily has 10 genera of lerp-building psyllids with *Glycaspis* (140 species) the largest genus. The subfamily also includes free-living psyllids (e.g., *Ctenarytaina* with 25 known species).

Scientific names of hosts—many *Eucalyptus* species, including *E. blakelyi*, *E. camaldulensis*, *E. delegatensis*, *E. globulus*, *E. grandis*, *E. obliqua*, *E. regnans*, *E. saligna*, *E. tereticornis*, *E. viminalis*

Distribution—Australia wide: all states have species of lerp psyllids

Summary of natural history and basic biology of the pest—Nymphs of lerp psyllids construct hard protective coverings—"the lerp"—under which the insect feeds. These tiny sap-sucking insects attack a wide range of eucalypts, though each psyllid species generally has a host range of only a few species or even just a single species; for example *C. densitexta* Taylor (pinkgum lerp) is found almost exclusively on *E. fasciculosa* (pink gum) (White 1970). Lerp psyllids are mostly rare and inconspicuous, but they can increase suddenly to extremely high populations, then just as suddenly crash to virtually undetectable levels. Factors that may be related to these fluctuations include weather, natural enemies, water stress, and nutritional quality of host plant (Morgan and Taylor 1988). The periods between outbreaks may be consistent or highly variable. Populations of *C. densitexta* reach outbreak every 4 to 6 years, while *C. albitextura* did not outbreak for more than 30 years in the same area. During 1984, a newly recorded species, *C. bilobata*, was found defoliating *E. regnans* in Victoria (Elliott and others 1998).

Most lerp psyllids have two to six generations per year, depending on species and location. Generation time varies from 1 to 2 months during summer, and longer in winter. A female psyllid is very mobile and can lay 45 to 700 eggs. The eggs are laid on leaves, usually in groups, and hatch in 10 to 20 days. The young nymphs search leaves on the host plant for a feeding site. The nymphs usually settle within 2 days and insert their stylets into the leaf to begin feeding. The lerp is constructed from the honeydew, which hardens when exposed to the air. These psyllids have five nymphal instars. With each molt, nymphs select new feeding sites, usually under the existing lerp, but occasionally they move to a new location and construct another lerp. During outbreaks, their feeding can cause leaf necrosis and premature leaf drop (White 1970, Hodkinson 1974, Morgan and Taylor 1988, Phillips 1996, Elliott and others 1998).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*Low* (RC) (Applicable risk criteria, from Ch. 1: b, c)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: b, c)

   Lerp psyllids feed only on leaves, not on the main trunk or large branches. Thus it would be very rare for any lerp psyllids to be found on logs or chips. Even during outbreaks, few psyllids would be expected on any logs or chip piles. These insects have a wide distribution in Australia, and have a high reproductive capacity. Although lerp psyllids may be on many eucalypt species, there is a low risk for them to be associated with logs or chips.

2. Entry potential:
   Logs—*Low* (VC) (Applicable risk criteria, from Ch. 1: none)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: none)

   These psyllids do not diapause. Nymphs and adults may overwinter with a period of quiescence. The egg stage lasts less than 20 days and requires a living leaf (Morgan and Taylor 1988). Nymphs and adults require eucalypt leaves for feeding. As long as leaves are not included with the logs or chips, these psyllids should not survive the international transport.

3. Colonization potential: *High* (VC) (Applicable risk criteria, from Ch. 1: a, b, e)

   Two lerp psyllids from Australia are already established in California. The red gum lerp psyllid, *Glycaspis brimblecombei* (Moore), was discovered in Los Angeles County during 1998 (Brennan and others 1999). The lemon-scented gum lerp psyllid, *Eucalyptolyma maideni* (Froggatt), was found near Los Angeles Airport during 2000 (Paine and others 2000). Other psyllids from Australia are also established in California. The first psyllid discovered was *Blastopsylla occidentalis* Taylor during 1983 (Brennan and others 1999). The eugenia psyllid, *Trioza eugeniae* Froggatt, was detected in California during 1988. Its host plant is bush cherry, *Syzygium* (*Eugenia*) *paniculatum*, which is native to Australia and a common ornamental plant in California (Dahlsten and others 1995). The blue gum psyllid, *Ctenarytaina eucalypti* (Maskell), was found in Monterey County during 1991. This free-living psyllid became a major pest in commercial foliage plantations.

It is also established in New Zealand, South Africa, Europe, and Sri Lanka (Dahlsten and others 1998b). Two other *Ctenarytaina* species from Australia, *C. longicauda* Taylor and *C. spatulata* Taylor, were not described prior to their discovery in California (Brennan and others 1999). The establishment of these non-native species shows that climatic conditions in California are favorable. Also lerp psyllids have a high potential for successful reproduction in the eucalypt plantings of California.

4. Spread potential: *Moderate* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, f)

   Adult psyllids are highly mobile, and natural dispersal, especially with wind currents, can be significant. Human transport of nursery stock is also a pathway for rapid spread into new areas. After *G. brimblecombei* was found in California, it was found throughout much of the state in less than 2 years. Also, *C. eucalypti* quickly spread throughout the California coastal area after it became established (Dalhsten and others 1998b). Eradication attempts are not expected to be effective for lerp psyllids. Foliar sprays of insecticides are not recommended, because the lerp covering provides protection from spray contact. Management of introduced lerp psyllids is likely with population monitoring and biological control projects (Dahlsten and others 2000).

B. Consequences of introduction

5. Economic damage potential: *High* (MC) (Applicable risk criteria, from Ch. 1: a, c)

   Lerp psyllids are occasional pests in Australia. Nymph feeding can result in leaf necrosis and premature leaf fall, which may weaken the tree and cause some branch dieback, but it rarely causes tree death. Populations are known to greatly fluctuate, from being inconspicuous for many years, suddenly increasing to outbreak status, and then quickly crashing. The impact on trees is related to the length of the outbreak. A single defoliation has minimal impact on established trees. However, repeated defoliations can cause significant stress and contribute to tree decline.

   The population dynamics of lerp psyllids in California are being investigated because of the recent arrival of two species. *Glycaspis brimblecombei* has heavily attacked eucalypts and caused heavy leaf drop. It is not known how long these high populations will last. This psyllid has been recorded on 27 species of eucalypts in California, while only 8 host species are known in Australia (Dahlsten and others 2000). Ornamental trees and windbreak plantings are most likely to be impacted by this lerp. It has not been recorded on *E. pulverulenta*, the main species used in commercial foliage plantations. The detection of *Eucalyptolyma maideni* is very recent (August 2000), and research on its host range and population dynamics is just starting. A very successful and cost-effective biological control program has been demonstrated with the free-living psyllid, *C. eucalypti*, in California (Dahlsten and others 1998a). A program to monitor populations and release biological control agents is likely to successfully manage introduced lerp psyllids (Dahlsten and others 2000).

   Lerp psyllids have the potential to cause economic damage to ornamental plantings, and the recent introduction of *G. brimblecombei* is substantiating that prediction. If a lerp psyllid with a preference for *E. pulverulenta* became established in California, it would likely be a major pest to the foliage industry. Economic damage would be likely even at low and moderate populations due to the honeydew excreted by the psyllids and the resulting sooty mold.

6. Environmental damage potential: *Low* (VC) (Applicable risk criteria, from Ch. 1: none)

   Lerp psyllids would not impact native ecosystems because eucalypts are the only known host plants of these psyllids (Taylor 1962). Use of chemical insecticides could increase to control these psyllids in ornamental plantings and commercial foliage plantations. However, the development of a monitoring program and a biological control program would reduce the pesticide load in the environment and any potential nontarget impacts (Dahlsten and others 2000).

7. Social and political considerations: *Low* (MC) (Applicable risk criteria, from Ch. 1: none)

   Outbreaks of lerp psyllids could result in aesthetic damage to landscape plantings of eucalypts. However, a management program based on pest monitoring and biological controls should be successful in reducing pest populations (Dahlsten and others 2000) and thus reduce concerns of homeowners and others with ornamental eucalypts. Also, the use of systemic insecticides is being investigated as a potential short-term and small-scale tool to reduce psyllid populations on high value trees and limit successive years of defoliation (Paine and others 2000).

C. Pest risk potential:
Logs—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

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"*Ctenarytaina spatulata*. This species is also established in New Zealand and Uruguay. [Taylor, K.L., 1997: A new Australian species of *Ctenarytaina* Ferris and Klyver (Hemiptera: Psyllidae: Spondyliaspidinae) established in three other countries. Australian Journal of Entomology. 36: 113–115]." (Bain)

"According to the risk assessment, the risks of entry of the psyllids on both logs and chips are low. The risks of entry are also rated as low. But, colonization of psyllids is rated as high—for a very good reason. Two lerp psyllids from Australia already have become established in California and other psyllids from Australia have become established in California as well. Some of these were reviewed. The blue gum psyllid was detected in Monterey County during 1991 and has become a major pest in commercial foliage plantations. This same species is reported to have become established in New Zealand, South Africa, Europe and Sri Lanka. Quite obviously, although the likelihood of introduction via raw logs or chips is rated as low, these insects *have* become established and *are* causing damage. Although the spread potential is rated as moderate, the very next pages states that adult psyllids are highly mobile and dispersal can be significant. *G. brimblecombei* was found in California and found throughout much of the state in less than 2 years. A very significant question arises—how do these insects invade California? Clearly, we need to know the answer. Even if 'hitchhiking' is low on logs or chips, the insects still get here, they do become established, and they do cause damage." (Lattin)

"While environmental damage was rated low, one must be realistic and examine the highly altered environment in, for example, the greater Bay Area to note that introduced vegetation is the rule rather than the exception—and thus environmental damage is certain to be high, not low. These insects deserve a much higher profile in this report than they have received." (Lattin)

"The entry potential for psyllids is listed in the assessment as low, and yet we now have 6-8 different species in the state. The fact that we have had these continual introductions suggests that the entry potential is anything but low. In fact, there are no psyllids or leaf beetles listed as high risk potential in the Abstract and yet they are here and causing considerable damage." (Paine)

"Under summary of natural history, it is stated that *Cardiaspina densitexta* is only found on *Eucalyptus fasciculosa*. In fact it is also found on *E. diversifolia* and *E. odorata* (ref. Morgan, F.D. 1984 'Psylloidea of South Australia' p. 113)." (Phillips)

Response to comments—We agree that Australian psyllids are becoming established in California at an alarming rate, and many are causing damage to eucalypt plantings. Colonization potential and economic damage potential are rated "*High*" in this assessment. However, the pathways for the introduction of these Australian psyllids are not known. This assessment considers logs and chips from 18 species of eucalypts as a potential pathway. Since lerp psyllids require living eucalypt leaves for survival, the pest with commodity at origin potential and entry potential are rated "*Low.*" Thus, the likelihood of introduction on logs and chips is rated "*Low.*" Other commodities that include living leaf tissue should be investigated as a potential pathway for these introductions.

Gum Tree Scales

Assessor—Dennis Haugen

Scientific names of pests—*Eriococcus* species, especially *E. coriaceus* and *E. confusus* (Homoptera: Eriococcidae). Currently, the taxonomic status of many Australian species is unclear, and further studies are needed before this group can be reorganized (Gullan and Vranjic 1991).

Scientific names of hosts—many eucalypt species, including *Eucalyptus amygdalina*, *E. camaldulensis*, *E. globulus*, *E. grandis*, *E. gunnii*, *E. nitens*, *E. obliqua*, *E. pilularis*, *E. regnans*, *E. saligna*, *E. tereticornis*, *E. viminalis*

Distribution—Australia wide: *E. coriaceus*, Queensland, New South Wales, Victoria, Tasmania, South Australia (also established in New Zealand); *E. confusus*, New South Wales, Victoria, Tasmania, South Australia. *Eriococcu*s species are also known from Western Australia (Loch and Floyd 2001), but the taxonomic status is unclear, and one type may be a variant of *E. coriaceus* (Gullan and Vranjic 1991).

Summary of natural history and basic biology of the pest—Gum tree scales may have two to five generations per year, depending on climate. Generations are discrete and generally take 2 months to complete during the summer. A female scale lays several hundred eggs under the scale covering. The eggs hatch within a few minutes after oviposition, and the young crawlers leave the scale covering within a day. The young crawlers search for a feeding site and generally settle near the mother scale within a short time (Patel 1971). Crawlers may be dispersed long distances by the wind or by hitchhiking on the feet of birds. Once the crawler settles, it inserts its stylet into a leaf or shoot to feed, and secretes the protective scale covering. The first instar nymph stage lasts about 7 days. The second instar nymph leaves the old scale covering, settles at a new feeding site, and secretes a new covering. The second instar nymph stage lasts 10 to 15 days. An adult female emerges from the scale covering of the second instar and searches for another feeding site. It inserts its stylet to resume feeding and secretes another scale covering. The female lives about 30 days. Males emerge as winged adults and search for females for mating. Adult males live only 2 to 3 days, and they do not feed (Phillips 1996, Elliott and others 1998).

Gullan (1999) described a new genus (*Subcorticoccus*) with three new species in the Eriococcidae family. These scales were collected under eucalypt bark in southeastern Australia. Little is known about their life history, distribution, host range, and potential pest status.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*Low* (RC) (Applicable risk criteria, from Ch. 1: b, c)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: b, c)

   Gum tree scales are not likely to be on logs or chips, because they are not found on the main trunk and large branches. These scales show a preference for 2-year-old growth (Patel 1971). The standard process of debarking eucalypt logs would remove any scales from the small-diameter portion of a log. Although these scales are capable of rapid population increase, and they are common and widely distributed throughout eucalypt plantations in Australia, the rating for being with the host commodity at origin is assessed as low.

2. Entry potential:
   Logs—*Low* (VC) (Applicable risk criteria, from Ch. 1: none)
   Chips—*Low* (VC) (Applicable risk criteria, from Ch. 1: none)

   Gum tree scales require succulent shoots for feeding throughout their life cycle, with the exception of a day or two when they are searching for a place to settle after each molt. They do not have a resting or diapause stage that would aid in survival during transport. Thus, they are not expected to survive international transport on logs or chips.

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, f)

   Gum tree scales have a wide distribution in Australia, and they are expected to be able to colonize any area in the United States with eucalypt plantings. Reproduction and successful establishment is very likely because these scales have a very high fecundity and multiple synchronized generations. *Eriococcus coriaceus* is established and distributed throughout New Zealand (Zondag 1977a). It was accidentally introduced on imported seedlings prior to 1900 (Patel 1971).

4. Spread potential: *Moderate* (RC) (applicable risk criteria, from Ch. 1: a, b, c)

   Crawlers generally settle close to the mother scale, but some disperse long distances through wind or hitchhiking on birds and can establish new infestations. These scales would likely be rapidly spread through infested nursery stock. The average fecundity ranges from 150 to 280 eggs per female with a maximum of 531 eggs (Patel 1971), thus in a suitable environment with host plants, these scales are very likely to establish quickly and spread rapidly. However, they are only known to feed on eucalypts, so their distribution would be limited by the distribution of their host plants.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RC) (Applicable risk criteria, from Ch. 1: a, b)

   In Australia, these scales are considered significant pests, and severe infestations may cause tree dieback and even tree mortality. Damage to young eucalypt plantations is most common. Even moderate infestations can cause malformation in terminal shoots, premature leaf fall, and growth reduction. This insect could impact the eucalypt-foliage and nursery industries in the United States. Heavy scale infestations can result in tree mortality, especially to young trees. Even low and moderate infestations could impact the foliage industry, where aesthetics are critical. The scales produce honeydew as they feed, and sooty mold grows on the honeydew, which results in a black coating on leaves and shoots. Chemical control of severe infestations is an option, but multiple well-timed applications would be needed. Biological control has been successful in New Zealand with a predatory ladybird beetle, *Rhizobius ventralis* Erichson (Zondag 1977a).

6. Environmental damage potential: *Low* (VC) (Applicable risk criteria, from Ch. 1: none)

   Gum tree scales would not impact native ecosystems, because these scales are known only to feed on eucalypt species. In New Zealand, *E. coriaceus* has not expanded its host range, and it is found only on introduced eucalypts (Zondag 1977a). Chemical insecticides may be used for scale control in the foliage industry, for nursery stock, and for ornamental plantings, but these should have limited impacts. Biological control could be a viable option for ornamental plantings, based on the success in New Zealand, which would reduce the need to spray insecticides. Less susceptible eucalypt species also could be considered.

7. Social and political considerations: *Low* (MC) (Applicable risk criteria, from Ch. 1: none)

   Gum tree scale infestations could result in aesthetic damage to ornamental plantings, and in rare instances result in tree mortality to young eucalypts. Public concern would be very localized and could be allayed with education on proper insecticide treatment or a biological control program.

C. Pest risk potential:
Logs—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)

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Reviewers' comments—none received.

Walking Sticks

Assessor—Andris Eglitis

Scientific names of pests—*Ctenomorphodes tessulatus* (Gray), *Didymuria violescens* (Leach), *Podacanthus wilkinsoni* Macleay (Phasmatodea: Phasmatidae)

Scientific names of hosts—All three species occur on *Eucalyptus delegatensis*, *E. grandis*, *E. pilularis*, and *E. viminalis*. Both *D. violescens* and *P. wilkinsoni* occur on *Eucalyptus bicostata*, *E. dalrympleana*, *E. dives*, *E. huberiana*, *E. laevopinea*, *E. major*, *E. mannifera*, *E. obliqua*, *E. pauciflora*, *E. radiata*, *E. regnans*, *E. robertsonii*, *E. saligna*; *D. violescens* also occurs on *E. maculosa*; *C. tessulatus* also occurs on *Eucalyptus acmenioides*, *E. intermedia*, *E. paniculata*, *E. propinqua*, *E. punctata*, *E. resinifera*, *E. tereticornis*, *E. triantha*, *E. umbra*, *Corymbia gummifera*, *C. maculata*, *Syncarpia laurifolia* Ten., *Casuarina torulosa* Aiton, and *Acacia floribunda* (Vent.) Willd; *P. wilkinsoni* also occurs on *Eucalyptus stellulata.*

Distribution—*C. tessulatus*: New South Wales, Queensland; *D. violescens*: New South Wales, Queensland, Victoria; *P. wilkinsoni*: New South Wales, Victoria

Summary of natural history and basic biology of the pests—The walking sticks are foliage-feeding insects that often resemble twigs or leaves (Borror and DeLong 1971). Most species are tropical, although the group is widely distributed in the world. Walking sticks are generally not considered to be harmful to cultivated plants, but they can become numerous on occasion and can damage trees (Borror and DeLong 1971). Repeated infestations by the two most common Australian species, *Didymuria violescens* and *Podacanthus wilkinsoni*, have produced severe mortality in *Eucalyptus* stands when populations have reached epidemic levels (Campbell and Hadlington 1967). A third species, *Ctenomorphodes tessulatus*, has also killed trees when it reached outbreak levels in the lowland coastal forests of southern Queensland and northeastern New South Wales (Elliott and others 1998).

Walking sticks *D. violescens* and *P. wilkinsoni* have a single generation in a year, although eggs often do not hatch until the second year after they were laid. As such, the insects are often abundant only in alternate years (Borror and DeLong 1971). In Australia, Campbell and Hadlington (1967) report that *P. wilkinsoni* adults appear in high numbers in the summers of even-numbered years and *D. violescens* adults are more abundant in odd-numbered years.

Mazanec (1966) describes the life cycle of *Didymuria violescens* in Australia as follows: Eggs hatch in the spring and early summer (October–December) and nymphs crawl from the soil to the tops of trees. The insect passes through five nymphal instars, each one lasting 1 to 3 weeks, depending on temperature. The first and second instars feed on only the youngest leaves, while later instars eat older leaves and may completely defoliate their host trees. Adults appear in mid- to late summer (between January and March). Each female can lay up to 400 eggs, which are dropped one at a time to the forest floor. After overwintering, a few eggs hatch during the following spring and early summer (called "1-year eggs"), but most insects have a 2-year life cycle, with egg hatch occurring 18 months after oviposition (Mazanec 1966). Outbreaks occur only in those areas where the 2-year life cycle predominates, and populations alternate between high and low levels in successive years (Mazanec 1966).

Podacanthus wilkinsoni also has a 2-year life cycle, although some 1-year life cycle forms occur as well (Campbell and Hadlington 1967). Adults are present between early summer and late fall (Campbell and Hadlington 1967). The females of *P. wilkinsoni* cannot fly when they are distended with eggs. While crawling and feeding on foliage they drop their eggs to the ground below. After the eggs hatch the small nymphs climb the tree into the foliage and begin feeding (Froggatt 1923). The nymphs pass through seven or eight instars before reaching adulthood (Campbell and Hadlington 1967).

The life cycle of *Ctenomorphodes tessulatus* is slightly different from the other two walking sticks. A 1-year life cycle is most common, and 2-year and 3-year cycles are rare (Elliott and others 1998). The first instar nymphs appear in late August, and most have emerged from the eggs before the end of September (Hadlington and Hoschke 1959). The young nymphs climb from the ground into the trees and begin feeding. There are six nymphal instars for males and seven for females (Hadlington and Hoschke 1959). Adults first appear in December and eggs are laid during January and February (Hadlington and Hoschke 1959). *C. tessulatus* females produce 300 to 900 eggs, which drop to the forest floor.

Neumann and Marks (1976) cite *D. violescens* and *P. wilkinsoni* as being among the major primary defoliators of commercial eucalypt forests. Numerous "plagues" have occurred in the central highlands of southeastern Australia since 1880 (Campbell and Hadlington 1967). Outbreak populations of *Didymuria violescens* have caused considerable damage to eucalypt forests in southeastern Australia (Neumann and Marks 1976). Geary (1974, cited by Neumann and Marks 1976) reported that a single severe defoliation by *D. violescens* resulted in the death of 40% of the subdominant *Eucalyptus regnans* trees in Victoria. Other stands of *E. regnans* experienced 80% mortality after two seasons of defoliation (Mazanec 1967, cited by Neumann and Marks 1976). One outbreak of *D. violescens* in New South Wales lasted for a decade, with epidemic populations noted every other year between 1952 and 1962 (Campbell and Hadlington 1967). *Podacanthus wilkinsoni*, a related species, has also caused serious defoliation of eucalypts in New South Wales (Neumann and Marks 1976, Carter and others 1981).

At least three significant outbreaks of *C. tessulatus* have occurred since the mid-1950s, with mortality occurring in a number of hosts. Hadlington and Hoschke (1959) described the typical stand where early outbreaks of *C. tessulatus* were recorded: the susceptible dry coastal hardwood stand consisted of grey gum (*Eucalyptus punctata*), white mahogany (*E. triantha*), ironbark (*E. paniculata*), spotted gum (*Corymbia maculata*), red bloodwood (*C. gummifera*), turpentine (*Syncarpia laurifolia*), and stringybark (*E. obliqua*). The understory of these typical stands contains forest oak (*Casuarina torulosa*) and tallowwood (*E. microcorys*). In the most recent outbreak, there was widespread mortality in *Eucalyptus tereticornis*, a species particularly sensitive to defoliation by *C. tessulatus* (Elliott and others 1998).

Most of the eucalypts are acceptable as a food source for walking sticks, but there are preferences within the genus (Campbell and Hadlington 1967). Where *D. violescens* and *P. wilkinsoni* occur together, their hosts are the same (Campbell and Hadlington 1967). Campbell and Hadlington (1967) reported observations made in the field on host preferences for the walking sticks: favored species (and the first to be defoliated in mixed stands) were the narrow-leaved peppermints (*Eucalyptus radiata* and *E. robertsoni*), the broad-leaved peppermint (*E. dives*) and the gums (*E. viminalis*, *E. huberiana*, *E. dalrympleana*, *E. mannifera*, *E. stellulata*, *E. pauciflora*, and *E. bicostata*). Although less favored than the previously mentioned hosts, *E. laevopinea*, *E. obliqua*, and *E. delegatensis* have also been seriously defoliated (Campbell and Hadlington 1967). Additional suitable hosts include *E. grandis*, *E. saligna*, and *E. major* (Campbell and Hadlington 1967). These authors report that the only field record of a host for *D. violescens* and *P. wilkinsoni* outside the genus *Eucalyptus* is brush box, *Tristania conferta*. They also point out that when no other food is available, adults may feed sparingly on *Angophora* but will die if this is their only host (Campbell and Hadlington 1967). Mazanec (1966) points out that the ashes (*Eucalyptus delegatensis* and *E. regnans*) are considerably more sensitive to defoliation than the gums and peppermints and that both species have suffered considerable mortality after 1 year of complete defoliation. Froggatt (1923) described extensive infestations of *P. wilkinsoni* in mixed forests, where only the gum trees were defoliated and other potential hosts (cherry, wattles, river oaks) were not affected. *Ctenomorphodes tessulatus* has a considerably broader host range than the other two phasmatids.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*Low* (RC) (Applicable rating criteria, from Ch. 1: b)
   Chips—*Low* (RC) (Applicable rating criteria, from Ch. 1: b)

   Although the phasmatids are capable of attaining high population levels, they have a limited geographical distribution and are restricted in the number of hosts they have, and their feeding habits are such that they are unlikely to be associated with the log or chip commodity. The only stage of the phasmatids that is associated with the bark is the early nymphal stage, as the young insects climb to the foliage from the ground (Froggatt 1923).

2. Entry potential:
   Logs—*Moderate* (RC) (Applicable rating criteria, from Ch. 1: d)
   Chips—*Low* (Applicable rating criteria, from Ch. 1: none)

   The only stage of the phasmatids that is associated with the bark is the early nymphal stage, as the young insects climb from the ground up the bole to the foliage (Froggatt 1923). The only applicable criterion for this element (and hence the "moderate" rating for logs) is that the young nymphs might be difficult to detect on the bark of a log. If a log with nymphal stages on the surface were chipped it is highly unlikely that the insects would survive the processing. Furthermore, survival of the nymphal stage during the transit period is very unlikely.

3. Colonization potential: *Moderate* (RC) (Applicable rating criteria, from Ch. 1: b, e)

   Eucalyptus viminalis is the only host of the phasmatids that has significance in the United States. Thus, there could be hosts in this country, and rating criterion "b" would apply. Additionally, criterion "e" applies, given the high fecundity of females (400 to 900 eggs per insect).

4. Spread potential: *Low* (RC) (Applicable rating criteria, from Ch. 1: c)

   The Australian walking sticks have a limited host range, mostly within the genus *Eucalyptus*, and some of their most prominent hosts are not widely planted in the United States. All three species of walking sticks have small wings, but they are not known as strong fliers. Only the males are capable of flight (Campbell and Hadlington 1967).

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RC) (Applicable rating criteria, from Ch. 1: b, c)

   In southeastern Australia, the walking sticks are considered important enough to warrant a policy by the Forests Commission of Victoria that calls for their rapid control by aerial spraying once outbreaks occur (Neumann and others 1980). Mortality has been extensive under certain conditions (Mazanec 1966, 1967), and outbreaks have been recorded in Victoria and New South Wales since the late 1880s (Carter and others 1981). The ashes (*E. regnans* and *E. delegatensis*) appear to be fairly vulnerable to the phasmatids; the gums less so (Mazanec 1966). The primary host grown in the United States (*E. viminalis*) is a species that has fairly poor wood quality (McClatchie 1902).

6. Environmental damage potential: *Moderate* (MC) (Applicable rating criteria, from Ch. 1: e)

   The only likely hosts for the walking sticks in the United States would be exotic plants of the genus *Eucalyptus.* However, there could be potentially negative environmental effects from an introduction of walking sticks if control or eradication programs led to increased use of insecticides.

7. Social and political considerations: *Moderate* (MC) (Applicable rating criteria, from Ch. 1: a)

   An insect capable of widespread defoliation and possibly death of host trees would clearly result in concerns from the public.

C. Pest risk potential:
Logs—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)

An evaluation of the pest risk potential based on chips rather than logs as the commodity entails revisiting the first two elements of the likelihood of introduction: (1) pest with host at origin potential and (2) entry potential. No evidence indicates that these foliage-feeding insects would be attracted to chips, nor that they would survive transport on that substrate. As such, the rating for both the first two elements (pest with host at origin and entry potential) would be "*Low*" and the pest risk potential would remain "*Low*" for phasmatids on the chip commodity.

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Reviewers' comments—"Entry potential, chips. Bark is unlikely to be an issue with eucalypt chips, and probably not even for logs. The author's judgment of low risk is correct. The discussion concerning pupae not surviving in chip piles also is correct, but irrelevant due to a lack of bark in the piles." (Cameron)

Response to comments—The entry potential is indeed "*Low*" for phasmatids, but not because of a complete lack of bark associated with the chip commodity. There is a tolerance for some level of bark on chips, and logs chipped during the summer months may still contain very small amounts of bark.

Gumleaf Skeletonizer Moth

Assessor—Andris Eglitis

Scientific name of pest—*Uraba lugens* Walker (Lepidoptera: Noctuidae)

Scientific names of hosts—*Eucalyptus acmenioides*, *E. andreana*, *E. baueriana*, *E. bicostata*, *E. blakelyi*, *E. bridgesiana*, *E. camaldulensis*, *E. crebra*, *E. dalrympleana*, *E. delegatensis*, *E. dives*, *E. drepanophylla*, *E. eugenioides*, *E. fastigata*, *E. globulus*, *E. grandis*, *E. hemiphloia*, *E. intermedia*, *E. largiflorens*, *E. macrandra*, *E. macrorhyncha*, *E. marginata*, *E. melanophloia*, *E. melliodora*, *E. nicholii*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. pauciflora*, *E. radiata*, *E. robertsonii*, *E. robusta*, *E. saligna*, *E. siderophloia*, *E. sideroxylon*, *E. stellulata*, *E. tereticornis*, *E. tessellaris*, *E. viminalis*; *Corymbia calophylla*, *C. citriodora*, *C. ficifolia*, *C. maculata*; *Angophora costata*, *A. subvelutina*; *Lophostemon confertus* (R. Br.) P.G. Wilson & Waterhouse, *Tristania suaveolens* [*Lophostemon suaveolens* (Sol. ex Gaertn.) P.G. Wilson & Waterhouse]

Distribution—New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia, New Zealand

Summary of natural history and basic biology of the pest—The gumleaf skeletonizer is considered one of the most common defoliating caterpillars of eucalypts in Australia (Elliott and de Little 1984) and occurs throughout most of the country except in the Northern Territory (Harris 1974). The insect utilizes more than 30 species of *Eucalyptus* as hosts, and to a lesser extent, some additional plants from other related genera. Larval survival varies considerably among these hosts (Morgan and Cobbinah 1977, cited by Elliott and others 1998). Harris (1974) cites Froggatt (1900) as the first to report this insect as a defoliator of river red gum (*Eucalyptus camaldulensis*). Since that time there have been numerous outbreaks recorded throughout Australia, including at least 10 in New South Wales in river red gum forests (Campbell 1962). Several of these outbreaks have covered large areas, from 40,000 to 250,000 hectares (100,000 to 620,000 acres) (Brimblecombe 1962, Harris 1974). Campbell (1962) pointed out that mean annual rainfall is extremely variable throughout the range of *U. lugens* [from less than 508 mm (20 in.) to more than 1,520 mm (60 in.) per year] but that areas where the skeletonizer has reached outbreak populations are all characterized by high relative humidity during a part of the year. Trees are seldom killed by *U. lugens*; even completely defoliated trees will refoliate through the production of epicormic branches (Brimblecombe 1962, Harris 1974). Nonetheless, Neumann and Marks (1976) report that the gumleaf skeletonizer seems associated with crown dieback in the eastern forests of Tasmania. Elliott and de Little (1984) reported that feeding damage on older trees is generally cosmetic, while younger trees can be totally defoliated and killed. Other damage effects from defoliation include the diversion of energy toward production of epicormic shoots instead of normal foliage and the resulting defects in wood (gum flecks) that arises from the instability of these epicormic shoots (Campbell 1962).

Several factors are responsible for the fact that high-quality sites are more severely affected by the gumleaf skeletonizer than lower quality sites. The survival of larvae is favored on higher quality sites because larvae are not very mobile and depend on interconnected crowns of host trees for getting to a new food source. If the larvae must navigate open ground to get to a new food supply they will not be successful (Campbell 1962). Furthermore, young undamaged leaves are preferred for oviposition by the next generation, and these are most readily available on good sites where damaged trees can more readily refoliate during the pupal period between the two generations of the insect.

Harris (1974) recognized three forms of *U. lugens*, which he called the inland, coastal, and highland forms. Both the coastal and inland forms complete two generations in one year, while the highland form produces only one generation in a year (Harris 1974). Although the forms are morphologically similar, there are some slight behavioral differences between the highland and coastal/inland populations (Campbell 1962). These behavioral differences are mostly in the egg-laying pattern of the females; the highland form lays eggs in a compact mass, wheras the coastal and inland females lay eggs in parallel rows that are separated by the width of one egg (Harris 1974).

Campbell (1962) described the biennial life cycle for the populations associated with the Murray Valley river red gum forests between New South Wales and Victoria. He termed the two generations the “winter” and “summer” generations. Adults of the summer generation emerge between March and May and mate shortly after emergence (Campbell 1962). Female moths do not fly far from their emergence site to lay eggs, yet males are fairly strong fliers (Campbell 1962). Eggs of the winter generation are usually laid on fresh or undamaged foliage, preferably within 2.2 m (7 ft) of the ground. The eggs hatch in May and June, and larvae feed gregariously on the leaf surface where the eggs were laid, causing wilting and browning of the affected foliage. Initially, feeding is in the form of “skeletonizing,” where larvae consume the epidermis and mesophyll layers but avoid the oil cells and veins of the leaf (Harris 1974). The early larval stages shed their entire skin, but from the fifth through the eleventh instar, they retain the head capsule and prothoracic skin from each previous instar and these remain attached with each successive molt. By the end of the larval period they carry a “head dress” of five or six head capsules and prothoracic skins attached above the prothorax by means of setae (Campbell 1962). Later instars of the larvae feed singly and consume the entire leaf except for the midrib (Harris 1974, Elliott and de Little 1984). Once mature, the larvae seek sheltered places for pupation, preferably beneath the forest litter. A second choice for pupation is beneath bark flakes of the lower rough-barked portion of the bole or on the bark of branches (Campbell 1962). Pupation takes place between mid-October and early December, and new adults emerge between December and January. The eggs of the summer generation are laid between December and February, and larvae feed from January to early March (Campbell 1962). Pupation occurs from mid-March to early April, and new adults emerge once again between March and early May. The pupal period varies from 13 days in the summer generation to 54 days in the winter generation (Campbell 1962). Campbell (1962) observed that in the Murray Valley there was no diapause in any part of the life cycle of either generation.

Farr (2002) studied the gumleaf skeletonizer in the southern jarrah (*Eucalyptus marginata*) forests of Western Australia. She found that jarrah and marri (*Corymbia calophylla*) are intermediate hosts for the gumleaf skeletonizer when compared with the more preferred hosts from eastern Australia. Farr (2002) also determined that the insect is univoltine in these jarrah forests, with the capability of bivoltinism when temperatures permit. She also noted that the ovipositional preference for the lower crown was less striking in Western Australia than it appears to be in the eastern states (Farr 2002). In feeding trials in Western Australia, the gumleaf skeletonizer showed good survival on species of eucalypts that had not previously been listed as hosts, including *Corymbia citriodora*, *C. ficifolia*, *Eucalyptus nicholii*, *E. macrandra*, and *E. sideroxylon* (Farr 2002). Egg counts taken from the field were highly variable, ranging from 28 to 344 eggs per "raft," with a mean of 100 eggs (Farr 2002).

The biennial form of the gumleaf skeletonizer has been a significant problem in forests of red river gum (*Eucalyptus camaldulensis*) in the Murray Valley between Victoria and New South Wales (Campbell 1962, Neumann and Marks 1976). Campbell (1962) described factors associated with outbreaks in river red gum stands. The occurrence of outbreaks appears to be related to the absence of flooding (Campbell 1962, Harris 1974, 1975). When flooding occurs, larval survival goes down because the preferred pupation sites are underwater, and larvae are forced to pupate in locations where they are exposed to parasitism. In addition, there is a dramatic increase in fungal diseases brought about by increased humidity during the flooding period. In the absence of flooding, insect survival is much greater and populations can build up rapidly.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (MC) (Applicable risk criteria, from Ch. 1: b, c, d, e, g, h)
   Chips—*Moderate* (RU) (Applicable risk criteria, from Ch. 1: c, e, g)

   A number of the risk criteria appear to apply for this element when the log commodity is considered. The gumleaf skeletonizer is widely distributed throughout Australia and has a broad host range within the genus *Eucalyptus* and related members of the family Myrtaceae. The insect also has a high biotic potential, based on two generations per year and on high female fecundity [over 500 eggs per female (Campbell 1962)]. The pupal stage is sometimes found under bark scales and in some instances may remain quiescent for a period of nearly 2 months before adults emerge (Campbell 1962). Three risk criteria still apply for the chip commodity (populations widely distributed, capable of surviving beneath bark, wide host range), but only if an infested log were to be chipped. The chip commodity itself would not be attractive to these insects.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)
   Chips —*Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   The pupal stage is the most likely to be transported with the log commodity and has a high probability of surviving if protected under bark scales. Although the distance involved is not great, it is interesting to note that *U. lugens* has been found in New Zealand, possibly transported in the pupal stage. The standard process of debarking logs and converting them to chips would probably destroy a large portion of pupae under bark scales, and those surviving chipping would be exposed to extremes in moisture and temperature in a chip pile. As such, risk criterion "d" (difficulty of detection and cryptic nature of organism) is the only criterion that could apply for chips, but does not seem very meaningful in the case of this commodity and thus is not assigned to the risk element.

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, e)

   Uraba lugens has been found in New Zealand. Although the means of transport is not known, it is likely to have been on golf equipment carried from Australia to New Zealand. The life cycle, with a sometimes prolonged and cryptic pupal stage together with a wide host range of eucalypts, lends itself for establishment in a new location. It is interesting to note that *U. lugens* demonstrated high survival when reared on a number of new species of eucalypts in Western Australia (Farr 2002), a strong testimonial to the adaptability of the insect.

4. Spread potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: b, c, f, g)

Risk criterion “b” applies to the discovery of *U. lugens* on a New Zealand golf course. Human transport is probably required for this insect to spread successfully in a new environment because females are poor fliers and larvae cannot move from one host to another unless the hosts have interconnected crowns (Campbell 1962). The host range is broad within the genus *Eucalyptus*, but it appears that these hosts must be on high-quality sites for the insect to be successful (Campbell 1962, Harris 1974).

B. Consequences of introduction

5. Economic damage potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: a, b, c)

Although *Uraba lugens* is not considered a mortality agent in its native range, it does cause some economic damage to affected hosts. Growth is reduced in defoliated trees, and the flush of epicormic branching on damaged trees may reduce wood quality once these unstable branches snap off (Campbell 1962). Further economic damage would occur if the insect became established in the United States where *Eucalyptus* is grown for its foliage in the floral industry. Given its many hosts, it is possible that *U. lugens* could infest those species of eucalypts grown for their foliage in California. It is also possible that defoliated trees could be weakened sufficiently to become more vulnerable to the two *Phoracantha* borers already occurring in California.

6. Environmental damage potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: e)

Uraba lugens is essentially a pest of the genus *Eucalyptus* and as such, would probably be limited to exotic hosts in the United States. The only applicable criterion for this element would be that control programs would probably be implemented and could lead to greater pesticide use, with potentially adverse environmental effects.

7. Social and political considerations: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: a)

The successful introduction of *U. lugens* would likely result in public concerns about the aesthetics of damaged trees in urban plantings.

C. Pest risk potential:
Logs—*Moderate* (Likelihood of introduction = *Moderate*; Consequences of introduction = *Moderate*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)

An evaluation of the pest risk potential based on chips rather than logs as the commodity entails revisiting the first two elements of the likelihood of introduction: (1) pest with host at origin potential and (2) entry potential. These elements for the chip commodity can be evaluated in two ways: first for the potential for survival of insects that were already on their hosts prior to chipping and second for chip attractiveness as a substrate for colonization. For the first element, *U. lugens* could only be associated with the commodity in the pupal stage and only if bark were present on the chips. Chips are generally bark free (or nearly so), and the bark is a rare pupation site for the gumleaf skeletonizer, a combination that makes this possibility of association with the chip commodity a very unlikely one. If the association were to occur, the second element of survival would also be rated as “*Low*” unless the pupae were near the surface of the chip pile. Based on the biology of the gumleaf skeletonizer, the inclination is to assign a rating of “*Low*” for both Introduction elements for the chip commodity, which results in a pest risk potential of “*Low*” as well.

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Reviewers' comments—"Paper cited [in draft] as Farr (2001, in press) can now be cited as Farr, J.D. 2002. Biology of the gumleaf skeletoniser, *Uraba lugens* Walker (Lepidoptera: Noctuidae) in the southern jarrah forest of Western Australia. Australian Journal of Entomology 41: 60–69." (Farr)

"Individual IPRAs. In the foliar diseases and gumleaf skeletonizer moth IPRAs, the assessors provide a third risk rating (assessor's judgment) for the risk elements pest-with-host-at-origin-potential and entry-potential. A criterion should be assigned to a risk element if supported by current data. If there are no data to support the criterion, it should not be assigned. Providing a third risk rating instead only confuses the reader." (Osterbauer and Johnson)

Response to comments—The published reference by Farr was added to the bibliography. The team agreed with the comment about a third risk rating, the "assessor's judgment," and eliminated this from the rating. Instead the assessor explained why he assigned a rating that was not entirely consistent with the rating criteria.

Ambrosia Beetles and Pinworms

Assessor—Andris Eglitis

Scientific names of pests—*Austroplatypus incompertus* (Schedl); *Platypus australis* Chapuis, *P. subgranosus* Schedl, *P. tuberculosus* Schedl (Coleoptera: Platypodidae); *Amasa* (=*Xyleborus*) *truncatus* (Erichson); *Ambrosiodmus compressus* Lea; *Xyleborus perforans* (Wollaston); *Xylosandrus* (=*Xyleborus*) *solidus* Eichhoff (Coleoptera: Scolytidae); *Atractocerus crassicornis* Clark, *A. kreuslerae* Pascoe, *Atractocerus* sp. (Coleoptera: Lymexylidae)

Scientific names of hosts—*Austroplatypus incompertus*: *Eucalyptus baxteri*, *E. botryoides*, *E. consideniana*, *E. delegatensis*, *E. eugenioides*, *E. fastigata*, *E. globoidea*, *E. macrorhyncha*, *E. muelleriana*, *E. obliqua*, *E. pilularis*, *E. radiata*, *E. scabra*, *E. sieberi*, *Corymbia gummifera*;
Platypus australis: Eucalyptus saligna;
P. subgranosus: Eucalyptus delegatensis (=*gigantea*), *E. goniocalyx, E. nitens, E. obliqua, E. regnans, E. saligna, Corymbia maculata, Nothofagus cunninghamii* (*Hook.*) *Oerst., Pinus radiata* D. Don;
P. tuberculosus: Eucalyptus cypellocarpa, E. nitens, E. ovata;
Amasa truncatus: Eucalyptus acmenioides, E. camaldulensis, E. piperita, E. propinqua, E. saligna, Eucalyptus spp.; *Corymbia citriodora, C. maculata*; *Angophora intermedia*;
Ambrosiodmus compressus: Eucalyptus saligna;
Xyleborus perforans: Eucalyptus deglupta, E. drepanophylla, E. grandis, E. intermedia, E. seeana, E. tereticornis, Eucalyptus spp., *Corymbia maculata, C. variegata*; *Pinus elliottii Engelm.*;
Xylosandrus solidus: Eucalyptus saligna

Both *Atractocerus crassicornis* and *A. kreuslerae* occur in *Eucalyptus diversicolor*, *E. marginata*, and *E. patens; A. kreuslerae* also occurs in *Eucalyptus astringens*, *E. gomphocephala*, *E. rudis*, *E. wandoo*, and *Corymbia calophylla*; a Tasmanian species of *Atractocerus* occurs in *E. obliqua.*

Distribution—*A. incompertus*: New South Wales, Victoria;
P. australis: New South Wales, Queensland;
P. subgranosus: Queensland, Tasmania, Victoria;
P. tuberculosus: New South Wales, Tasmania; Victoria;
A. truncatus: New South Wales, Queensland, Tasmania, New Zealand;
Ambrosiodmus compressus: New South Wales, Queensland, New Zealand;
X. perforans: Queensland;
X. solidus: New South Wales, Queensland, Tasmania, New Zealand;
Atractocerus crassicornis: Western Australia;
A. kreuslerae: New South Wales, Queensland, South Australia, Western Australia;
Atractocerus sp.: Tasmania

Summary of natural history and basic biology of the pests—Ambrosia beetles belong to the families Platypodidae and Scolytidae. The platypodid family of semi-tropical ambrosia beetles is well represented in Australia and New Zealand. Froggatt (1926) discusses five Australian species of *Platypus* that have a variety of hosts including *Eucalyptus* in some cases. Some of these beetles attack freshly cut logs, stumps, and fallen trees that have sufficient moisture to support the associated fungus that provides food for the developing larvae. Attacks may also occur in live trees that have been wounded or are in poor condition (Froggatt 1926), or in some cases, in live trees that are not damaged (Harris and others 1976). Species attacking live trees can be found in southeastern Australia (Neumann and Harris 1974, Elliott and others 1998). The platypodid beetles bore deeply into the wood and then form transverse galleries with characteristic oval chambers in double rows that will be occupied by the developing larvae. Attacks occur in the summer and are easily recognized by the boring dust surrounding the main gallery into the wood (Froggatt 1926). The symbiotic fungi are carried by the beetles in specialized repositories (mycangia) and are introduced into the wood as the beetles construct their tunnels (Neumann and Harris 1974). Only moist wood is infested; as soon as the host material reaches a certain stage of dryness, adults leave the wood and immature stages die in the galleries (Froggatt 1926). Neumann and Harris (1974) found that the risk of infestation is minimal when moisture content of host material drops below 40%, but 20% moisture content may be sufficient to sustain a colony that is already present.

The life cycles of platypodid ambrosia beetles are quite variable. Tropical beetles may complete a generation in 4 to 10 weeks, whereas in temperate forests life cycles can vary from 15 months to 5 years (Neumann and Harris 1974). The two most important Australian species associated with eucalypts require 2 to 3 years (*Platypus subgranosus*) and at least 4 years (*Austroplatypus incompertus*) to complete a generation (Neumann and Harris 1974). Colonies may contain various developmental stages within the same infested host (Neumann and Harris 1974).

Hogan (1948) studied *P. subgranosus* in the Central Highlands of Victoria and described its life cycle as follows: Adult emergence begins in October and continues until April, with the peak flights occurring in January and March. Flight capability of both sexes is described as “weak and slow” (Hogan 1948). Male beetles find new host material and make the initial entry into the wood by constructing a short gallery about ½-in. long (Hogan 1948). They wait for females to arrive and mating takes place outside the gallery. The females then continue the remaining gallery excavation and lay their eggs near the far end of the gallery (Hogan 1948). Relatively few eggs are laid by each female, 6 to 10 per gallery at any one time, and oviposition is spread over a long time period (Hogan 1948). There is no additional gallery construction by the female once oviposition has begun, but once larvae are full grown, they will extend the galleries. The total gallery produced by *P. subgranosus* is relatively short when compared with galleries typical of the platypodid family and are most commonly 4 to 6 in. (10 to 15 cm) in length (Hogan 1948). Larvae produce fine granular frass; the adult produces a "splintery" frass (Hogan 1948). The mature larvae construct pupal chambers and use those to transform into new adults. Only one generation occurs in a given gallery, and new adults emerge from the original entry hole made by the parents (Hogan 1948). The maximum number of beetles reported emerging from one gallery system is 34 (Hogan 1948). The rate of beetle development is controlled by temperature, and duration of a generation is believed to range from 10 months to 5 years. An average length of the life cycle in Victoria in the Central Highlands is from 2 to 3 years (Hogan 1948). The food source for developing broods is a fungus, identified as *Leptographium lundbergii*, which is introduced by the beetles and grows inside the gallery (Hogan 1948). Yeast is also present in the gallery and may be of equal importance to the fungi as a food source for the beetles (Hogan 1948). *Platypus subgranosus* infests both living trees and fresh logs and causes wood degradation in the process (Neumann and Marks 1976). Neumann and Harris (1974) found long established colonies of *P. subgranosus* in pure stands of live *Eucalyptus nitens* in eastern Victoria.

Neumann and Marks (1976) report that *P. subgranosus* has been associated with widespread death of myrtle beech, *Nothofagus cunninghamii*, in Tasmania. The ambrosia beetle has proven to be an inadvertent vector of a pathogenic fungus *Chalara australis* that causes wilt disease (Ian W. Smith, Victoria Department of Natural Resources and Environment, 2001, personal communication). *P. subgranosus* infests trees that are dying from wilt disease and in the process of constructing tunnels produces copious amounts of frass that contains the wilt fungus. The frass accumulates outside the infested tree and is transported by the wind, along with the fungus, into wounds of otherwise healthy myrtle beeches. These trees then become sufficiently weakened by the wilt fungus to make them susceptible to ambrosia beetle attack, and the cycle continues. (In the absence of the ambrosia beetle, the fungus causing wilt disease spreads by root contact (Ian W. Smith, Victoria Department of Natural Resources and Environment, 2001, personal communication).)

Austroplatypus incompertus occurs widely throughout southeastern Australia (Victoria and New South Wales) and is the more common of the two primary platypodid ambrosia beetles (Neumann and Harris 1974). Several high-value species are infested as live trees, and the wood is devalued by the combined action of beetle tunneling and the staining from the associated ambrosia fungi that provide a food source for the beetles (Neumann and Marks 1976). Trees are infested even when healthy and undamaged (Browne 1971, Harris and others 1976). Neumann and Harris (1974), citing Campbell (1969), report that *A. incompertus* only infests "rough-barked" live eucalypts over 35 cm (13.8 in.) in diameter. Elliott and others (1998) point out that *A. incompertus* is one of the very few ambrosia beetles that attack living, undamaged trees. Wright and Harris (1974) studied stands of *Eucalyptus delegatensis* in Victoria and found that many live trees were infested by the ambrosia beetle. Some of these trees had been infested for many years (up to 36 years) and still contained live insects and fungi in galleries long after the initial attack.

The galleries of *A. incompertus* are fairly complex. The initial entry tunnel goes through the bark and extends radially into the sapwood 50 to 80 cm (19.7 to 31.5 in.) and then follows the early wood of a growth ring (Wright and Harris 1974). This secondary gallery will contain the eggs and eventually the perpendicularly oriented chambers that are occupied by the larvae and pupae. Wright and Harris (1974) reported that a gallery may eventually be extended into a multi-branched system deep into the heartwood, but the original point of entry remains the only opening to the outside. Unlike the case with *P. subgranosus*, these complex galleries of *A. incompertus* are not linked to the galleries of other beetles (Neumann and Harris 1974). The formation of galleries that extend deep into the heartwood of mature trees requires more than one generation of activity (Wright and Harris 1974, Harris and others 1976). The beetles attempt to keep the galleries free of insect-generated frass and the kino that is produced by the host in response to the infestation. If the beetles are unable to keep the gallery clear, it may become occluded and will eventually grow over with a callus that develops in the cambium (Wright and Harris 1974).

Wright and Harris (1974) described the life cycle of *A. incompertus* as follows: Most new galleries are initiated in standing trees between November and April (the peak emergence of beetles from their hosts), although fresh attacks can occur over most of the year. Eggs are found in galleries not less than 1 year old, and larvae are present in galleries not less than 2 years old. The authors found five larval instars, but neither pupae nor pupal cells in galleries less than 4 years old (Wright and Harris 1974). The original parents tend the gallery and may rear several generations, producing a colony that may persist for several years (Harris and others 1976). Wright and Harris (1974) reported typical beetle emergence as ranging from 20 to 40 beetles per gallery, while Harris and others (1976) reported annual emergence ranging from 1 to 84 with a mean of five beetles per gallery. An important observation reported by Wright and Harris (1974) was that *A. incompertus* beetles emerged for 3 years from an infested tree after it was felled.

In Australia, the scolytid ambrosia beetles have habits similar to the platypodids (Elliott and others 1998). Some differences do exist, however, including a sex ratio in the scolytids that is strongly skewed toward females, the host-finding sex (Elliott and others 1998). Females are considerably larger than males. The females mate after emergence and fly off to establish new broods, which they tend until maturity (Elliott and others 1998).

The important Australian species of scolytid ambrosia beetles are currently, or at one time have been, in the genus *Xyleborus*. Wood (1982) describes the genus *Xyleborus* as being exceedingly large and complex. More than 70 species occur in North and Central America, but those represent a small portion of the species occurring worldwide (possibly 1,500 species). Most of the American species are tropical or subtropical, although numerous species also occur in the northernmost states of the United States. The taxonomy of the genus is also extremely complex, owing in part to the beetles' unique reproductive behavior (arrhenotokous parthenogenesis) that can lead to difficulties in distinguishing species (Wood 1982). The males are relatively rare and are flightless. Females select new host material and establish galleries. An unmated female apparently produces only male offspring. She may later mate with some of these offspring to produce additional females (Wood 1982). Some mating between siblings also occurs in the brood chambers. The developing larvae help to enlarge the galleries that can sometimes be highly complex and branched, or may be much simpler in some species (Wood 1982).

The genus *Xyleborus* includes an array of insects whose hosts range from healthy trees to old logs, but most of the species prefer recently cut, injured, or unthrifty material (Wood 1982). All the species feed on an associated ambrosial fungus that grows on the walls of their tunnels. The moisture content of host material is critical to insure proper growth and survival of this associated fungus; if host material is too dry, the fungus dies; if too wet, the fungal growth overwhelms the galleries and the developing insects suffocate. Damage associated with these insects is in the form of wood degrade due to fungal staining that occurs in association with adult and brood tunneling. Ambrosia beetles in this genus are generally not considered to be tree killers.

Xyleborus perforans is considered one of the most important ambrosia beetle species in eastern Australia (Elliott and others 1998), attacking dead and dying trees, green logs, and newly sawn lumber. Less commonly, live trees can also be attacked through wounds or diseased patches of bark (Elliott and others 1998). Elliott and others (1998) reported that these polyphagous beetles infested fire-killed *Pinus elliottii* in a plantation and caused considerable damage to wood intended for poles. The beetles do not discriminate with respect to size of their host; branches as well as large logs can be infested (Elliott and others 1998). The females construct a tunnel with numerous branches but no brood chambers. Eggs are laid in the parent galleries and the larvae move freely within these tunnels, consuming the ambrosia fungus (Elliott and others 1998). During the summer, the life cycle can be completed in 2 to 3 months (Elliott and others 1998). These insects are widely distributed throughout the world and have produced considerable economic loss (Elliott and others 1998).

A *Eucalyptus*-inhabiting species in New Zealand since 1930, *Xyleborus truncatus* (now *Amasa truncatus*) is thought to have a life cycle of less than 1 year and may complete two generations in a year (Zondag 1977b). *Amasa truncatus* appears to have considerably more hosts in New Zealand than in its native Australia, where it is recorded only on *Eucalyptus saligna*. In New Zealand, the ambrosia beetle has been found breeding in *Leptospermum ericoides*, *L. scoparium*, *Knightia excelsa*, *Metrosideros robusta*, *M. excelsa*, *Weinmannia racemosa*, *Albizzia lophanta*, *Acacia verticillata*, *A. decurrens*, and several species of *Eucalyptus* including *E. botryoides*, *E. globulus*, *E. obliqua*, *E. ovata*, and *E. viminalis* (Zondag 1977b). Several other hosts have also been attacked, but no broods were produced in them (Zondag 1977b). Zondag (1977b) reports that the only living trees to be attacked by *A. truncatus* are eucalypts, especially *E. globulus*, in which severe branch dieback can occur. Attacks on live trees by the ambrosia beetle are followed by rapid wilting of the foliage, leading to the conclusion that an associated fungus other that the ambrosia fungus may be responsible for killing the sapwood (Zondag 1977b). Despite this capability of producing branch dieback and infesting numerous hosts, *A. truncatus* is considered of little economic importance in New Zealand (Zondag 1977b).

The adult female of *A. truncatus* bores an entry tunnel into the wood to a depth of about 30 mm. There may be one or two short additional tunnels that branch from the main tunnel (Zondag 1977b). Eggs are laid in the far end of the tunnel, and small larvae make a small excavation called a "keyhole chamber" where they feed and develop. Eggs are apparently laid over a long period of time, because larvae of all sizes, pupae, and young adults can all be found in the gallery at the same time (Zondag 1977b). Most of the larvae develop into females, which emerge in the spring and summer (Zondag 1977b).

Little is known about the biology of the lymexylids, although Fairey (1955) describes some characteristics of the family and distinguishes the behavior of these beetles from the platypodids. Unlike the platypodids and scolytids, these lymexylid beetles (pinworms) do not appear to be symbiotically associated with fungi, although some fungal staining can sometimes be seen near their larval galleries (Neumann and Harris 1974). The female beetles lay eggs in old wounds, broken branch stubs, or other areas on the bole where the bark has been removed (Clark 1925). As they tunnel in the wood, the larvae produce a long threadlike core of packed boring dust that extends outward from the tunnel, breaks off, and accumulates at the base of the infested tree (Clark 1925). The larvae require several years to mature and are therefore able to construct a substantial gallery during their lengthy feeding period. Although they are usually horizontal, the galleries may go in all directions and will extend deeply into the tree (Clark 1925). These galleries may be up to 2 m long and 3 mm (0.12 in.) in diameter by the time they are completed (Elliott and others 1998). Succeeding generations of lymexylids may reinfest the host, producing larval galleries of different sizes in the same material (Elliott and others 1998). As the pinworm larvae near maturity they appear to turn in their tunnels and burrow back out toward the entrance, enlarging the tunnel and packing it behind themselves with frass (Clark 1925). The insects pupate near the surface of the wood, and adults emerge in summer (January) (Clark 1925). *Atractocerus kreuslerae* occurs in Western Australia, attacking jarrah (*Eucalyptus marginata*) and karri (*E. diversicolor*) trees through fire scars and other wounds, whereas fresh logs are seldom attacked (Neumann and Harris 1974, Neumann and Marks 1976). Clark (1925) identified a number of additional hosts for *A. kreuslerae* in Western Australia, including tuart (*E. gomphocephala*), flooded gum (*E. rudis*), and marri (*Corymbia calophylla*). He observed *A. kreuslerae* working in stumps and logs of *E. gomphocephala* but pointed out that this behavior was not seen on other hosts (Clark 1925). Other lymexylid species of economic importance in Australia include *A. crassicornis* attacking *Eucalyptus diversicolor*, *E. marginata*, and *E. patens* in Western Australia and an unidentified species of *Atractocerus* in Tasmania that causes significant degrade in *Eucalyptus obliqua* (Elliott and others 1998). In all, Fairey (1955) lists ten species of lymexylids in three genera that have been described from Australia.

The two platypodid ambrosia beetles *P. subgranosus* and *A. incompertus*, along with a lymexylid pinworm, *Atractocerus kreuslerae* Pasc., are considered most important among borers that cause timber degrade in Australia (Clark 1925, Neumann and Marks 1976).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, d, e, f, g, h)
   Chips—*Moderate* (VU) (Applicable risk criteria, from Ch. 1: e, h)

   Austroplatypus incompertus is found in 16 species of *Eucalyptus* and in two Australian states; *Platypus subgranosus* also occurs in two states but has fewer *Eucalyptus* hosts. Both these species of platypodid ambrosia beetles possess a strong ability to locate and colonize hosts, be they standing trees (*A. incompertus*) or freshly cut material (*P. subgranosus*), and if log moisture remains suitable, they can survive in this material for some time (Neumann and Harris 1974, Wright and Harris 1974). Both species of platypodids have flight periods that extend over a significant portion of the year. As such, host material available in log form could readily be colonized by *P. subgranosus*, if not already infested as a standing tree prior to felling. A "*High*" rating for the log commodity is derived from the fact that *Xyleborus* ambrosia beetles are frequently intercepted in foreign ports and risk criterion "a" applies. In an analysis of interception records Haack (2002, in press) reports that *Xyleborus* is the fifth most commonly intercepted scolytid genus in the United States from Australia.

   If logs/trees were previously infested and were then chipped, it is extremely unlikely that any early developmental stages of either ambrosia beetles or pinworms could survive for any length of time after the chipping was complete. It is possible that a small percentage of mature adults could survive the chipping process, based on their small size. McNee and others (2002) found a small number of similarly sized insects (*Pityophthorus* spp.) surviving the chipping of branches infected with pitch canker fungus. The relevance of those observations is a matter of speculation, however, because ambrosia beetles are generally intolerant of changes in the moisture content of the wood, and if surviving the chipping process, those near the surface of the pile might be inclined to leave the chips. If they survived chipping but were well within the pile, they would be subjected to extreme temperatures that could be lethal. Nonetheless, lacking clear evidence to the contrary it does seem conceivable that a small percentage of mature individuals could be contained in chips, making criteria "e" (organism likely to survive) and "h" (organism unlikely to be dislodged during handling) applicable. In the case of material not previously infested, the only risk criterion that applies for the chip commodity is the attractiveness due to the host volatiles emanating from the material. However, this criterion is not significant because chips would not be a suitable substrate for colonization.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c)
   Chips—*Moderate* (VU) (Applicable risk criteria, from Ch. 1: b)

   Neumann and Harris (1974) pointed out that platypodids can survive in their host material if the moisture content is above 20%. *Austroplatypus incompertus* was found emerging from infested material for 3 years after it was felled (Harris and others 1976, Wright and Harris 1974). There is less information on which to base a "*High*" rating for *Atractocerus* than for the platypodids, but the biologies of the two groups appear to be comparable and the "High" rating is applied to the pinworms on that basis for the log commodity.

Even though the lymexylids do not appear to have the strong dependency on associated fungi that occurs with platypodids and scolytids, they probably are nonetheless affected by moisture content of the host. As such, they may survive transport in a log as long as the moisture content does not change dramatically from that of a live tree.

Given the importance of moisture content for the successful colonization and survival of these insects, it seems extremely unlikely that chips would harbor live insects after they have been stockpiled and transported, as the moisture would likely be altered. However, criteria "b" and "c" could technically apply for a small portion of adults surviving the chip process and being somewhere near the surface of the pile during transport. A rating of "*Moderate*" is assigned for chips, given the possibility that some adults could survive transport in chips.

3. Colonization potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: b, d)

   A number of the natural hosts for both platypodids and scolytids occur in California and in other parts of the United States where eucalypts have been planted. Risk criterion "b" (hosts available near ports) would probably not apply for the lymexylids due to their narrower host range, and the rating for the element would be "*Low*" for them instead of "*Moderate*."

4. Spread potential: *High* (MC) (Applicable risk criteria, from Ch. 1: b, e, f, g, h)

   The reproductive potential of these insects is fairly low, and their innate dispersal capability is unknown. Platypodids, scolytids, and lymexylids are fairly cryptic insects, leaving little evidence that they have infested a tree. Boring dust would be evident on the bole of infested trees, but would probably be noticed only by careful scrutiny of an attacked tree. Infested material may inadvertently be transported by humans to a new location, and new infestation centers could be established if suitable hosts were present. Criterion "h" is added because of the capabilities demonstrated by *P. subgranosus* for assisting the spread of Chalara wilt disease in two Australian states and by *Amasa truncatus* for causing dieback in *E. globulus* through an associated fungus that it introduces as it infests live hosts.

B. Consequences of introduction

5. Economic damage potential: *High* (MC) (Applicable risk criteria, from Ch. 1: a, c, d, f)

   The damage associated with platypodid and scolytid ambrosia beetles and lymexylid pinworms is primarily the degrade caused by their galleries and in the case of the ambrosia beetles, the localized staining by the symbiotic fungi. Neumann and Harris (1974) report that in Victoria, the damage by *A. incompertus* is encountered only in certain locations, but there have been cases where mills needed to be compensated for defect reduction in lumber that resulted from ambrosia beetle attack. Harris and others (1976) discuss additional damage associated with heavy attacks by *A. incompertus*. They refer to brown staining that discolors large sections of heavily infested logs and lines of weakness caused by wood decaying fungi where the galleries occur. Neumann and Harris (1974) also point out that heavy costs have been incurred throughout the world from the enforcement of stringent quarantine regulations for insects such as these. Controls are currently not available for these insects. There is also concern over the association of these insects with fungi that are clearly pathogenic (for example, *Chalara australis* with *Platypus subgranosus* and a fungus with *Amasa truncatus*) in their natural environment. Similar associations or vector relationships could be expressed or discovered in other members of this group once introduced into a new environment.

6. Environmental damage potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: d)

   The hosts of the scolytid ambrosia beetles are primarily from the family Myrtaceae although one species (*Xyleborus perforans*) has been associated with *Pinus elliottii*. With two exceptions, the hosts of both *A. incompertus* and *P. subgranosus* are all eucalypts that are exotic in the United States. *Platypus subgranosus* has a beech (*Nothofagus cunninghami*) as a host, but this genus occurs rarely as an ornamental in some parts of the United States. However, attacks of *P. subgranosus* have also occurred on damaged *Pinus radiata* (Elliott and others 1998), although the details of this association are unknown. Criterion "d" is applied to this element based on the limited range of Monterey pine in the United States and its potential as a host for *P. subgranosus*.

7. Social and political considerations *Moderate* (MC) (Applicable risk criteria, from Ch. 1: a)

   Although these platypodids, scolytids and lymexylids are not agents of mortality, their establishment in ornamental *Eucalyptus* plantings or in recreational settings could be of importance, especially if infested live hosts are weakened by decay fungi to the point of causing branch breakage leading to safety hazards.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *High*)
Chips—*Moderate* (Likelihood of introduction = *Moderate*; Consequences of introduction = *High*)

An evaluation of the pest risk potential based on chips rather than logs as the commodity entails revisiting the first two elements of the likelihood of introduction: (1) pest with host at origin potential and (2) entry potential. These elements for the chip commodity can be evaluated in two ways; first for the potential for survival of insects that had already infested their hosts prior to chipping and second for chip attractiveness as a substrate for colonization. In the first case, it does not seem that immature life stages could survive in chips, because moisture content is such a critical factor in development of these insects. Conceivably, a mature life stage could survive in a chip if that chip were on the surface of a pile, but in reality, that stage of the insect would be likely to be dispersing from the host at that time, and might not be associated for that reason. Elsewhere within the pile, the heat and moisture that is generated should be unfavorable for any life stage of these insects. For the second case, there may be attraction to a chip pile created by the release of host volatiles, but the substrate would be unfavorable for colonization due to moisture content being different from a host tree or log and due to diminished opportunities for egg-laying. For the chip commodity, both of the first two elements, (1) pest with host at origin potential and (2) entry potential, would drop to "*Moderate*," causing the overall Likelihood of Introduction to drop to "*Moderate*" and the pest risk potential to also drop to "*Moderate*." The "*Moderate*" pest risk potential rating for the chip commodity is derived from the possibility that a very small portion of mature beetles surviving the chipping process could also survive transport to their new environment.

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Reviewers' comments—Section C, pest risk potential. The discussion of association of ambrosia beetles with chips is logical but involves much speculation—research is needed. The assumed attraction of beetles to chip piles created by the release of host volatiles may occur, but is likely transient." (Cameron)

"Finally, I must say that I still cannot accept statements such as 'insects vector a disease' or 'disease spreads by root contact' (summary of natural history section)." (Cobb)

"Individual IPRAs. Many of the IPRAs address groups of pests. However, in two IPRAs, the platypodid ambrosia beetles and pinworms and the ghost moths and carpenter-worms the assessor chose to split the group into individual species for the risk element pest-with-host-at-origin. If the IPRA is for a group of pests, this risk element's rating should be based on the group's behavior and distribution. Instead, the assessors looked at the behavior of the pests as individual species resulting in a lower rating for this risk element." (Osterbauer and Johnson)

"Pests as vectors for unknown or for native pathogens. Several platypodid ambrosia beetles and pinworms have associated pathogenic or potentially pathogenic fungi (e.g., *Leptographium lundbergia* and *Chalara australis*). However, little mention is made of the potential impact of these fungi on U.S. forests. When considering the economic and environmental impact of these insect pests, the impact of their fungal associates should also be considered. Also, the assessor should consider the impact these pests could have as vectors for pathogens native to the U.S. *Leptographium wageneri* is an example of a native root rot pathogen that may benefit from the introduction of a possible new vector." (Osterbauer and Johnson)

"Adult ambrosia and bark beetles will survive in chips, although the numbers are greatly decreased. Please see our recent paper in Can. Ent. 134: 47-58, where we chipped pine tips infected with pitch canker. There can be many survivors in a mountain of chips where maybe 99% of the beetles died." (David Wood)

Response to comments—We agree with the reviewer comment that attraction of ambrosia beetles to chip piles would likely be transient and would not result in successful colonization of the commodity.

In response to the second reviewer comment, the language in the natural history section was changed from "disease" to "pathogen" or "fungus."

Based on some reviewer comments expressed about the incompleteness of Table 7 (Insects of Concern), this IPRA was modified by adding another group of ambrosia beetles, the scolytids. By including this family, there are some changes made in the first risk element (pest with host-commodity at origin, logs) because an additional risk criterion applies—scolytid ambrosia beetles (especially *Xyleborus*) have been intercepted in many foreign ports, and some have become established in new environments including the United States. In addition, the judgment that the group being evaluated does not have a broad host range was reconsidered. As such, the first element for Likelihood of Introduction changes from "*Moderate*" to "*High*," and the overall Likelihood of Introduction is also changed to "*High*" because another risk criterion was also added for the spread potential to change that element from "*Moderate*" to "*High*."

The discussion of insect/fungus interactions was strengthened in response to the reviewer comment that the ambrosia beetles could be vectors of native or unknown pathogens. Criterion "h" (potential to be a more efficient vector of native or introduced pests) was added for the spread potential thus raising the rating for this element from "*Moderate*" to "*High*."

Survival of adult ambrosia beetles in chips requires some speculation because specific information on the group is not available. Although the ambrosia beetles are of similar size as the *Pityophthorus* beetles discussed in McNee and others, Can. Ent. 137:47-58, there are certain behavioral differences in some ambrosia beetle species that suggest they would not remain in wood that has been felled and/or chipped, where the moisture content has changed. Some adult platypodids are known to leave their host immediately, once it is felled (for example, *Megaplaypus parasulcatus*, commom in South America). On the other hand, some evidence also exists that some ambrosia beetles of the same family may persist in host material long after it has been felled (for example, *Austroplatypus incompertus* in Australia). Furthermore, the worldwide interception records from APHIS indicate that *Xyleborus* is the fifth most commonly intercepted scolytid genus from Australia (Haack in press), suggesting that some individuals of that genus may survive in wood in use. In light of the plausibility that some mature beetles *could* survive the chipping process, the author reconsidered the statements made in the draft IPRA. That percentage of surviving insects would be expected to be very small, however (R. A. Haack, U.S. Department of Agriculture, Forest Service, North Central Research Station, 2002, personal communication; R. I. Gara, University of Washington, 2002, personal communication).

Round-Headed Wood Borers

Assessor—Andris Eglitis

Scientific names of pests—*Callidiopsis scutellaris* (Fabricius), *Coptocercus rubripes* (Boisduval), *Coptocercus* sp.; *Epithora dorsalis* McL., *Hesthesis cingulata* (Kirby), *Macrones rufus* Saunders, *Phlyctaenodes pustulosus* Newman, *Phoracantha* (=*Tryphocaria*) *acanthocera* (Macleay), *P.* (=*Tryphocaria*) *mastersi* Pascoe, *P. odewahni* Pascoe, *P. punctipennis* (Blackburn), *P.* (*Tryphocaria*) *solida* Blackburn, *P. tricuspis* Newman, *Scolecobrotus westwoodi* Hope, *Tessaromma undatum* Newman, *Zygocera canosa* (Erichson) (Coleoptera: Cerambycidae)

Scientific names of hosts—*Callidiopsis scutellaris*: *Eucalyptus delegatensis*, *E. obliqua*, *E. viminalis*;
Coptocercus rubripes: *Eucalyptus delegatensis, E. obliqua, E. odorata, E. pilularis, E. regnans, E. saligna, Corymbia maculata, Angophora intermedia*;
Coptocercus sp.: *Eucalyptus diversicolor, E. gomphocephala, E. marginata*;
Epithora dorsalis: *Eucalyptus agglomerata, E. beyeri, E. delegatensis, E. obliqua, E. robertsonii, E. saligna, E. viminalis, Corymbia maculata, Angophora intermedia, Gmelina leichhardtii R. Br.*;
Hesthesis cingulata: *Eucalyptus globulus, E. obliqua, E. pilularis*;
Macrones rufus: *Eucalyptus polyanthemos, E. saligna, E. viminalis*;
Phlyctaenodes pustulosus: *Eucalyptus amygdalina, E. obliqua, E. regnans, Casuarina* sp.;
Phoracantha acanthocera: *Eucalyptus acmenioides, E. camaldulensis, E. diversicolor, E. globulus, E. gomphocephala, E. grandis, E. jacksonii, E. marginata, E. nitens, E. paniculata, E. patens, E. propinqua, E. punctata, E. redunca var. elata, E. regnans, E. resinifera, E. saligna, E. wandoo, Eucalyptus* spp., *Corymbia calophylla, C. ficifolia, C. maculata, Angophora lanceolata, Agathis robusta* (C. Moore ex F. Muell.) Bailey, *Araucaria cunninghamii* Aiton ex D. Don;
Phoracantha mastersi: *Eucalyptus amygdalina, E. globulus, E. nitens, E. obliqua, E. pilularis, E. regnans, E. viminalis, Eucalyptus* spp., *Corymbia maculata, Acacia* spp.;
Phoracantha odewahni: *Eucalyptus diversicolor, E. wandoo, Eucalyptus* spp., *Corymbia calophylla*;
Phoracantha punctipennis: *Eucalyptus diversicolor, E. wandoo, Corymbia calophylla*;
Phoracantha solida: *Eucalyptus camaldulensis, E. grandis, E. micrantha, E. microcorys, E. pellita, E. propinqua, E. resinifera, E. saligna, E. tereticornis, Angophora intermedia*;
Phoracantha tricuspis: *Eucalyptus botryoides, E. melliodora, E. paniculata, E. robusta, E. viminalis, Eucalyptus* spp.;
Scolecobrotus westwoodi: *Eucalyptus amygdalina, E. corymbosa, E. globulus, E. gracilis, E. johnstonii, E. melliodora, Eucalyptus* sp., *Corymbia gummifera, Amyema* sp.;
Tessaromma undatum: *Eucalyptus camaldulensis, E. dalrympleana, E. delegatensis, E. globulus, E. grandis, E macarthurii, E. melliodora, E. obliqua, E. polyanthemos, E. saligna, E. sieberi, E. viminalis, Acacia dealbata Link, Nothofagus moorei* (F. Muell.) Krasser;
Zygocera canosa: *Eucalyptus amygdalina, E. obliqua*

Distribution—*Callidiopsis scutellaris*: Australian Capital Territory, New South Wales, Tasmania, Victoria, New Zealand;
Coptocercus rubripes: New South Wales, Queensland, South Australia, Tasmania, Western Australia, New Zealand;
Coptocercus sp.: Western Australia;
Epithora dorsalis: Australian Capital Territory, New South Wales, Tasmania;
Hesthesis cingulata: New South Wales, Queensland, South Australia, Tasmania, Victoria;
Macrones rufus: New South Wales; Phlyctaenodes pustulosus: New South Wales, South Australia, Tasmania, Victoria;
Phoracantha acanthocera: New South Wales, Queensland, South Australia, Victoria, West Australia;
Phoracantha mastersi: New South Wales, Queensland, South Australia, Tasmania, Victoria;
Phoracantha odewahni: South Australia, Victoria, Western Australia;
Phoracantha punctipennis: South Australia, Western Australia;
Phoracantha solida: New South Wales; Northern Territory, Queensland, South Australia, Western Australia;
Phoracantha tricuspis: New South Wales, Northern Territory, Queensland, South Australia, Victoria;
Scolecobrotus westwoodi: Australian Capital Territory, New South Wales, South Australia, Tasmania, Victoria, Western Australia;
Tessaromma undatum: Australian Capital Territory, New South Wales, Queensland, South Australia, Victoria, New Zealand;
Zygocera canosa: Tasmania

Summary of natural history and basic biology of the pests—The cerambycids of Australia include more than 1,100 described species, a number that represents one of the most diverse assemblages of longhorned borers of any continent (Hawkeswood 1992). Despite this diversity of cerambycid species occurring in Australia, there is limited biological information available for many of them. Some authors have prepared lists of cerambycids associated with certain species of plants (Moore 1972, Webb 1987, Webb and others 1988, Hockey and DeBaar 1988, Hawkeswood 1992, Hawkeswood 1993), but hosts are still not known for many of the longhorned borers (Webb and others 1988, Hawkeswood 1992). As is typical of the family in general, most Australian cerambycids infest the boles or branches of recently dead host material. With some exceptions, live hosts are usually infested only if they that have been damaged or are growing under stressful conditions. Some of the Australian round-headed wood borers are fairly specific in their host preferences, while others are polyphagous and feed on plants from several genera.

Callidiopsis scutellaris is an example of a monophagic species feeding only on *Eucalyptus* (Hawkeswood 1993). Hawkeswood (1993) points out that all the current host information for this species comes from New South Wales although the species also occurs in Tasmania, where its hosts are not known. *Phlyctaenodes*, on the other hand, is a polyphagous genus feeding on a number of unrelated plant genera and species (Hawkeswood 1993). One of the two species of this genus (*P. pustulatus* [Hope]) has been recorded from an exotic weed species (*Lantana camara* L. [Verbenaceae]), an unusual occurrence because this plant has few native cerambycids associated with it (Hawkeswood 1993).

Froggatt (1923) described the behavior of *Scolecobrotus westwoodi* in *Eucalyptus corymbosa*. The larva enters the stem about 1 foot above the ground; it bores upward, hollows out branches, turns downward toward the point of entry, and then girdles the stem. Once the larva matures, it pupates a few inches above the ground (Froggatt 1923). This beetle is also particularly destructive to young saplings of *E. amygdalina* (Froggatt 1923).

Taylor (1951) described *Epithora dorsalis* as being almost as common in New South Wales as the two most common longhorned borers (*Phoracantha recurva* and *P. semipunctata*). The host list includes a number of *Eucalyptus* species as well as other genera such as *Angophora* (Myrtaceae) and *Gmelina* (Verbeneaceae). Trees under attack are stressed or dying. In Tasmania, the beetles have a 1-year life cycle, with adults appearing in early summer and laying eggs in batches of 1 to 35 in bark fissures on logs or stressed trees (Elliott and others 1998). As is typical of so many members of the family, the larvae feed initially in the cambial region before entering the wood (Elliott and others 1998). The larvae pass through at least five larval instars before pupating in the heartwood. Some adults emerge in the second year of attack (Elliott and others 1998). Bashford (1994, cited by Elliott and others 1998) found that predatory beetles (Elateridae and Cleridae) along with parasitoids (Diptera and Hymenoptera) caused heavy losses of *E. dorsalis* in the larval stage.

Hesthesis cingulata is associated with very young eucalypts. The females deposit eggs on the stem just above the ground. Larvae burrow in a spiral manner into the center of the stem and then down into the taproot to pupate. Sometimes the infested stem is swollen in response to the larval tunneling and may contain holes through which boring dust extrudes (Elliott and others 1998). The spiral burrowing severs the stem above the ground line (Elliott and de Little 1984). Moore (1966) reported that *H. cingulata* damaged plants of *Eucalyptus pilularis* ranging from 45 to 120 cm (18 in. to 4 ft) in height. *E. globulus* is a favored host in Tasmania (Elliott and others 1998). The species is univoltine, with oviposition occurring between October and January and with adults emerging between September and December (Moore 1966). Damage is quite variable; in some cases the infested plant dies before the adult emerges, whereas in other cases there are numerous shoots of regrowth and the larva continues to tunnel in the taproot (Moore 1966).

With respect to borers of eucalypts, the genus *Phoracantha* is clearly the most well known in Australia. In addition to *P. semipunctata* and *P. recurva*, which have been transported to several parts of the world (including the United States), numerous other species have been studied due to their importance in Australia. After a recent taxonomic revision (Wang 1995), the genus *Phoracantha* now contains 40 species, including all the species that were formerly in the genus *Tryphocaria.* The known hosts are mainly from the genus *Eucalyptus*, with a few species being associated with *Acacia* (Wang 1995). Wang (1995) reports that the borers in this genus *Phoracantha* can be divided into two groups based on their biology: (1) those beetles living in dead and dying trees (including *Phoracantha semipunctata*, *P. recurva*, *P. tricuspis* and *P. punctata*) and (2) beetles infesting living trees (including *P. acanthocera*, *P. mastersi*, *P. frenchi*, *P. impavida*, *P. synonyma*, *P. solida* and *P. odewahni*). Wang (1995) stated that these are clearly defined functional groups and that all the *Phoracantha* beetles fit easily into one of them. Most of the beetles in the latter group were previously in the genus *Tryphocaria*. Under the old nomenclature, *Phoracantha* borers were those generally preferring dying or dead trees and were considered secondary beetles, whereas *Tryphocaria* borers were those breeding in living trees. Clark (1925) reported that *Phoracantha* beetles appeared to spend most of their developmental time in the cambium and sapwood, while *Tryphocaria* beetles spent very little time in the sapwood, developing mostly in the interior of the tree. Wang (1995) noted some other important biological differences between the two groups of borers: The dead/dying tree borers (Group 1) have one or two generations per year, attack newly felled and dying trees of all ages, have broad host ranges, and lay eggs under loose bark in batches of 23 to 340 eggs. The larvae radiate from the egg mass in all directions and feed in and under the bark for 2 to 6 months (Wang 1995). The damage to trees is largely due to the large number of larvae produced (Wang 1995). The living-tree borers (Group 2) require 2 to 3 years to complete a generation. They attack live trees of all ages but particularly young trees from 6 to 20 years of age (Wang 1995). Typically, the beetles in this second group have narrower host ranges, and only about 20 species of *Eucalyptus* have been recorded as hosts for the entire group (Wang 1995). Eggs are laid singly or in small groups (1 to 18 eggs) in bark cracks or where injuries have occurred. The larval feeding activity results in a number of heavily damaged areas under the bark that extend well into the wood (Wang 1995). Wang (1995) reports that in general, one tree will support only one species of borer from this group and only a few larvae, but these may be sufficient to kill the tree.

All the Australian states have species of *Phoracantha* borers, and eight species are widely distributed in both coastal and central areas (Wang 1995).

Perhaps the most important species in the genus is the bullseye borer, *Phoracantha acanthocera.* As a member of the former genus *Tryphocaria*, its biology follows that described by Wang (1995) for those borers attacking live, apparently healthy trees. *Phoracantha acanthocera* has a life cycle requiring two full years. Eggs are laid in bark cracks, usually near the base of the tree, and the newly hatched larvae tunnel upward erratically, periodically entering the sapwood (Phillips 1996). In the course of their development, the larvae may excavate three to five irregularly shaped and connected patches of damage in the sapwood (Elliott and others 1998). Each larva makes a gallery well in excess of 1 m in length (Elliott and others 1998, Farr and others 2000). Occasionally, vents are opened through the bark surface through which frass is expelled (Elliott and others 1998). These vents, exuding insect frass and kino, can be a dependable way of identifying trees infested by the wood borers (Farr and others 2000).

Clark (1925) described the activities of the marri borer, *Tryphocaria hamata* (later synonymized with *Phoracantha acanthocera*), in Western Australia. He found that trees of all growth stages were affected by this borer, but the preference was for trees about 1 foot (30 cm) in diameter (Clark 1925). Adults are found flying at dusk during January and February, sometimes hiding under loose bark on tree trunks during the day (Clark 1925). The females lay eggs in bark cracks and the newly hatched larvae chew through the bark and begin feeding in the cambium. Once the larva is over 1 in. (2.5 cm) long, it begins to tunnel upward through the heartwood and may make a gallery from 8 to 12 ft (2.4 to 3.6 m) in length by the time it matures 2 years later (Clark 1925). Wang (1995) reported that adults have been collected during 6 months of the year (January to March and October to December), either in light traps or under loose bark of host trees.

Phoracantha acanthocera occurs throughout Australia and has a fairly broad host range that takes in species outside the Myrtaceae family (for example, *Agathis robusta* and *Araucaria cunninghamii*). In Western Australia, damage is common in karri (*Eucalyptus diversicolor*) and marri (*Corymbia calophylla*) (Farr and others 2000). Wylie and Peters (1993, cited by Elliott and others 1998) reported bullseye borer attacks in plantations of *E. grandis* and *E. resinifera* in Queensland. Several species, including *E. grandis*, *E. saligna*, and *Corymbia maculata*, are also infested in the north coastal forests of New South Wales (Stone 1993). Phillips (1993) reported that adult beetles were emerging from a 4-year-old plantation of *E. globulus* in South Australia.

Phoracantha acanthocera, along with *P. solida*, is named by Wang and others (1999) as being the most widely adapted species of the genus in Australia. Due to the local pest status of both species, Wang and others (1999) stated that these insects could become even more serious pests than *P. semipunctata* has been, if introduced into a new environment. However, Wang and others (1999) also point out that *P. solida* and *P. acanthocera* may be less able to survive a lengthy transport period because unlike *P. semipunctata*, they are insects of healthy trees.

Froggatt (1923) cites French (no reference available) who described *Phoracantha mastersi* as an important pest of young saplings of *Eucalyptus amygdalina* and the final cause of death of numerous blue gums (*E. globulus*) in the Melbourne Public Gardens. Elliott and others (1998) make reference to several other cases where *P. mastersi* has been problematic, including in spotted gum (*Corymbia maculata*) in Queensland, fuelwood and shelterbelt plantings of *E. nitens* and *E. globulus* in Tasmania, and plantations of *E. regnans* previously defoliated by leaf beetles. *P. mastersi* has been an important mortality agent in each of these situations, affecting all sizes of trees. The larvae mine around the trunk under the bark and subsequently work their way into the top portion of the stem, which eventually snaps off (Froggatt 1923). Pupation occurs in the broken portion of the stem and adults emerge in the summer (Froggatt 1923). Larger infested trees will not break off, and pupation will take place within the standing tree (Elliott and others 1998).

Phoracantha solida attacks living and apparently healthy trees of all sizes and has a life cycle that requires 2 years (Wang 1995). Attacks are initiated at old branch stubs or at sites of injury on trees 10 cm (3.9 in.) or more in diameter (Wang 1995). The larval feeding produces a circular area of damage that may be 20 cm (7.9 in.) in diameter and 1 to 3 cm (0.4 to 1.2 in.) deep (Wang 1995). Several entries are made into the heartwood before the larva reaches maturity (Elliott and others 1998). The bark is not retained over the damaged portion of the bole, unlike the case with the bullseye borer, *P. acanthocera* (Wang 1995). Elliott and others (1998) cite references that regard *P. solida* as an important pest of young trees in plantations of *Eucalyptus grandis* in Queensland and of *E. saligna* in Western Australia. The insect occurs in these hosts in other states as well, but effects are less well known in the forest setting (Elliott and others 1998). In Queensland, attacks of *P. solida* sometimes occur in the same trees with the giant wood moth, *Endoxyla cinereus*, and the incidence of that borer attack was significantly higher in fertilized plots (Elliott and others 1998). Brown (1983) and Galloway (1985) reported heavy levels of infestation by *P. solida* and *P. acanthocera* in trees planted on old mining sites in Western Australia. Eucalypts in these rehabilitated sites were variable in terms of susceptibility to the borers, with *E. diversicolor, E. patens, E. resinifera*, and *E. saligna* showing the highest incidence of attack (Galloway 1985).

Phoracantha tricuspis, the largest species in this genus, attacks dead or dying trees of several species of *Eucalyptus* (Froggatt 1923). The larvae penetrate to the center of the stem where they hollow out large flat chambers that are several inches (several centimeters) in diameter and remain for several years (Froggatt 1923). Wang and others (1999) regard this species as one to be taken seriously from a quarantine standpoint due to the similarity of its biological requirements to the closely related *P. semipunctata*.

Hawkeswood (1993) summarized the published biological observations for *Tessaromma undatum*, citing Best (1882), who noted that this round-headed borer was common and widespread in Victoria and that adults were present throughout the year under the bark of *Eucalyptus melliodora*. Other authors, also cited by Hawkeswood (1993), reported that larvae feed beneath or in the bark of felled *Eucalyptus* species and pupate in or below the bark, with adults emerging during spring or autumn. *T. undatum* also has hosts outside the genus of *Eucalyptus*, as noted by Williams (1985), who reared adults that emerged in June and September from dying branches of *Nothofagus moorei* from a cool temperate rain forest in New South Wales.

Regarding *Zygocera canosa*, Webb and others (1988) list a related species as having *Pinus radiata* and *P. elliottii* as hosts in New South Wales. Another species of the same genus (*Z. elongata*) has been reported on *Malus* sp. and on *Cedrela australis* (Webb 1987).

Because very little specific information is available about the biologies of most of these round-headed borers, the evaluation of the following risk criteria is largely based on characteristics that apply to the cerambycid family as a whole.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, c, d, e, f, h)
   Chips—*Low* (MC) (Applicable risk criteria, from Ch. 1: c)

   Most of the round-headed borers in Australian eucalypts are secondary and are most likely to be associated with mature forests and with trees in a poor state of vigor. As such, many of these species would not commonly be found in plantations of vigorously growing trees that are typically harvested before they are 15 years old. However, there are some species, particularly in the genus *Phoracantha*, that have been found in young trees and in plantations. A subgroup of that genus (many of the beetles previously belonging to the genus *Tryphocaria*) is associated with live trees in apparently good health. Even though their host range is narrower than that of *Phoracantha* species that infest dead and dying trees, the former *Tryphocaria* beetles are widely distributed throughout Australia and do represent a concern for some plantation eucalypts.

   Although the borer species being considered here have not been intercepted in U.S. ports, the criterion “a” is applied for logs based on attributes of the family Cerambycidae, which has species that are frequently intercepted with unprocessed wood products. Two other species of *Phoracantha* (*P. semipunctata* and *P. recurva*) have already become established in California. Adults of most wood borer species have a flight period that spans several weeks during the spring, summer, or fall. Considering the family as a whole, the flight period of all cerambycids associated with a particular species of *Eucalyptus* could cover several months, allowing for a high likelihood that felled material could be infested before it is removed from the woods. The biological requirements of cerambycids coincide well with commodities such as logs, and if large volumes of logs are transported, there is a reasonable likelihood of association even if infestation levels are low.

   The chip commodity carries a “*Low*” rating because only one risk criterion still applies: the wide distribution of insects. Even though criterion “f” (the attraction to host material via the volatile substances given off from chips) also applies, the criterion is not considered relevant because the insects would not be able to successfully colonize chips. For material infested prior to chipping, it seems unlikely that any life stage that passed successfully through the chipping process could subsequently survive in chips due to altered moisture and temperature. Mature adults and pupae might be the only exceptions, but because many of them are fairly large, their survival still seems unlikely. (Chipping is standard treatment used in the eradication efforts for Asian Longhorned Beetle).

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: d)

   Although the specific biologies of many Australian species are unknown, it is reasonable to assume, based on our knowledge of the family traits of the Cerambycidae, that they have a life cycle that includes a prolonged period in an immature developmental stage within the wood that is sufficient to survive transport to a new location if the commodity being shipped is an unprocessed log. The Cerambycidae are some of the insects most commonly intercepted in U.S. ports in connection with trade involving various forms of solid unprocessed wood.

Two species of *Phoracantha* (*P. semipunctata* and *P. recurva*) have already been introduced into the United States and are thriving in their new environment. Two other species (*P. acanthocera* and *P. solida*) have broad host ranges comparable to those of *P. semipunctata* and *P. recurva* and are more widely adapted within Australia than most other species of that genus (Wang and others 1999). However, Wang and others (1999) questions whether *P. solida* and *P. acanthocera*, being pests of live trees, could survive lengthy shipment in logs. Our experiences with the introduction into the United States of *Anoplophora glabripennis*, an insect requiring live hosts, would lead us to conclude that we should not assume they cannot survive in cut wood.

For the chip commodity, the rating for this element would drop to "*Low*" in spite of the fact that criterion "d" probably applies (cryptic nature of the insect). Immature stages would probably have difficulty surviving in chips due to altered moisture and temperature regimes. Mature stages are of sufficient size to be damaged in the chipping process or to be dislodged during processing and handling.

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, d)

Although most of the species being considered are fairly specific to the genus *Eucalyptus*, there are some such as *Epithora dorsalis* and *Tessaromma undatum* that have host plants in families other than the Myrtaceae. Another genus being considered (*Phlyctaenodes*) has a species that has adapted to an exotic weed in Australia that naturally has few cerambycid hosts (Hawkeswood 1993). Yet another genus (*Zygocera*) has a species that has adapted to two exotic pine species planted in Australia. As such, we would be concerned that some of these round-headed borers could be transported into the United States via their *Eucalyptus* host and on arrival could possibly find suitable hosts in the United States in other genera.

4. Spread potential: *High* (MC) (Applicable risk criteria, from Ch. 1: a, b, d, e, f)

Many cerambycids have strong flight capability as well as good survivability in wood (for human transport) that could aid in their spread. Control or eradication may be at least difficult if not impossible for those borers infesting live trees.

B. Consequences of introduction

5. Economic damage potential: *High* (MC) (Applicable risk criteria, from Ch. 1: a, b, c, d)

Most of these beetles attack recently cut wood or trees under stress. Other members of the family (for example, two species of *Phoracantha*) have shown the capability of killing drought-stressed trees in their new environments, and based on that evidence, criterion "b" is applied for this element. Additional species in the same genus attack apparently healthy trees in their natural environment. Infestations in recently cut logs could reduce the value of lumber or other products cut from this material. Although many of the round-headed wood borers being considered here are associated only with eucalypts, some have either demonstrated adaptability to new hosts when given the opportunity (*Zygocera* spp.) or already have hosts outside that genus (for example, *Tessaromma undatum*, *Phoracantha acanthocera*, *P. mastersi*). As such, economic damage from introductions could occur in tree species other than those in the eucalypt genera.

6. Environmental damage potential: *Low* (RU) (Applicable risk criteria, from Ch. 1: none)

Based on the predominant host selection habits of these beetles (secondary infestation of dead wood), the environmental effects would probably not be significant. Some species of *Phoracantha*, however, do infest live, apparently healthy trees in Australia, and could be considerably more serious if introduced into an environment with suitable hosts.

7. Social and political considerations: *High* (RU) (Applicable risk criteria, from Ch. 1: a, c)

The presence of a new wood borer could have implications on international trade. Homeowner concerns have been expressed at the loss of urban plantings following the establishment of two *Phoracantha* borers in California.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *High*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

An evaluation of the pest risk potential based on chips rather than logs as the commodity entails revisiting the first two elements of the likelihood of introduction: (1) pest with host at origin potential and (2) entry potential. These elements for the chip commodity can be evaluated in two ways: first for the potential for association and survival of insects that had already infested their hosts prior to chipping, and second for chip attractiveness as a substrate for colonization. Although it may be attractive to adult beetles due to host volatiles, the chip substrate would not be suitable for successful oviposition, and even if egg-laying were to occur, larvae could not develop in such a medium. Insect survival in chips during their transport seems unlikely in any stage except the adult and possibly pupal stage.

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Reviewers' comments—"Likelihood of introduction. As with the ambrosia beetles, the assumed attraction to chip piles created by the release of host volatiles may occur, but is likely transient. It is unclear why the author rated the cerambycids as moderate while ambrosia beetles were rated as low." (Cameron)

"Scientific names of pests. Cannot find reference to *Phorocantha semipunctata* in the list of scientific names of pests and hosts despite it being a major borer species around Australia, as well as being mentioned in the report." (Collett)

"*Callidiopsis scutellaris* is established in New Zealand (Kuschel, G., 1990: Beetles in a suburban environment: a

New Zealand case study: the identity and status of Coleoptera in the natural and modified habitats of Lynfield, Auckland (1974-1989). DSIR Plant Protection Report No. 3, 118 p. Milligan, R.H., 1970: Overseas wood- and bark-boring insects intercepted at New Zealand ports. Forest Research Institute, New Zealand Forest Service Technical paper No. 57. 80 p.).” (Bain)

“Categorization of *Phoracantha* species into two groups that prefer dying or dead trees (the original *Phoracantha* species) versus living trees (formerly *Tryphocaria* species) is a bit misleading because *P. semipunctata* and *P. recurva* attack and kill living trees that would otherwise survive in many parts of the world where the beetles have been introduced. Thus these species are not secondary pests, and the same may be true for other *Phoracantha* species when introduced into a new region. In other words, a secondary species in Australia can become a tree killer in other parts of the world.” (Hanks)

“It is risky to assume that a species that feeds in living hosts is unlikely to survive transportation in cut wood. A classic example is that of Asian longhorned beetle, the larvae of which can only develop in living hosts. This species, and two congeners, have survived the trip from China to the United States many times, and have succeeded in founding populations in some cases.” (Hanks)

“Likelihood of Introduction should include criterion “g” because eucalypt hosts of these Australian longhorned beetles are widely distributed in several regions of the world. The statement that cerambycids that are “secondary pests” are unlikely to occur in young plantations in misleading. For example, *P. semipunctata* is a very strong flier and adept at locating fresh hosts. In fact, when trees are felled, the adults appear on them that evening and are ovipositing. Moreover, populations of these beetles may be maintained by infesting fallen branches. Thus trees harvested anywhere in Australia are very likely to become rapidly infested with wood borers of a variety of species.” (Hanks)

“Spread potential should include criterion “f” because of the difficulty in eradicating wood borers. Detection and elimination of the larvae is particularly problematical. An example is the eradication program for Asian longhorned beetle in New York, which is very unlikely to succeed.” (Hanks)

“Consequences of Introduction should include criterion “b” because some of these species may be able to kill trees, such as has been the case with *P. semipunctata* and *P. recurva*. That would increase the risk value to ‘high’.” (Hanks)

“Social and Political Considerations should include criterion “a” because loss of trees would inevitably result in concern over urban plantings. Such certainly has been the case with introduction of *P. semipunctata* and *P. recurva* into California.” (Hanks)

“Pest risk potential, last sentence. How about pupae surviving in chips?” (Hodges)

Response to comments—The significance of host volatiles is recognized as being potentially important for attracting ambrosia beetles and wood borers to chip piles, but colonization of chips would be unlikely to take place in either case.

Phoracantha semipunctata is mentioned in the report and is listed in Table 7 (Insects of Concern), but it is not treated in the wood borer IPRA because it is already widespread in California.

Based on the reviewer comment of Dr. Bain, New Zealand was added to the distribution of *Callidiopsis scutellaris.*

The distinction that is made in Australian literature between former *Tryphocaria* and former *Phoracantha* beetles involves more than their tendency to infest live versus dying trees. It also includes differences in breadth of host range, fecundity, life cycle, attack densities and larval behavior. It is a distinction that makes sense in Australia but does not imply that the same behavior will be manifested in a new environment. It simply forms a starting point for understanding some of the variation that occurs within the group of borers currently known as *Phoracantha.*

The statement questioning the survival ability of live-tree wood borers in cut wood was a citation from Australian literature (Wang and others 1999). Lacking evidence to the contrary, the assessor of this IPRA made the assumption that later developmental stages could survive in cut wood, based on the recognition that there are live tree-infesting cerambycids such as Asian longhorned beetle that are frequently intercepted in foreign ports. The team agrees.

The statement that cerambycids are unlikely to occur in young plantations is based on our understanding of the experiences of Australian entomologists with whom the team consulted during the Site Visit. Their observations indicated that they do not find evidence of wood borers in these young vigorously growing trees and that trees are harvested well before they show the signs of the stresses that seem to invite wood borer attack. We believe this to be true and saw no evidence to the contrary. However, once the WIPRAMET members gathered to evaluate reviewer comments, it became clear that there were some good points being brought up regarding the statements that we had made about wood borers in a plantation setting. For example, it was suggested that if a plantation has been in place for an extended period of time, and is not harvested in a timely manner (perhaps waiting for markets to improve) it begins to resemble the natural forest, complete with tree crowding, stem breakage, falling branches, etc., and over time may be difficult to distinguish from a natural forest. (This situation may already be occurring to a certain extent in some older Australian plantations of *Pinus radiata*.) It was also pointed out that even a healthy plantation could have stem breakage and host material could be provided in that way for wood borers and other opportunists. As a result, we concluded that although the typical tree growing in a plantation would be highly unlikely to harbor wood borers, we should not assume that no wood borers could be present in the area and that freshly harvested material could not be colonized, as long as bark is still present.

We agree that there is good current evidence that wood borers may be difficult to eradicate if they are not promptly detected. As such, criterion "f" was added to the Spread Potential, elevating that risk element from "*Moderate*" to *High*" for wood borers. The resulting Likelihood of Introduction is unchanged and remains "*High*" for the log commodity.

Criterion "b" (capability of killing trees) was added based on the behavior of the two *Phoracantha* species already introduced into California. This changed the Economic Consequences of Introduction from "*Moderate*" to "*High*."

Criterion "a" was added to the Social and Political Considerations, based on the reviewer comment that the tree-killing capabilities of *Phoracantha semipunctata* and *P. recurva* in California have led to important homeowner concerns about losses of urban plantings.

The last sentence in the pest risk potential discussion was modified to include the possibility of pupae surviving in chips.

Ghost Moths and Carpenterworms

Assessor—Andris Eglitis

Scientific names of pests—*Abantiades latipennis* Tindale, *Aenetus eximius* (Scott), *A. ligniveren* (Lewin), *A. paradiseus* Tindale, *Zelotypia stacyi* Scott (Lepidoptera: Hepialidae); *Endoxyla cinereus* (Tepper) (=*Xyleutes boisduvali* Rothschild), *Endoxyla* spp. (=*Xyleutes* spp.) (Lepidoptera: Cossidae)

Scientific names of hosts—*Abantiades latipennis*: *Eucalyptus globulus*, *E. obliqua*, *E. regnans*;
Aenetus eximius: *Eucalyptus grandis, E. pilularis, E. saligna*;
Aenetus ligniveren: *Eucalyptus delegatensis, E. globulus, E. grandis, E. obliqua, E. regnans, E. viminalis, Leptospermum, Melaleuca, Tristania*, other Myrtaceae*, Acacia, Ulmus, Dodonaea* (Sapindaceae), *Olearia* (Asteraceae), *Pomaderris* (Rhamnaceae), *Prostanthera* (Lamiaceae), *Malus pumila* (Rosaceae), *Rubus idaeus* (Rosaceae);
Aenetus paradiseus: *Eucalyptus* spp.;
Zelotypia stacyi: *Eucalyptus grandis, E. saligna, E. tereticornis*;
Endoxyla cinereus: *Eucalyptus camaldulensis*, *E. cloeziana*, *E. globulus*, *E. grandis*, *E. tereticornis*;
Endoxyla spp.: *Eucalyptus diversicolor*, *E. globulus*, *E. obliqua*, *E. saligna*, *E. regnans*

Distribution—*Abantiades latipennis*: Tasmania, Victoria, Western Australia; *Aenetus eximius*: New South Wales, Queensland, Tasmania, Victoria; *Aenetus ligniveren*: New South Wales, Queensland, South Australia, Tasmania, Victoria; *A. paradiseus*: Tasmania: *Zelotypia stacyi*: New South Wales, Queensland; *Endoxyla cinereus*: New South Wales, Queensland; *Endoxyla* spp.: Tasmania, Victoria, Western Australia

Summary of natural history and basic biology of the pests—The family Hepialidae includes more than 150 species in Australia. These insects are generally phytophagous; some are economic pests in pastures (Tindale 1938, cited by Kile and others 1979) while others are stem-borers of standing trees. Larvae of some of the hepialid species (*Aenetus* spp.) feed in the trunks of eucalypts while others (*Abantiades* spp.) feed externally on the roots (Elliott and de Little 1984). Larvae of *Aenetus* spp. form vertical tunnels in the center of the infested stem, with a horizontal tunnel connecting to the stem surface (Elliott and de Little 1984). The entrance of the tunnel is often located near a branch fork (Elliott and de Little 1984). Once the larvae have matured, they pupate near the tunnel entrance in a cavity covered with webbing and frass (Elliott and de Little 1984). Adult moths of *Aenetus* emerge in the spring and early summer. Froggatt (1923) reported that larvae of *Aenetus lignivorus* (=*Charaga lignivora*; =*A. ligniveren*) also feed on the stems of numerous shrubs including *Leptospermum*, *Melaleuca*, and *Tristania* in addition to *Eucalyptus*. Additional hosts later identified for *A. ligniveren* include all the family Myrtaceae as well as representatives from numerous other families including Mimosaceae (*Acacia*), Ulmaceae (*Ulmus*), Sapindaceae (*Dodonaea*), Asteraceae (*Olearia*), Rhamnaceae (*Pomaderris*), Lamiaceae, (*Prostanthera*) and Rosaceae (*Malus pumila* and *Rubus idaeus*) (Herbison-Evans and Crossley 2001).

Tindale (1953) reported on *Aenetus* (=*Oenetus*) *paradiseus* occurring in *Eucalyptus* saplings from Tasmania. During thinning operations, these insects were discovered inside the stems of trees being culled from young plantations. While the hepialids themselves were not adversely affecting the growth of the young trees, there was significant damage resulting from feeding by cockatoos (*Calyptorhynchus funereus*) as they gouged out large holes in search of the larvae. The damaged trees subsequently broke off during high winds (Tindale 1953). Attacks by a subspecies of this hepialid were noted in small trees ranging from slightly less than 1 in. (2.54 cm) to 4 in. (10.16 cm) in diameter and growing at 4,500 ft (1,372 m) elevation (Tindale 1953). It was speculated that the life cycle of *A. paradiseus montanus* might require 2 to 3 years (Tindale 1953).

The hepialid *Zelotypia stacyi* pupates inside the infested wood in December, and the moth emerges in March (Froggatt 1923).

The externally feeding *Abantiades* can be found in tunnels as deep as 350 mm (13.8 in.) in the soil, where larvae feed on the adjoining roots. Their feeding can cause girdling of roots and the development of a swelling or gall (Elliott and de Little 1984).

Kile and others (1979) described the association between the root-feeding *Abantiades latipennis* and two species of *Eucalyptus* (*E. obliqua* and *E. regnans*) in Tasmania. The favored habitat of *A. latipennis* appears to be young stands of *Eucalyptus* regeneration (Kile and others 1979). The authors noted three types of larval feeding damage: (1) partial removal of bark from the root surface (the most common), (2) removal of bark around entire root circumference, and (3) minor root damage (Kile and others 1979). The damaged portions of the root usually contained discoloration, decay, and swelling along with the formation of kino in localized areas (Kile and others 1979). There were no crown symptoms to indicate that the roots had been attacked, although the authors noted that some of the trees had also been infested in the main stem by the other helipalid, *Aenetus* sp. (Kile and others 1979). Most of the active larval feeding by *A. latipennis* was noted on saplings 2 to 6 years old (Kile and others 1979). Multiple lesions on the root system were common. In addition to saplings of *Eucalyptus regnans* and *E. obliqua*, the authors also noted old feeding lesions on 60- to 70-year-old *E. globulus* and considered this species another likely host for *A. latipennis*. Some of the feeding lesions were found to harbor rhizomorphs of Armillaria root disease (Kile and others 1979). Kile and others (1979) noted that *Acacia* spp. growing in the same stands were not affected. Although not considered an important problem at this time, the authors speculated that root-feeding by *A. latipennis* could be important by reducing the vigor and competitive advantage of affected trees and by allowing for entry of *Armillaria* spp. or decay fungi into the root system (Kile and others 1979).

Froggatt (1923) described the "giant wood moth" (called *Zeuzera macleayi* in the 1920s) as an important pest of the gums, including Tasmanian blue gum, *E. globulus*. He pointed out that there is considerable variation in colors and sizes between the sexes, casting some doubt on the original names of the Australian wood moths. The species named *Z. macleayi* is probably the same as *Eudoxyla* [sic] (=*Xyleutes*) *boisduvalli* [sic] (*boisduvali*) (Froggatt 1923). Currently this insect is known as *Endoxyla cinereus* (Tepper) and is one of about 60 species of *Endoxyla* wood moths that occur in Australia (Monteith 2000). *Endoxyla cinereus* occurs commonly all along the Queensland coast, including suburban Brisbane, where it infests eucalypts in parks and gardens (Monteith 2000). The giant moths appear briefly in the summer to mate and lay eggs on new hosts. Each female may carry as many as 20,000 eggs. These eggs are laid in bark crevices and covered with a glutinous secretion for protection (Monteith 2000). The tiny first-instar larvae lower themselves to the ground on silken threads, and their activity during the first year is unknown, although it is suspected that they feed on roots (Monteith 2000). They reappear later as well-developed larvae that are ready to bore into the boles of their host trees (Monteith 2000). These larvae chew through the bark, construct a chamber beneath the bark, and partially plug the entry hole with a mixture of sawdust and silk. A small hole remains in the plug to allow for clearing out additional sawdust and excrement when the main tunnel is constructed in the wood (Monteith 2000). This sawdust accumulates on the ground and is a good indicator of infestation by the wood moth (Monteith 2000). The developing larvae continue to enlarge the chamber beneath the bark, and they construct a vertical tunnel in the sapwood. The food source for the larvae appears to be the callus tissue that is generated by the tree in an effort to seal off the burrow created by the insect (Monteith 2000). The larvae develop for 2 years within the host tree until they reach a length of 15 cm (5.9 in.) at maturity (males are smaller). The mature larva enlarges its chamber and chews an exit hole above the original entry hole; then it retreats into the far corner of its main tunnel, which is now 20 to 30 cm (8 to 12 in.) long, and forms the pupa in a chrysalis (Monteith 2000). The pupa wriggles down the burrow and works its way to the exit hole, from which the adult moth emerges and flies away. Monteith (2000) reports that unhealthy trees are usually damaged more heavily than healthy ones, and that small trees may break off in the wind after being weakened by the insect tunnels. Further damage results when the yellow-tailed black cockatoos (*Calyptorhynchus funereus*) chew into the infested stems in search of the larvae (Monteith 2000).

The giant wood moth has produced significant losses in some plantations of *Eucalyptus grandis* being grown for pulpwood production (McInnes and Carne 1978). Similarly, Harris (1986) reported damage in stands of 45-year-old mountain ash (*Eucalyptus regnans*) in Victoria resulting from the feeding of a complex of wood moths. Harris (1986) found galleries of various ages in the merchantable boles of infested trees. Many of these galleries were associated with branches and branch stubs. Galleries containing three species of larvae (two cossids and a xyloryctid) were within 3 cm (1.2 in.) of the bark surface, but older galleries filled with kino were also evident, sometimes at depths of 10 cm (3.9 in.) from the bark surface (Harris 1986). This damage resulted in the degrading of 20% of the sawlogs to pulpwood with a significant loss in value (Harris 1986). Harris (1986) estimated that this stand had been infested over a two-decade period and may have been the result of stress on the stand, possibly from poor site quality.

A species of *Xyleutes* (*X. magnifica*) is discussed by Moore (1972), who called this the largest of many cossid species that damage stems of *Eucalyptus* spp. He described larval damage in stems of large *E. saligna* trees that can be found from 0.3 to 2 m. (1 to 6 ft) above the ground line. The entry hole into the wood is 10 to 15 mm (0.39 to 0.59 in.) in diameter and is covered with a combination of webbing, excreta, and pieces of wood and bark produced by the larvae. The bark is stained red beneath the entry hole, but otherwise little external evidence is present to indicate the damage that has been done beneath the bark. The larvae feed extensively in the sapwood and shortly before pupation remove much of the bark above the damaged sapwood. In addition, a larval gallery may extend upward from an irregular exit hole into the heartwood for a distance of 25 cm (10 in.) (Moore 1971).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*Moderate* (RC) (Applicable risk criteria, from Ch. 1: b, c, e, h)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Both the hepialids and cossids lay extremely large numbers of eggs (many thousands per female), providing them with the potential for large population increases if conditions are favorable. Although individual species are not particularly widespread, there are many species in each family and as a group they cover a large part of Australia. If trees are infested when cut, the insects inside logs could probably survive, especially if they are in the pupal stage. The leopard moth, *Zeuzera pyrina* (Linnaeus) (Lepidoptera: Cossidae), was successfully transported from Europe and became established in the United States in 1882 (Anderson 1966), giving testimony to the potential for introduction of members of the carpenterworm family.

None of the risk criteria apply for the chip commodity. The life stages of these insects are either very delicate (eggs) or very large (larvae) and would not survive the chipping process if they were present in logs before processing. The chip would not provide a suitable habitat for the life stages of either the wood moths or ghost moths.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Risk criterion "d" relating to the cryptic nature may or may not apply for the log commodity, depending on the level of infestation and the degree of maturity of the insects inside. The large larvae are likely to produce large amounts of sawdust that would be visible on the ground, perhaps along with the plugged entry holes (Monteith 2000). Smaller larvae associated with branch stubs might be less conspicuous. Nonetheless, the introduction into the United States of the leopard moth *Zeuzera pyrina* shows that the potential exists for wood-infesting Lepidoptera to be introduced if infested host material is transported. Cossid and hepialid larvae or pupae inside wood may be just as likely to survive transport as immature stages of cerambycids.

   Given the altered moisture and temperature regimes in chips, the survival of any early developmental stage seems very unlikely in this commodity. Later developmental stages (larger larvae) would not be sheltered within the chip commodity due to their large size, nor would they have available food for development. As such, the rating for the chip commodity for this element is "*Low*."

3. Colonization potential: *Moderate* (RU) (Applicable risk criteria, from Ch. 1: b, e)

   Although most of the Australian cossid and hepialid species are somewhat restricted in their hosts and distributions, they are widely distributed as a group. As such, rating criterion "b" (high probability of encountering favorable climate) may apply for the group but not necessarily for any given species. Species in both families have a high biotic potential through their high fecundity rate, but the host range is fairly narrow for most species except *Aenetus ligniveren*, which feeds on a number of families of plants in addition to many members of the Myrtaceae.

4. Spread potential: *Moderate* (RC) (Applicable risk criteria, from Ch. 1: c, e, f)

   The Australian hepialids and cossids individually have narrow host ranges, in some cases including only two or three species of *Eucalyptus* (*Aenetus ligniveren* is an exception). The biotic potential is high, based on large numbers of eggs per female, but a compensatory factor for this biotic potential is that the eggs are laid indiscriminately and early larval survival is probably low. The males of both families are strong fliers, but carpenterworm (cossid) females heavy with eggs are notoriously poor fliers (Solomon 1995). The leopard moth *Zeuzera pyrina*, introduced into the United States from Europe in 1882, has not spread extensively due in part to poor flight capability of gravid females (Solomon 1995). Both families are fairly cryptic in nature, and infestations could easily go undetected for some time.

B. Consequences of introduction

5. Economic damage potential: *High* (MC) (Applicable risk criteria, from Ch. 1: a, c, d, f)

   The ghost moths and wood moths are considered significant plantation pests in three of the Australian states (Tasmania, Bashford 1993; New South Wales, Stone 1993; Queensland, Wylie and Peters 1993). The insects in these two families are not known as tree killers, but they are capable of reducing the value of wood they infest. Some economic losses have been incurred in Australia from infestations by wood moths of the Cossidae (Harris 1986). These losses were in the form of defects that brought a lower market price for the devalued wood. The ghost moths are probably less damaging in an economic sense than cossids because they tend to infest saplings and smaller trees than those infested by the wood moths. Controls for wood-infesting insects are generally ineffective due to the inaccessibility of the insects; usually infested material must be destroyed in order to eliminate the pests.

6. Environmental damage potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: e)

   Eradication or control efforts could lead to increased use and possibly misuse of pesticides with adverse consequences to the environment.

7. Social and political considerations: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: a)

   The most likely concerns would be from homeowners interested in protecting their ornamental plantings.

C. Pest risk potential:
   Logs—*High* (Likelihood of introduction = *Moderate*; Consequences of introduction = *High*)
   Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

The altered moisture and temperature would make survival in chips unlikely for any of the wood-inhabiting insects. Chip piles may be attractive due to host volatiles but would not be suitable for egg deposition nor for larval development.

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Reviewers' comments—"Pest risk potential. The assumed attraction to chip piles created by the release of host volatiles may occur, but is likely transient." (Cameron)

"I do not understand how the source (logs vs chips) could affect the consequences of an introduction, e.g., the ghost moths cause high consequences if brought in on logs, but only moderate if in chips." (Cobb)

"Individual IPRAs. Many of the IPRAs address groups of pests. However, in two IPRAs, the platypodid ambrosia beetles and pinworms and the ghost moths and carpenterworms, the assessor chose to split the group into individual species for the risk element pest-with-host-at-origin. If the IPRA is for a group of pests, this risk element's rating should be based on the group's behavior and distribution. Instead, the assessors looked at the behavior of the pests as individual species resulting in a lower rating for this risk element." (Osterbauer and Johnson)

Response to comments—The reviewer is correct in that attraction of moths to a chip pile through host volatiles would be transient. As stated in the pest risk potential, this attraction would not be expected to lead to successful colonization of chips.

The Consequences of Introduction do not change with the commodity; a typing error occurred in the draft document, and was corrected in the final to indicate "*High*" Consequences of Introduction of wood moths and ghost moths for both log and chip commodities.

The team disagrees with the reviewers' comment about assessing groups of pests but applying lower ratings based on individual organisms. The biological information that is available on individual organisms is presented in the IPRA as typifying the group, and in fact, the ratings are intended to be for the group as a whole.

True Powderpost Beetles

Assessor—Michael Haverty

Scientific names of pests—*Lyctus brunneus* (Stephens), *L. costatus* Blackman, *L. discedens* Blackburn, *L. parallelocollis* Blackburn, *Minthea rugicollis* (Walker) [Coleoptera: Lyctidae (in Australia family Bostrichidae, subfamily Lyctinae)]

Scientific names of hosts—*Eucalyptus amygdalina*, *E. cloeziana*, *E. delegatensi*, *E. dunnii*, *E. globulus*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. regnans*, *E. saligna*, *E. viminalis*, *Corymbia calophylla*, *C. citriodora*, and *C. maculata*. These species are listed because they are not resistant to lyctid infestation due to the diameter of their xylem vessels. Numerous hardwood species could be susceptible to attack. Other species of interest are resistant because xylem vessels are too small to allow insertion of the female's ovipositor (Erskine 1965).

Distribution—*Lyctus brunneus*: cosmopolitan; *L. costatus*: South Australia and Tasmania; *L. discedens*: Queensland and New South Wales; *L. parallelocollis*: Queensland, New South Wales and South Australia; *Minthea rugicollis*: Queensland and South Australia.

Summary of natural history and biology of the pest—Three families of beetles, Lyctidae, Bostrichidae, and Anobiidae, are often collectively referred to as powderpost beetles because their larvae reduce wood to a mass of powdery or pelleted frass (Ebeling 1975). There is no general agreement among specialists as to exactly which beetles should be classified as "powderpost beetles" or even whether the term should be used (Moore 1979). However, to distinguish the Lyctidae from the others, the Lyctidae are known as true powderpost beetles in the United States (Ebeling 1975).

The Lyctidae make their presence known by numerous small [<3 mm (<0.12 in.) diameter] exit holes on the surface of wood (Peters and others 1998). They attack sapwood of dead hardwood trees almost exclusively, especially dried and cured lumber (Peters and others 1996). Several generations can re-infest the same piece of wood until it is riddled with exit holes and only the outer shell remains (Brimblecombe 1947, Ebeling 1975, Peters and others 1996). Beneath the surface of the infested wood are galleries or tunnels filled with frass (a mixture of fecal material and wood fragments), usually following the grain of the wood (Ebeling 1975, Moore 1979, Anonymous 1986).

Most parts of the world are inhabited by both indigenous and introduced, well-established species of lyctids. In the United States, lyctids are second only to termites in their destructiveness to wood and wood products (Ebeling 1975). They confine their attacks to large-pored hardwoods. Powderpost beetles may be found in hardwood flooring, hardwood timbers, plywood, and wood articles such as crating and furniture. The damage the beetles cause consists of reducing sound wood to fine powder. This damage is usually not evident until the emergence holes of the adults are observed (Moore 1979, Anonymous 1986). Lyctids are generally brought into buildings in wood that contains their eggs or larvae, but once an infestation is established, it can continue unabated in hardwood lumber, cabinetry, and furnishings within the structure (Ebeling 1975).

The chief source of food for powderpost beetles is starch; they also digest whatever sugar and protein may be present. They do not digest cell walls, for the larvae cannot digest cellulose, hemicellulose, lignin, or pentosans; these components of wood pass through the alimentary canal undigested. Lyctids will not oviposit in sapwood with a starch content of less than 3% (Ebeling 1975). Adult females will bite the surface of wood to test for starch content before ovipositing (Moore 1979, Ito 1982, Peters and others 1996, 1998). Development time is reduced the greater the concentration of starch. Lyctids can live in wood with a water content between 8% and 32%. Because the water content of green wood is commonly 50% or more, attack by powderpost beetles is generally confined to partially or wholly seasoned wood. The greatest lyctid beetle activity is found in wood with a moisture content ranging from 10% to 20% (Ebeling 1975).

Lyctids are small beetles ranging from 2 to 7.5 mm (0.08 to 0.3 in.) in length. They are reddish, various shades of brown, or black; have a prominent head not covered by the prothorax; have short, 11-segmented antennae, each with a 2-segmented terminal club; and have tibiae with distinct spurs (Ebeling 1975, Moore 1979, Anonymous 1986, Peters and others 1996, 1998). Adult lyctids mate soon after they emerge from infested wood. Females have a long, flexible ovipositor that they insert deeply into the pores of hardwoods, laying one or more eggs/pore (Ebeling 1975). The vessels or pores in which the eggs are deposited are exposed when the wood is cut, or may be opened by the beetle herself when sampling for starch content.

The incubation period for lyctid eggs can range from 1 to 3 weeks. Young larvae usually tunnel with the grain of the wood, but later take an irregular course, sometimes intersecting the tunnels of other larvae. The tunnels are packed with a fine, powder-like, boring dust. Larvae do not penetrate to the wood surface but, like termites, leave a thin, unbroken surface layer. Mature larvae bore to a point near the surface of the wood and build a pupal chamber. The pupal period lasts from 12 days to a month. After metamorphosis, adults chew their way to the surface, open an exit hole 2 to 3 mm (0.08 to 0.12 in.) in diameter, and push some of the fine dust out of the hole when emerging. Small piles of the dust are common near new emergence holes. Although the larva confines its burrowing to sapwood, if the adult has no other way of emerging it can bore its way through heartwood. Adults conceal themselves in cracks and holes in the wood during the day, become active at night, fly readily, and are positively phototrophic (Ebeling 1975, Moore 1979, Peters and others 1996, 1998).

The life cycle, from egg-laying to emergence of adults, ordinarily requires 9 to 12 months but under conditions in Australia may be as little as 3 to 4 months. Under exceptionally favorable conditions of high temperature and high starch content of wood, that period may be reduced to only 6 or 7 months. Outdoors, the larvae grow chiefly during spring and summer, but in heated rooms they can develop continuously. Under adverse conditions of temperature and nutrition, the life cycle may be prolonged to as much as 4 years. There can be a great difference in the length of the life cycles of different species. For example the average for *Trogoxylon parallelopipedum* (Melsheimer) is 3 to 4 months, compared with 9 to 12 months for *Lyctus planicollis* LeConte (Ebeling 1975).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e, f, g, h)
   Chips—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e, f, g, h)

   A majority of the commercial eucalypt species could supply harborage for all stages of powderpost beetles. The likelihood of powderpost beetles ovipositing in freshly cut logs is not great. However, as the outer sapwood dries in log decks, either in the forest, at ports, or in chipping mills, the likelihood of adults finding the wood suitable for oviposition increases. Chips, even though they average only 30 to 40 mm (1.2 to 1.6 in.) square by 10 mm (0.4 in.) thick (Gadgil and others 1996), are drier, have a plethora of open pores, and ample starch to support larval development. Lyctid eggs and early instar larvae would likely survive the chipping process.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d)
   Chips—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d)

   Powderpost beetles could survive quite well during transit. In log decks, adults could easily be concealed between the logs or within cracks and crevices of the log surface. Eggs and early instar larvae could survive in the sapwood and would be nearly impossible to detect. Normal transit time from the bush to the port and transit to the United States would normally not exceed one month so that powderpost beetles would still be in the larval stage of the first generation. Adults are unlikely to complete development and emerge before logs are off-loaded at the port of entry unless the logs have been held for a long time before shipment. Therefore, the characteristic emergence holes and powdery frass would not be present to aid in identification of infested logs. The presence of eggs or larvae would easily go undetected in shipments of chips, although there is, as yet, no evidence in the literature that lyctids could complete their life cycle in wood chips. The greatest risk of introducing powderpost beetles would result from logs (or chips) that are shipped from plantations or ports in Australia with these species present, and then remain in storage at the import site for extended periods of time. Waste lumber at lumberyards or sawmills has been reported to be commonly infested with *Lyctus* beetles (Froggatt 1926a).

3. Colonization potential: *High* (RC) (Applicable risk criteria from Ch. 1: a, b, c, d, e)

   Powderpost beetles are generally polyphagous. The presence of an acceptable host is not the critical factor, because these powderpost beetles can infest numerous tree species and wood in service. The factors limiting host acceptability are moisture content, starch content in the sapwood, and pore size. If logs or chips arriving at a port are not immediately utilized or are left in a refuse pile, powderpost beetles can reinfest the parent material or disperse to find other suitable materials. For example, infestations that become established in lumber storage facilities are very difficult to eradicate because of the ready supply of seasoned, susceptible wood. The adults are strong fliers and are attracted to lights. They could easily become established in solid wood products, such as hardwood pallets, that would be in the vicinity of ports of entry. Once established, these beetles could infest dead wood in exotic trees grown as ornamentals (Bockerhoff and Bain 2000). Colonization potential is great at all ports, regardless of the climate.

4. Spread potential: *High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d, e, g)

   Powderpost beetles do not fly great distances. However, infested wood, moved by humans in commerce, would spread these insects at a much faster rate than their natural spread. Also, once established at the receiving seaport or inland destinations, powderpost beetles can go undetected when they infest new material and because of their cryptic habits, populations can be large before the first evidence of their activities (emergence holes and piles of characteristic powdery frass) is apparent. Before an infestation is noticed, additional wood or trees could become infested and distributed within the continental United States or its territories and possessions. Furthermore, Australian powderpost beetles could be misdiagnosed or confused with native species.

B. Consequences of introduction

5. Economic damage potential: *High* (VC) (Applicable risk criteria, from Ch. 1: a, c, d, e)

Powderpost beetles can attack most hardwood species that are not protected by a wood surface treatment, such as varnish or wax. Their damage to wood in houses can be severe but is usually restricted to hardwood elements, such as those found in flooring, cabinetry, and furniture. Once they are in a structure, spread of powderpost beetles to other parts of the structure can be rapid, and the economic impact can be quite high. The economic losses due to damage by powderpost beetles in the United States are second only to those of subterranean termites. Control methods for infestations of powderpost beetles in structures are currently available and rely on fumigation of the entire structure with methyl bromide. Soon this fumigant will be phased out of production and use. The only available substitute, sulfuryl fluoride, is much more expensive and requires very high dosages to kill the egg stage.

6. Environmental damage potential: *Low* (MC) (Applicable risk criterion from Ch. 1: none)

Powderpost beetles would not likely cause large outbreaks nor do they affect live trees. They would breed in dead wood in live trees or in wood in use. Introduced powderpost beetles could displace some native species of wood-boring beetles.

7. Social and political considerations: *Moderate* (RC) (Applicable risk criterion from Ch. 1: c)

Powderpost beetles do not cause aesthetic damage in forests. Damage to hardwood components in structures or finished hardwood products destined for export would cause the consumer the greatest concern, adding to concerns about other powderpost beetle species worldwide. Control methods for powderpost beetles are available but can be expensive. Fumigant gases stop infestations but provide no residual protection. Furthermore, one of the fumigant gases (methyl bromide) is being phased out of use due to concerns over adverse effects to environmental quality through depletion of the ozone layer.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *High*)
Chips—*High* (Likelihood of introduction = *High*; Consequences of introduction = *High*)

As the eggs and larvae of true powderpost beetles would likely survive the chipping process and could survive transit, the pest risk potential for chips remains "*High.*"

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Reviewers' comments—"Powderpost beetles…are seldom an industry problem in Tasmania until the logs reach the sawmills where logs often will be stockpiled for periods of time. *Lyctus brunneus* survives in cambial layer tissue left on boards and beams after sawing and so is a common problem in newly constructed buildings…. Powderpost beetles are usually only a problem for air-dried boards or 'back-yard' constructions. My overall view is that there is low danger of attack if logs are debarked at landing and not stacked for long periods of time before processing. Holding under sprinklers again solves that problem. In Tasmania we have *L. brunneus* (Stephens); *L. costatus* Blackburn, and *Trogoxylon ypsilon* (Lesne), the latter attacking *Acacia dealbata*. *L. brunneus* is a very common species attacking drying hardwood timber. Debarking prevents some field attack. *L. brunneus* is usually a pest of timber in construction, attacking cambial layer. Could attack debarked hardwood logs if left on wharf for weeks and logs dry out. If held under sprinklers not a problem. The other species are not a problem from Tasmania. I very much doubt survival in woodchips for any of these species." (Bashford)

"The pest risk assessments for these two groups of insects (true powderpost beetles and false powderpost beetles) are well written and thorough. However, I question whether either powderpost beetles or false powderpost beetles could successfully complete development in chips. As discussed, chips average only 30 to 40 mm square by 10 mm thick and are not likely to be selected by adult females for oviposition. Is there any evidence that eggs or young larvae that survive the chipping process can complete their life cycle within chips? (It is hard to imagine that a beetle ranging in size up to 20 mm would be able to complete development in a 30 to 40 mm chip.) If larvae are unable to complete development in chips, then the likelihood of their introduction and establishment in the U.S. from chips would be nil. Unless there is strong evidence that powderpost beetle larvae can mature and emerge as adults equally well from eucalypt chips as from logs, I suggest the risk for entry potential (for emerging adults, not larvae) for powderpost beetles in chips be reduced to moderate or low (rather than high) for both groups of beetles. If such evidence exists, it should be cited in the assessment document. The entry potential on logs should retain a 'high' rating. You state 'If logs or chips arriving at a port are not immediately utilized or are left in a refuse pile, powderpost beetles can reinfest the parent material'; is this true for chips?" (Billings)

"You state that given favourable conditions, life cycles can be reduced from 12 to 6 to 7 months. Experience in Australia is that given a hot climate/heated surroundings in houses etc., this can be reduced to 3 to 4 months." (Collett)

"Is there evidence in the literature that they (powderpost beetles) would develop completely in chipped material?" (Seybold)

In referring to the statement in the IPRA "…infested wood, moved by humans in commerce, would spread these insects at a much faster rate than their natural spread." The reviewer states "This is why many species currently have cosmopolitan distributions." (Seybold)

"I believe that you have done an excellent job in summarizing the risk potential of these insects arriving in the U.S. in *Eucalyptus* spp. logs and chips. I have taught the biology of these beetles for over 30 years and you had some information that was new for me. I concur with all of your conclusions! As with Monterey pine logs imported from New Zealand, importing *Eucalyptus* logs and chips from Australia would be another open pathway for pests to enter North America. We already have too many powderpost beetle species introduced to the U.S.! Thank you for the opportunity to make comments on these assessments." (David Wood)

"My participation in previous pest risk assessments was based on my experience with bark and ambrosia beetles (Scolytidae & Platypodidae). Although I have collected and observed powderpost beetles in Australia, New Guinea, and South America, I do not consider myself a specialist on powderpost beetles. I have, however, seen rather considerable and extensive plantings of non-native eucalypt trees on the Pacific Coast in the USA, in Mexico, and Central and South America where those trees were almost free of insect and disease problems. The importation of unprocessed eucalypt logs and chips will almost certainly have serious impact on existing plantings on our Pacific Coast, including southern Nevada, most of Arizona, and other southern areas. Most powderpost beetles are much more difficult to detect and can remain in the wood much longer than is possible for scolytids and platypodids, hence the potential for introduction of pest species is much greater. We cannot afford to lower the barriers on eucalypt materials as was done for Oregon and Washington a couple of decades ago that resulted in the introduction of more than a dozen pest species of oaks and conifers that are now here to stay. Some are now becoming significant pests here. I am unequivocally opposed to the importation of unprocessed logs or chips of any tree species into this country. In the long run it will be far less expensive to grow them here." (Stephen Wood)

Response to comments—The concerns expressed by Seybold, David Wood, and Stephen Wood are the main reason for conducting the pest risk assessment. This IPRA does not address prevention or remediation; however, the comments made by Bashford can be used by whoever develops guidelines for prevention and remediation. Although there is doubt of survival or continued development in chips, this has yet to be proven or disproven.

There is no evidence in the literature that powderpost beetles will develop completely in chipped material. All we have is one empirical observation, so stated in the text. This would be a good research project, both in the laboratory and by sampling chips arriving in Japan.

The shorter time frame of the life cycle pointed out by Collett is indicated in the revised text.

In response to concerns expressed by Billings, lyctids could be transported in chips as (1) adult hitchhikers, (2) eggs or larvae from logs that were later chipped, and (3) as eggs or larvae that started in chips, not logs. To the team's knowledge, there is no experimental or empirical evidence of lyctids selecting chips for ovipositing, eggs or larvae surviving the chipping process (although we strongly suspect they would), oviposition in chips (we strongly suspect they would do this), or larvae completing their development in chips. It cannot be assumed that beetle larvae would be restricted to a single chip to complete its life cycle. The chip piles at the originating port and receiving port, as well as during transit, are packed together and could allow larvae to move among the chips as if they were one piece of wood. Because we have no knowledge of the potential for lyctids to successfully inhabit chips and survive transport, the team chose to err on the conservative side and maintain the pest risk potential at "high."

False Powderpost or Auger Beetles

Assessor—Michael Haverty

Scientific names of pests—*Bostrychopsis jesuita* (F.), *Mesoxylion collaris* (Erichson), *Sinoxylon anale* (Lesne), *Xylion cylindricus* Macleay, *Xylobosca bispinosa* (Macleay), *Xylodeleis obsipa* Germar, *Xylopsocus gibbicollis* (Macleay), *Xylothrips religiosus* (Boisduval), *Xylotillus lindi* (Blackburn) (Coleoptera: Bostrichidae)

Scientific names of hosts—*Eucalyptus amygdalina*, *E. cloeziana*, *E. delegatensis*, *E. dunnii*, *E. globulus*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. regnans*, *E. saligna*, *E. viminalis*, *Corymbia calophylla*, *C. citriodora*, and *C. maculata.* These species are listed because they are not resistant to bostrychid infestation due to the xylem vessel diameter. Numerous hardwood and softwood species could be susceptible to attack. Other species of interest are resistant because pores are too small to allow insertion of the female's ovipositor (Erskine 1965).

Distribution—*Bostrychopsis jesuita*: Queensland, New South Wales, Victoria, South Australia, Western Australia, and Northern Territory; *Mesoxylion collaris*: New South Wales, Northern Territory, and Tasmania; *Sinoxylon anale*: South Australia and Northern Territory; *Xylion cylindricus*: Queensland, New South Wales, Northern Territory, and Tasmania; *Xylobosca bispinosa*: Queensland, New South Wales, Western Australia, Tasmania, and Northern Territory; *Xylodeleis obsipa*: Queensland, New South Wales, Western Australia, and Northern Territory; *Xylopsocus gibbicollis*: Queensland, New South Wales, Tasmania, Western Australia, and Northern Territory; *Xylothrips religiosus*: Queensland, Western Australia, and Northern Territory; *Xylotillus lindi*: New South Wales and South Australia.

Summary of natural history and biology of the pest—Three families of beetles, Lyctidae, Bostrichidae, and Anobiidae, are often collectively referred to as powderpost beetles because their larvae reduce wood to a mass of powdery or pelleted frass (Ebeling 1975). There is no general agreement among specialists as to exactly which beetles should be classified as "powderpost beetles"or even that the term should be used (Moore 1979). However, to distinguish the Bostrichidae from the others the bostrichids are known as false powderpost beetles in the United States (Ebeling 1975). In Australia they are known as auger beetles because of the neat, drill-like holes the adults bore into wood (Peters and others 1996).

These insects make their presence known by numerous entrance and exit holes [3 to 9 mm (12 to 0.35 in.) in diameter] on the surface of wood. They attack mainly freshly felled logs and unseasoned sawn lumber (Peters and others 1996, Elliott and others 1998). Beneath the surface of the infested wood are frass-filled galleries or tunnels, usually following the grain of the wood. Unlike the platypodids, scolytids, and lymexylids, bostrichid galleries and exit holes are not discolored or pigmented. The false powderpost beetles tightly pack their galleries with a boring dust, often containing small wood fragments. The frass in bostrichid galleries is somewhat coarser than that of the lyctids and tends to stick together.

False powderpost beetles range in size from small [3 mm (0.12 in.) in length] to large [20 mm (0.79 in.) in length] with a considerable number of large species. They are usually elongate and cylindrical, and are brown, reddish brown, or black. In most bostrichid species the head is not visible from above, being hidden from view beneath a large thorax that gives the beetle a humpbacked appearance. The thorax is noticeably roughened in most species. Bostrichids and lyctids both have short antennae, but the bostrichids have three or four enlarged, sawtoothed, terminal segments, compared with two more rounded terminal segments for the lyctids. The tibiae of bostrichids have distinct spurs.

False powderpost beetles attack and infest the sapwood of both hardwoods and softwoods that have high moisture content (above 30%) and contain starch (Ebeling 1975, Peters and others 1996). However, bostrichids mainly attack hardwoods, which is their preferred wood. A few species also infest stressed living trees, weakening branches and stems and contributing to the general debilitation of these trees (Elliott and others 1998). The bostrichids differ from lyctids in that the adult beetles bore into the wood, preparing "egg tunnels" instead of ovipositing in surface cracks or pores. The adult beetles bore (auger) circular tunnels in branches and stems, sometimes making large cavities in which several beetles may live as a small colony (Brimblecombe 1956). Eggs are laid in the walls of the cavities or in branch tunnels (Elliott and others 1998). The female deposits eggs into pores leading from the tunnels (Ebeling 1975, Robinson 1990). After hatching, the larvae feed and tunnel in the sapwood, obtaining their nourishment from the starch in the wood (Peters and others 1996). Thus, bostrichid tunnels vary greatly in size and shape. Pupation takes place in a pupal cell, and the newly emerged adult bores a round exit hole to the exterior (Peters and others 1996). The life cycle varies between 3 and 12 months, depending on beetle species and time of year (Peters and others 1996).

Like the lyctids, bostrichids can continue to develop in a piece of wood for long periods. Only one Australian species, *B. jesuita*, has been recorded as being able to reinfest seasoned lumber (Elliott and others 1998). Some species attack and breed in both hardwoods and softwoods. The bostrichids are most abundant in the tropics and are not as economically important as the lyctids, especially in temperate regions.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
Logs—*High* (MC) (Applicable risk criteria, from Ch. 1: b, c, d, e, f, g, h)
Chips—*High* (MC) (Applicable risk criteria, from Ch. 1: b, c, d, e, f, g, h)

A majority of the commercial eucalypt species could supply harborage for all stages of false powderpost beetle. The likelihood of false powderpost beetles ovipositing in freshly cut logs is great. However, as the outer sapwood dries in log decks, either in the bush, at ports, or in chipping mills, the likelihood of adults finding the wood suitable for oviposition decreases. Chips average only 30 to 40 mm square by 10 mm thick (Gadgil and others 1996) and are drier than freshly cut logs. Therefore, they are not likely to be selected by adult bostrichids for tunneling or oviposition, even though they have a plethora of open pores and ample starch to support larval development. Bostrichid eggs and early instar larvae that are already in logs would likely survive the chipping process.

2. Entry potential:
Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)
Chips—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)

False powderpost beetles could survive quite well during transit. In log decks, adults could easily be concealed between the logs or within galleries below log surface. Eggs and early instar larvae could survive in the sapwood and would be nearly impossible to detect. Normal transit time from the bush to the port and transit to the United States would normally not exceed 1 month, so false powderpost beetles would still be in the larval stage of the first generation. Beetles are unlikely to complete development and emerge as adults before logs are off-loaded at the port of entry, unless the logs have been held for a long time before shipment. Characteristic emergence holes and powdery frass would not be present to aid in identification of infested logs; however, entry holes (and the wood shavings resulting from their construction) should be visible on the surface of logs. The presence of eggs or larvae would easily go undetected in shipments of chips. The greatest danger of introducing false powderpost beetles would result from logs that are shipped from plantations or ports in Australia with these species present, and then remain in storage at the import site for extended periods of time.

3. Colonization potential: *High* (MC) (Applicable risk criteria from Ch. 1: b, c, d, e)

False powderpost beetles are generally polyphagous. The presence of an acceptable host is not the critical factor, because these beetles can infest numerous tree species and occasionally wood in service. The factors limiting host acceptability are moisture content (Erskine 1965) and starch content in the sapwood (Peters and others 1996). If logs arriving at a port are not immediately utilized or are left in a refuse pile, false powderpost beetles can reinfest the parent material or disperse to find other suitable materials. The adults are strong fliers and are attracted to lights. They could easily become established in dead wood in live trees in the vicinity of ports of entry. Once established, these beetles could infest dead wood in exotic trees grown as ornamentals (Bockerhoff and Bain 2000). The greatest danger would be in warmer, subtropical areas of the United States.

4. Spread potential: *High* (MC) (Applicable risk criteria, from Ch. 1: b, c, d, e, g)

False powderpost beetles do not fly great distances. However, infested wood, moved by humans in commerce, would spread these insects at a much faster rate than their natural spread. However, once established at the receiving seaport or inland destinations, false powderpost beetles would not likely go undetected when they infest new material because their characteristic entrance holes and piles of powdery frass would be apparent. Before an infestation is noticed, additional wood or trees could be infested and distributed within the continental United States or its territories and possessions. Infested wood can, however, be fumigated or destroyed. Furthermore, Australian false powderpost beetles could be misdiagnosed or confused with native species.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (VC) (Applicable risk criteria, from Ch. 1: a, c, d)

False powderpost beetles are the least economically important of the three powderpost beetle families in the United States (Ebeling 1975, Anonymous 1986). Most false powderpost beetles do not generally attack dried hardwood lumber, especially if the wood is protected by a treatment of the surface, such as varnish or wax. There are examples, however, of false powderpost beetles that do infest finished wood products in Australia (*B. jesuita*, Elliott and others 1998) and the United States [*Scobicia declivis* (LeConte) and *Polycaon stoutii* (LeConte), Ebeling 1975]. Their damage to wood in structures would be rare and would be restricted to hardwood elements, such as flooring and paneling. Control methods for infestations of false powderpost beetles in structures are currently available and rely on fumigation of the entire structure with methyl bromide. Soon this fumigant will be phased out of production and use. The only available substitute, sulfuryl fluoride, is much more expensive and requires very high dosages to kill the egg stage.

6. Environmental damage potential: *Low* (VC) (Applicable risk criterion from Ch. 1: none)

   Introduced false powderpost beetles would not likely cause large outbreaks nor do they affect live trees. They would breed primarily in dead wood on live trees. They could displace some native species of wood-boring beetles.

7. Social and political considerations: *Low* (VC) (Applicable risk criterion from Ch. 1: none)

   False powderpost beetles do not cause aesthetic damage in forests. Damage to hardwood components in structures or finished hardwood products destined for export would be rare. Control methods for false powderpost beetles are available but can be expensive. Fumigant gases stop infestations but provide no residual protection. Furthermore, one of the fumigant gases (methyl bromide) is being phased out of product due to concerns over adverse effects to environmental quality through depletion of the ozone layer.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)
Chips—*High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)

As the eggs and larvae of false powderpost beetles would likely survive the chipping process and could survive transit, the pest risk potential for chips remains "*High.*"

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Reviewers' comments—"I very much doubt survival in woodchips for any of these species." (Bashford)

"Bostrichidae in Tasmania: *Mesoxylion* (*Xylion*) *collaris* (Erichson) is a common species in *Eucalyptus*, *Banksia* and *Acacia* species; *Xylion cylindricus* (Macleay) is an uncommon species. *Xylobosca bispinosa* (Macleay) is a common species. *Xylopsocus gibbicollis* (Macleay) has been collected in pitfall trap, but is uncommon. *Xylobosca canina* (Blackburn) in *Acacia dealbata* is uncommon." (Bashford)

"*M. collaris* attacks a wide range of eucalypts within a week of the trees being felled, debarking at landing prevents attack. Have not seen any attack in debarked logs. The other species are not a problem from Tasmania." (Bashford)

"The pest risk assessments for these two groups of insects (true powderpost beetles and false powderpost beetles) are well written and thorough. However, I question whether either powder post beetles or false powder post beetles could successfully complete development in chips. As discussed, chips average only 30 to 40 mm square by 10 mm thick and are not likely to be selected by adult females for oviposition. Is there any evidence that eggs or young larvae that survive the chipping process can complete their life cycle within chips? (It is hard to imagine that a beetle ranging in size up to 20 mm would be able to complete development in a 30 to 40 mm chip.) If larvae are unable to complete development in chips, then the likelihood of their introduction and establishment in the U.S. from chips would be nil. Unless their is strong evidence that powderpost beetle larvae can mature and emerge as adults equally well from eucalypt chips as from logs, I suggest the risk for entry potential (for emerging adults, not larvae) for powderpost beetles in chips be reduced to moderate or low (rather than high) for both groups of beetles. If such evidence exists, it should be cited in the assessment document. The entry potential on logs should retain a 'high' rating. You state 'If logs or chips arriving at a port are not immediately utilized or are left in a refuse pile, powderpost beetles can reinfest the parent material'; is this true for chips?" (Billings)

"Generally, the comments you provide are a good summary of the insect. The only minor additions I would make are that, unlike the pinhole borers (Platypodids, Scolytids, Lymexylids), there is no discolouration of the timber associated with insect activity. You mention that some species breed in both hardwood and softwoods, which is quite correct. However, it is important to state that auger beetles mainly attack hardwoods, their preferred host timber type. You state the boring dust of auger beetles is coarse, often containing small wood fragments—in my experience, the frass is fine and powdery, similar to that produced by lyctids." (Collett)

"There are many other hosts (non-eucalypt) for these beetles, but I assume these are not relevant to importing of logs and chips into the USA. Some additional distributions for false powderpost beetles are: *Xylion cylindricus*—also found in Northern Territory, *Xylobosca bispinosa*—also found in Northern Territory, Western Australia and Tasmania, *Xylodeleis obsipa*—also found in Western Australia and Northern Territory." (Phillips)

Concerning pore size, the reviewer states "Female bostrichids tunnel into wood to oviposit, so I am not sure what the significance of pore size is for these guys." (Seybold)

"Some North American species have extended life cycles (e.g., *P. stoutii*). Not sure about this with Australian species." (Seybold)

"Like the lyctids, I wonder if there is evidence for survival and development in chips." (Seybold)

Response to comments—The distribution information provided by Bashford was included. This IPRA does not address prevention or remediation; however, these comments can be used by whoever develops guidelines for prevention and remediation. Even though there is doubt of survival or continued development in chips, this has yet to be proven or disproven.

All of the suggestions by Collett have been incorporated into the natural history and biology section. Phillips is correct in that our concern is limited to the eucalypt species identified in the scope of the assessment.

Pore size is significant. Bostrichids do construct egg galleries, but they deposit their eggs into the pores. The egg galleries cut across the pores and expose them. This is documented and discussed in Ebeling (1975) on pages 175–176 and Robinson (1990) page 289. There was no mention of an extended life cycle in the literature on Australian auger beetles. There is evidence for survival and development in chips. All we have is one empirical observation that concerns lyctids. The assessor assumed that the same possibility exists for bostrichids. This would be a good research project, both in the laboratory and by sampling chips arriving in Japan.

In response to concerns expressed by Billings, Bostrichids could be transported in chips as (1) adult hitchhikers, (2) eggs or larvae from logs that were later chipped, and (3) as eggs or larvae that started in chips, not logs. To the team's knowledge there is no experimental or empirical evidence of bostrichids selecting chips for ovipositing, eggs or larvae surviving the chipping process (although we strongly suspect they would), oviposition in chips (we strongly doubt this), or larvae completing their development in chips. It should not be assumed that a beetle larva would be restricted to a single chip to complete its life cycle. The chip piles at the originating port and receiving port, as well as during transit, are packed together and could allow larvae to move among the chips as if they were one piece of wood. Because we have no knowledge of the potential for bostrichids to successfully inhabit chips and survive transport, the team chose to err on the conservative side and maintain the pest risk potential at "*High*."

Dampwood Termite

Assessor—Michael Haverty

Scientific name of pest—*Porotermes adamsoni* (Froggatt) (Isoptera: Termopsidae)

Scientific names of hosts—*P. adamsoni* infests live trees in eucalypt forests, particularly in high quality *Eucalyptus delegatensis* and *E. regnans* forests. It can also cause damage to the heartwood of *Pinus radiata* D. Don, *Araucaria cunninghamii* Aiton ex D. Don, *Ceratopetalum apetalum* D. Don, and *Nothofagus cunninghamii* (Hook.) Oerst.

Distribution—*Porotermes adamsoni* has a wide distribution in southern Australia. It is found in coastal and adjacent highland areas from southern Queensland west to South Australia and south to Tasmania (Gay and Calaby 1970, French 1986, Elliott and others 1998).

Summary of natural history and biology of the pest—All species of termites are social insects and live in colonies. Some species of the higher termites, such as *Coptotermes* or *Nasutitermes,* are found in discrete nest structures and construct mounds. *Porotermes* lives in diffuse nests, usually within one piece of wood. If a colony is somehow broken into one or more subunits, even without reproductives, these subunits are capable of continuing all of the functions of the parent colony. Generally there are five types of individuals in a colony: immatures or larvae, workers, soldiers, reproductives, and nymphs (Miller 1969). Nymphs will eventually metamorphose into adults with wings (alates) that serve to disperse and establish new colonies a significant distance from the natal colony. Colonies contain a large proportion of wingless workers whose role is the care of the immatures and reproductives, whereas the soldiers defend the colony from predators. Workers are the individuals that damage the wood. Flights of the future reproductives (alates) generally occur during summer. In *Porotermes* workers and nymphs are capable of becoming replacement (or supplementary) reproductives and assuming the reproductive role if their subunit is permanently separated from the main colony. It is primarily this capacity for establishing new colonies (by budding) from subcolonies that makes dampwood termites a threat for introduction into non-endemic sites.

Porotermes adamsoni lives mainly in hardwood forests, where it forms moderately large colonies in both dead and living trees, as well as in logs. In living trees, colonies begin in scars caused by fire or mechanical damage near the base of tree trunks but may also begin in branch stub holes up to 30 m (98.4 ft) above the ground. Infestation rarely occurs until trees have attained a diameter of 0.3 m (0.98 ft) and never occurs in undamaged living tissue of the tree. Colonies can also be founded in wood in service, particularly when it is damp through contact with soil or through poor ventilation. Colonies initiated in the upper parts of a tree usually remain small, but those that are established at the base of the tree may extend into large roots, through the trunk, and often into the main branches. Commonly the entire diameter of the tree from pith to sapwood is extensively damaged, or the central portion may be completely destroyed and replaced by tightly packed fecal matter excreted over many years. In Tasmania, Victoria, and New South Wales, *P. adamsoni* is considered a significant pest in indigenous forests, especially in older trees (Greaves and others 1965, Greaves 1959, Elliott and Bashford 1984). Trees attacked by *Porotermes* seldom show any outward sign of damage, and there is no evidence of galleries extending from one tree to another. Large colonies in fallen trees frequently contain primary queens, indicating that the reproductives may be very long-lived. Winged adults occur in colonies in the summer (December to early February in Australia). Colonizing flights take place in the early evening; the entire population of winged adults appears to leave at once. Replacement reproductives are commonly produced, especially where gallery systems are very extensive and diffuse.

Several species of dampwood termites are mentioned by Edwards and Mill (1986) as significant pests of wood in buildings, but seldom have they been exported and established in other countries. *Porotermes* has been introduced to New Zealand on at least four occasions in wood other than *Eucalyptus* logs but has not become established (Gay 1969). Similarly, the dampwood termite, *Zootermopsis angusticollis* (Hagen), from the Pacific coastal area of the United States has been introduced to numerous localities throughout the world (Gay 1969), and has now become established on the island of Maui, Hawaii (Woodrow and others 1999, Haverty and others 2000).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e, f, g, h)
   Chips—*Low* (MC) (Applicable risk criteria, from Ch. 1: c, d, f, g)

   Just about any of the commercial eucalypt species could supply harborage for dampwood termites. The likelihood of association of dampwood termites with freshly cut logs is greater in natural forests in which silvicultural practices include precommercial thinning and use of prescribed fire. *Porotermes* occurs throughout much of the range of *Eucalyptus*, *Araucaria*, *Ceratopetalum*, *Nothofagus*, or *Pinus* harvested for wood chips. However, the damage done by these termites is easily detected in logs and would result in redirecting logs to a local chip mill rather than being shipped overseas as whole logs. Even though many of the rating criteria apply, termite colonies or subcolonies would not likely survive the chipping process.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: d)

   Porotermes has been introduced numerous times into New Zealand but has not yet become established (Bain and Jenkin 1983). Viable colonies of *P. adamsoni* would likely survive the 14-day journey to port cities in the United States, although they should be detectable within the moist cavity in the log by the presence of the packed fecal material. Recently cut logs and the moist fecal material would provide conditions suitable to dampwood termites during transit. The greatest danger exists if items are shipped from plantations in Australia with these species present and remain in storage at the import site in a suitable habitat, such as Hawaii or Puerto Rico, for extended periods of time. Wood chips are highly unlikely to harbor viable groups of termites, because the chips are handled roughly when moved from the home port to the ship and from the ship to the receiving port and then again when transported to the paper mill.

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Ch. 1: b, d, e)

   P. adamsoni has not become established elsewhere (Gay 1969). *P. adamsoni* is not restricted by hosts. Even partial colonies can contain many individuals capable of differentiating into a reproductive caste. If a colony contains alates and they were to fly after arriving in the United States, incipient colonies could easily be established. Because these dampwood termites can infest numerous tree species and wood in service, the presence of an acceptable host is not the critical factor. Rather, a suitable environment, with an adequate supply of wood and appropriate temperature and moisture conditions, is the key factor. The initiation of a colony is a slow process, but wood in ground contact, moist wood in structures, and suitable host trees with scars or wounds at ports and storage facilities may provide an infestation site. The adults (alates) fly only about 100 m (328 ft) but are capable of moving up to 1 km (0.62 miles) depending on wind conditions and weather. Long-range [>10 km (>6.2 miles)] establishment of colonies from alates has a very low probability. Colonization potential for *Porotermes* would be greatest under cool, moist conditions.

4. Spread potential: *High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d, e, f, g)

   Termites spread slowly [15 to 300 m (49 to 984 ft) per year], and less than 1% of the alates eventually establish a new colony. However, an important factor concerning dampwood termites is that infested wood or plants in containers with soil, moved by humans in commerce, spreads termites at a much faster rate than their natural spread. Also, once established at the receiving seaport or inland destinations, dampwood termites are often not detected because of their cryptic habits; colonies can be large before the first evidence of their activities is apparent. By this time multiple colonies will already be established adjacent to the invading colony and additional wood or plants could become infested and distributed within the continental United States or its possessions. Furthermore, dampwood termites could be misdiagnosed or confused with endemic species.

B. Consequences of introduction

5. Economic damage potential: *High* (VC) (Applicable risk criteria, from Ch. 1: a, b, c, d, f)

   Dampwood termites will attack untreated wood and live trees. *Porotermes* would not do well in extremely cold climates but could be a problem in moist, warm climates along the western, southern, and southeastern coasts of the continental United States and subtropical and tropical locations of the United States and its protectorates and possessions. They could pose a significant hazard to the numerous eucalypt trees planted as ornamentals, for windbreaks, or for fiber. Control methods for termites are available but can be expensive and could be a risk to environmental quality through increased pesticide use.

6. Environmental damage potential: *Moderate* (MC) (Applicable risk criterion, from Ch. 1: d)

   These termites would not likely cause large outbreaks or kill an excessive number of trees. Trees at greatest risk would be street trees or native trees with a limited distribution, such as Torrey pine (*Pinus torreyana*).

7. Social and political considerations: *High* (RC) (Applicable risk criterion, from Ch. 1: a, c)

   Damage to wood in structures and to fruit or ornamental trees would cause significant concerns, adding to concerns about other exotic termite species.

C. Pest risk potential:
   Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *High*)
   Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

   Termite colonies or subcolonies would not likely survive the chipping process.

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Reviewers' comments—"Entry potential. Is the statement 'Wood chips are not likely to harbor viable groups of termites' supported by references?" (Cameron)

Response to comments—The team is not aware of any literature that documents termites in shipments of chips. The statement above was made from empirical observations of the chipping of logs at mills in Australia, the transportation of the chips from the mill to the chip pile, and subsequent transportation to the ship (see trip report). The assumption was made that the chips would be similarly handled from the ship to the port and then to the vehicles that would take them to the paper plant. The statement in question has been modified to reflect these empirical observations.

Giant Termite

Assessor—Michael Haverty

Scientific name of pest—*Mastotermes darwiniensis* Froggatt (Isoptera: Mastotermitidae)

Scientific names of hosts—*M. darwiniensis* will attack or infest just about any hardwood or softwood species, including live fruit trees.

Distribution—*Mastotermes darwiniensis* is a tropical species that is widely distributed in the Northern Territory, north Queensland, and Western Australia. The southern limit of its distribution is approximately the Tropic of Capricorn, both in coastal and inland localities (Gay and Calaby 1970, French 1986, Elliott and others 1998).

Summary of natural history and biology of the pest—All species of termites are social insects and live in colonies. Some species of the higher termites, such as *Coptotermes* or *Nasutitermes,* are found in discrete nest structures and construct mounds. *Mastotermes* lives in diffuse nests, much of them below ground. If a colony is somehow broken into one or more subunits, even without reproductives, these subunits are capable of continuing all of the functions of the parent colony. Generally there are five types of individuals in a colony: immatures or larvae, workers, soldiers, reproductives, and nymphs (Miller 1969). Nymphs will eventually metamorphose into adults with wings (alates) that serve to disperse and establish new colonies a significant distance from the natal colony. Colonies contain a large proportion of wingless workers whose role is the care of the immatures and reproductives, whereas the soldiers defend the colony from predators. Workers are the individuals that damage the wood. Flights of the future reproductives (alates) generally occur during summer. In *Mastotermes* workers and nymphs are capable of becoming replacement (or supplementary) reproductives and assuming the reproductive role if their subunit is permanently separated from the main colony. It is primarily this capacity for establishing new colonies (by budding) from subcolonies that makes the giant termite a threat for introduction into non-endemic sites.

Mastotermes is one of the most destructive Australian termites, although its total economic impact on forests and timber is less than several others because of its limited distribution. It attacks wood in service as well as growing trees, shrubs, and vegetables (Peters and others 1996). *Mastotermes* is not a mound builder, and normally it nests in or under the boles of trees or in logs or stumps (Elliott and others 1998). Under natural conditions, colonies of *M. darwiniensis* attain population levels less than 100,000 but may have colonies of more than 1,000,000 (Gay and Calaby 1970). Knowledge of the foundation of new colonies is scant. Colonies are normally headed by replacement reproductives; primary queens have only been seen once. Neither the primary nor replacement reproductives are significantly physogastric. The rarity of primary reproductives and the prevalence of relatively small colonies containing replacement queens suggest that new colonies are likely formed by budding from the parent colony (Gay and Calaby 1970).

Edwards and Mill (1986) mention several species of termites as significant pests of wood in buildings, but seldom have they been exported and established in other countries. *Mastotermes* has become established in New Guinea and has been found attacking structural timber, posts, and numerous living trees and shrubs (Gay 1969).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential: Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e, f, g, h)
   Chips—*Low* (MC) (Applicable risk criteria, from Ch. 1: c, d, f, g)

   Just about any of the commercial eucalypt species could supply harborage for colonies or subcolonies of the giant termite. The likelihood of association of these termites with freshly cut logs is greater in natural forests in which silvicultural practices include precommercial thinning and use of prescribed fire. *Mastotermes* has a limited distribution for eucalypts that are harvested for wood chips, either from native or plantation forests. However, the damage done by these termites is easily detected in logs and would result in redirecting logs to a local chip mill rather than being shipped overseas as whole logs. Even though many of the rating criteria apply, termite colonies or subcolonies would not likely survive the chipping process.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c)
   Chips—*Low* (MC) (Applicable risk criteria, from Ch. 1: d)

   Mastotermes darwiniensis has been introduced and is established in New Guinea. Viable colonies of *M. darwiniensis* would likely survive the 14-day journey to port cities in the United States, although they should be detectable within the log by the presence of an extensive gallery system. Recently cut logs would provide conditions suitable to *Mastotermes* during transit. The greatest danger exists if items are shipped from plantations in Australia with these species present and remain in storage at the import site, in a suitable habitat such as Hawaii or Puerto Rico, for extended periods of time. Wood chips are unlikely to harbor viable groups of termites, because the chips are handled roughly when moved from the home port to the ship and from the ship to the receiving port, then again when transported to the paper mill.

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e)

   Mastotermes has become established in New Guinea and is not restricted by hosts. *M. darwiniensis* can infest numerous species of live trees. Even partial colonies can contain many individuals capable of differentiating into a reproductive caste. If a colony contains alates and they were to fly after arriving in the United States, incipient colonies could easily be established. Because these dampwood termites can infest numerous tree species and wood in service, the presence of an acceptable host is not the critical factor. Rather, a suitable environment with an adequate supply of wood and appropriate temperature and moisture conditions are the key factors. The initiation of a colony is a slow process, but wood in ground contact, moist wood in structures, and suitable host trees with scars or wounds at ports and storage facilities may provide an infestation site. The adults (alates) fly only about 100 m (328 ft) but are capable of moving up to 1 km (0.62 miles), depending on wind conditions and weather. Long-range [>10 km (>6.2 miles)] establishment of colonies from alates has a very low probability. Colonization potential for *Mastotermes* would be greatest under warm, moist conditions.

4. Spread potential: *High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d, e, f, g)

   Termites spread slowly [15 to 300 m (49 to 984 ft) per year], and less than 1% of the alates eventually establish a new colony. However, an important factor concerning *Mastotermes* is that infested wood or plants in containers with soil, moved by humans in commerce, spreads termites at a much faster rate than their natural spread. Also, once established at the receiving seaport or inland destinations, *Mastotermes* might not be detected because of their cryptic habits; colonies can be large before the first evidence of their activities is apparent. By this time multiple colonies will already be established adjacent to the invading colony, and additional wood or plants could become infested and distributed within the continental United States or its possessions.

B. Consequences of introduction

5. Economic damage potential: *High* (VC) (Applicable risk criteria, from Ch. 1: a, b, c, d, f)

   The giant termite will attack untreated wood and live trees. *Mastotermes* would not fare well in extremely cold climates but could be a problem in moist, warm climates along the western, southern, and southeastern coasts of the continental United States, and subtropical and tropical locations of the United States and its protectorates and possessions. They could pose a significant hazard to the numerous eucalypt trees planted as ornamentals, for windbreaks, or for fiber. Furthermore, many of these same areas are known for fruit and nut trees. Control methods for termites are available but can be expensive and could be a risk to environmental quality through increased pesticide use.

6. Environmental damage potential: *Moderate* (MC) (Applicable risk criterion from Ch. 1: d)

   These termites would not likely cause large outbreaks or kill an excessive number of trees. Trees at greatest risk would be orchard trees, street trees, or native trees with limited distribution, such as Torrey pine (*Pinus torreyana*).

7. Social and political considerations: *High* (RC) (Applicable risk criterion from Ch. 1: a, c)

   Damage to wood in structures and to fruit or ornamental trees would cause significant concerns, adding to concerns about other exotic termite species.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *High*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

Termite colonies or subcolonies are not likely to survive the chipping process.

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Reviewers' comments—"Entry potential. Is the statement 'Wood chips are not likely to harbor viable groups of termites' supported by references?" (Cameron)

Response to comments—The team is not aware of any literature that documents termites in shipments of chips. The statement above was made from empirical observations of the chipping of logs at mills in Australia, the transportation of the chips from the mill to the chip pile, and subsequent transportation to the ship (see trip report). The assumption was made that the chips would be similarly handled from the ship to the port and then to the vehicles that would take them to the paper plant. The statement in question has been modified to reflect these empirical observations.

Drywood Termites

Assessor—Michael Haverty

Scientific names of pests—Drywood termites (Isoptera: Kalotermitidae) are represented by six genera: *Neotermes* Holmgren [specifically *N. insularis* (Walker)], *Kalotermes* Hagen [specifically *K. rufinotum* Hill and *K. banksiae* Hill], *Ceratokalotermes* Krishna [specifically *C. spoliator* (Hill)], *Glyptotermes* Froggatt (specifically *G. tuberculatus* Froggatt), *Bifiditermes* Krishna [specifically *B. condonensis* (Hill)], and *Cryptotermes* Banks [specifically *Cryptotermes primus* Hill, *C. brevis* (Walker), *C. domesticus* (Haviland), *C. dudleyi* Banks, and *C. cynocephalus* Light]

Scientific names of hosts—Just about any hardwood or softwood could be infested.

Distribution—*Neotermes insularis* is the only species of this genus in Australia. Its distribution extends from Victoria to Torres Strait and across to Darwin, Northern Territory, and it has been introduced into New Zealand, apparently in shipments of hardwood poles. However, *N. insularis* is not considered to be established in New Zealand. All reports of this species in New Zealand concern imported Australian hardwood poles, some of which have been in service for up to 20 years. No infestations have been found in locally grown (New Zealand) material (Bain and Jenkin 1983). Almost all collections of this species are from forests within 80 km (49.7 miles) of the coast (Gay and Calaby 1970, French 1986). *Kalotermes rufinotum* is distributed from Victoria to southern Queensland. *Kalotermes banksiae* occurs in Victoria, New South Wales, and South Australia, and has also been recorded from New Zealand (Gay and Calaby 1970, Bain and Jenkin 1983, French 1986). *Ceratokalotermes* is a genus that is endemic to Australia. *C. spoliator* is the only species in this genus and occurs in the coastal and adjacent highland areas from new South Wales to northern Queensland (Gay and Calaby 1970). *Glyptotermes tuberculatus* occurs in New South Wales and has been introduced to New Zealand, but is not established there (Gay and Calaby 1970, Bain and Jenkin 1983). *Bifiditermes condonensis* is the only Australian species of this genus. It is distributed in coastal areas from southern Queensland to Western Australia and has been collected from low-rainfall areas [<30 cm (<11.8 in.)/year], an unusual habitat for kalotermitids in Australia (Gay and Calaby 1970). *Cryptotermes primus* is found from northern Queensland to southern New South Wales (Gay and Calaby 1970). *Cryptotermes domesticus*, *C. dudleyi*, and *C. cynocephalus* are found in northern Queensland; *Cryptotermes domesticus* has also been reported from the Australian Capital Territory. *Cryptotermes domesticus* occurs widely throughout the Indo-Malayan Region and in numerous islands and island groups over a wide area of the Pacific, but its exact origin is not known. It has been introduced into Panama and Guam (Gay 1969). *Cryptotermes cynocephalus* is endemic to the Philippine Islands, where it attacks isolated boards in houses, and has recently been reported established in Hawaii (Woodrow and others 1999, Haverty and others 2000). *Cryptotermes brevis* is a cosmopolitan species and has been reported from Queensland and New South Wales and has become established in numerous regions throughout the world (Gay 1969, Weesner 1970, French 1986, Peters and others 1996) and is of significant economic importance in Hawaii and Florida (Bess 1970, Weesner 1970, Su and Scheffrahn 1990).

Summary of natural history and biology of the pest—Of the 2,300 species of termites known to exist in the world, only 183 are known to cause damage to structures, and of these, 83 have a significant economic impact. Drywood termites account for less than 20% of the economically important species, and the genus *Cryptotermes* contains the largest number of economically important species (Gay 1969, Edwards and Mill 1986).

Drywood termites live entirely within wood, do not need to maintain a connection with the ground or soil, and do not absolutely require free water. In fact, some species, such as *C. brevis*, do not survive under conditions of high relative humidity or water content in the wood (Collins 1969). This species produces metabolic water from wood and cannot excrete enough water to survive under high humidity. Most drywood termites are heavily protected from water loss by cuticular hydrocarbons and the cement layer on the cuticle. They adjust their water retention or excretion by absorbing water from their feces. In high humidity they excrete liquid fecal material; under dry conditions water is resorbed in the rectum and fecal material is excreted as a pellet (Collins 1969). Due to their ability to survive in wood with little moisture content, drywood termites can maintain viable colonies or portions of colonies for extended periods and would remain viable during transportation across vast stretches of land or water.

All species of drywood termites are social insects and live in colonies. They do not live in discrete nest structures. They live in a diffuse gallery system entirely within one or more pieces of wood. Individuals within this gallery system, including the reproductives, are mobile and can move within this system to areas with the most suitable environmental conditions. Generally there are five types of individuals in a colony: immatures or larvae, workers, soldiers, reproductives, and nymphs (Miller 1969). Nymphs will eventually metamorphose into adults with wings (alates) that serve to disperse and establish new colonies a significant distance [100 m (328 ft)] from the natal colony. Colonies contain a large proportion of workers and nymphs whose role is the care of the immatures, feeding and foraging, and cleaning, whereas the soldiers defend the colony from predators. The workers and younger nymphs are the individuals that damage the wood. Flights of the future reproductives (alates) can occur anytime during the year in tropical environments.

Mature colonies can contain up to several thousand individuals, but even mature colonies never reach the size of mature subterranean termite colonies (Mampe 1990, Thorne 1998). Colonies as young as 4 years old can produce alates that fly off to establish new colonies. Incipient colonies can reinfest the same piece of wood occupied by the natal colony or other suitable wood nearby. To initiate a new colony, alates need only find a gap or hole big enough for them to enter, seal off, and begin to excavate. Most drywood species in Australia establish colonies in dead wood on trees, within branch stubs, or in wounds or scars in the bark. Occasionally, the exit holes of wood-boring beetles are utilized to establish an incipient colony site. Colonies can be established low on the bole or high into the canopy of trees (Gay and Calaby 1970). Wood species is not a critical factor for pest species of drywood termites. Many drywood species utilize seasoned wood as host material (Mampe 1990, Peters and others 1996). Workers and nymphs are capable of becoming replacement (neotenic) reproductives and assuming the reproductive role if the reproductives die or a portion of the colony is permanently separated from the main colony. It is this capacity for establishing new colonies from partial colonies or subcolonies that makes drywood termites a threat for introduction into nonendemic sites.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, c, d, e, f, g, h)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Any of the commercial *Eucalyptus* species could supply harborage for drywood termites. The likelihood of association of drywood termites with freshly cut logs is greater in older trees in natural forests or in plantations in which silvicultural practices include pruning and use of prescribed fire. The damage done by these termites may not be easily detected in logs. Termite colonies or subcolonies would not survive the chipping process.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Drywood termites could survive quite well during transit and may not be detected if they are within the wood. The most likely indication of the presence of drywood termites would be piles of characteristic fecal pellets on horizontal surfaces, but these pellets are usually not discharged until colonies are well established in the wood. The greatest danger exists if items are shipped from plantations in Australia with these species present and remain in storage at the import site, in a suitable habitat such as Hawaii or Puerto Rico, for extended periods of time. Wood chips are not likely to harbor viable groups of termites.

3. Colonization potential: *High* (RC) (Applicable risk riteria from Ch. 1: a, b, c, d, e)

   Even partial colonies can contain many individuals capable of differentiating into a reproductive caste. If a colony contains alates and they were to fly after arriving in the United States, incipient colonies could easily be established. Because these drywood termites can infest numerous tree species and wood in service, the presence of an acceptable host is not the critical factor. Rather, a suitable environment with an adequate supply of wood and appropriate temperature and moisture conditions are the key factors. The initiation of a colony is a slow process, but dry wood in structures and suitable trees with scars or wounds at ports and storage facilities might provide an infestation site. The adults (alates) fly only about 100 m (328 ft) but are capable of moving up to 1 km (0.62 miles), depending on wind conditions and weather. Long-range [>10 km (>6.2 miles)] establishment of colonies from alates has a very low probability. Colonization potential is greatest at ports with warm, moist conditions similar to those in Hawaii, southern California, the Gulf Coast, and the southern Atlantic coast.

4. Spread potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e, g)

   Termites spread slowly [15 to 300 m (49 to 984 ft) per year], and less than 1% of the alates eventually establish a new colony. However, an important factor concerning drywood termites is that infested wood, moved by humans in commerce, spreads termites at a much faster rate than their natural spread. Also, once established at the receiving seaport or inland destinations, drywood termites are often not detected because of their cryptic habits; colonies can be large before the first evidence of their activities (piles of characteristic fecal pellets) is apparent. By this time multiple colonies will already be established adjacent to the invading colony and additional wood or trees could become infested and distributed within the continental United States or its territories and possessions. Furthermore, drywood termites could be misdiagnosed or confused with endemic species.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (VC) (Applicable risk criteria, from Ch. 1: a, c)

   Termites will attack untreated wood. Their damage to wooden houses can be severe if not detected at an early stage. Once they are in a structure, spread of drywood termites to other parts of the structure can be rapid. Most species of *Cryptotermes* probably would not do well in extremely cold climates but could be a problem in moist, warm climates along the western, southern, and southeastern coasts of the continental United States. Drywood termites cause a small portion of the economic losses due to wood-destroying insects in the United States. However, where they are abundant (southern Florida, southern California, and Hawaii), the cost for control and repair of their damage rivals that of subterranean termites. Potential economic losses caused by all species of *Cryptotermes* could be comparable with those currently caused by the exotic *C. brevis* and the endemic *Incisitermes minor* (Hagen). If *C. primus or C. domesticus* were to be as aggressive as *C. brevis* and *I. minor*, it could cause an additional $100 million in damage and control costs within 30 years. Control methods for termites are available but can be expensive.

6. Environmental damage potential: *Low* (MC) (Applicable risk criterion from Ch. 1: none)

   These termites would not likely cause large outbreaks or kill an excessive number of trees. Drywood termites would most likely feed on dead wood in live trees or dead wood on the ground. Control efforts could be a risk to environmental quality through increased pesticide use.

7. Social and political considerations: *Moderate* (RC) (Applicable risk criterion from Ch. 1: a)

   Drywood termites do not cause aesthetic damage in forests. They can infest live trees by attacking pruning and fire scars. This could degrade the value of timber species grown where drywood termites live. Damage to wood in use would cause the consumer the greatest concern, adding to concerns about other termite species. Control methods for termites are available but can be expensive. Spot treatments do not eliminate the problem, and fumigant gases stop the infestation but provide no residual protection.

   Any species of *Cryptotermes* becoming successfully established in the United States or in one of its protectorates or possessions would probably be as damaging as *C. brevis* or *I. minor*.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*;
Consequences of introduction = *Moderate*)
Chips—*Low* (Likelihood of introduction = *Low*;
Consequences of introduction = *Moderate*)

Termite colonies or subcolonies would not survive the chipping process.

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Reviewers' comments—"Distribution. It is probably worth noting that although *Neotermes insularis* has been 'introduced' into New Zealand (in fact it was described from there) it is not considered to be established there [Bain, J.; Jenkin, M.J., 1983: *Kalotermes banksiae*, *Glyptotermes brevicornis*, and other termites (Isoptera) in New Zealand. New Zealand Entomologist 7: 365–371.]. Apart from the original description, which was based on alates, all records of this species in NZ concern imported Australian hardwood poles (some of which have been in service up to 20 years). No infestations have been found in locally grown material." (Bain)

"Distribution. *Kalotermes banksiae* also occurs in New South Wales and South Australia [Bain & Jenkin 1983]. The species of *Kalotermes* on the Kermadec Islands (and on Lord Howe Island and Norfolk Island) has been referred to a discrete species, *Kalotermes cognatus* Gay [Gay, F.J., 1976: Isoptera of the Kermadec Islands. New Zealand Entomologist 6 (2): 149–153.]." (Bain)

"Distribution. *Glyptotermes tuberculatus*. This species is not considered to be established in New Zealand. All records of it from New Zealand have been in imported Australian hardwood material [Bain & Jenkin 1983]." (Bain)

"Entry potential, last line. Is the statement that 'Wood chips are not likely to harbor viable groups of termites' supported by references?" (Cameron)

"The IPRA for drywood termites discusses the economic costs associated with pesticide controls for this type of pest. However, under environmental damage potential, no mention is made of the possible adverse environmental effects of those same control measures. Why? This same thing happens in the IPRA for subterranean termites." (Osterbauer and Johnson)

Response to comments—The information about and reference on *N. insularis* was added. The distribution information was expanded and the reference to Kermadec Islands was dropped. The reference to *Glyptotermes tuberculatus* was kept, but a disclaimer about establishment was added. It has been introduced, but no claim of establishment was made.

The team is not aware of any literature that documents termites in shipments of chips. The statement above was made from empirical observations of the chipping of logs at mills in Australia, the transportation of the chips from the mill to the chip pile, and subsequent transportation to the ship (see trip report). The assumption was made that the chips would be similarly handled from the ship to the port and then to the vehicles that would take them to the paper plant. The statement in question has been modified to reflect these empirical observations.

The team felt that the direct environmental impact of the establishment of drywood termites would be negligible. Control efforts would be limited to structures and would involve spot treatments or fumigation of entire structures, but would have limited impact on general environmental quality.

Subterranean Termites

Assessor—Michael Haverty

Scientific names of pests—Subterranean termites (Isoptera: Rhinotermitidae and Termitidae) in the genera *Schedorhinotermes* Silvestri [specifically *Schedorhinotermes intermedius intermedius* (Brauer), *S. i. actuosus* (Hill), *S. i. breinli* (Hill), *S. i. seclusus* (Hill), and *S. reticulatus* (Froggatt)], *Heterotermes* Froggatt [specifically *Heterotermes ferox* (Froggatt), and *H. paradoxus* (Froggatt)], *Coptotermes* Wasmann [specifically *Coptotermes acinaciformis* (Froggatt), *C. frenchi* Hill, *C. lacteus* (Froggatt), and *C. raffrayi* Wasmann], *Microcerotermes* Silvestri [specifically *Microcerotermes boreus* Hill, *M. distinctus* Silvestri, *M. implicadus* Hill, *M. nervosus* Hill, and *M. turneri* (Froggatt)], and *Nasutitermes* Dudley [specifically *Nasutitermes exitiosis* (Hill)]

Scientific names of hosts—Just about any hardwood or softwood could be infested.

Distribution—*Schedorhinotermes*, *Heterotermes*, *Coptotermes, Microcerotermes*, and *Nasutitermes* are all pantropical genera. Many of the individual taxa in these genera are difficult to identify. The taxonomy of several of the subterranean genera in Australia is in desperate need of revision (Gay and Calaby 1970, Watson and others 1989, Brown and others 1994). Light (1927) suggested that several factors make species determinations in termites difficult. First, termites are practically lacking in ornamentation and have few definite differences in position or number of parts that facilitate species diagnosis. Second, termite species are extremely plastic and exhibit a wide range of variation, from region to region and among colonies within the same region. Third, the characters that prove useful are differences in range of size of parts or of the entire individual or differences in size relations (that is, in the proportions of parts). Definitive species determinations of the Australian fauna will require the use of modern diagnostic techniques, such as characterization of cuticular hydrocarbons (Brown and others 1996) or cladistics (Miller 1997). Therefore, the distributions reported in the literature for a given species may, in fact, represent a combined distribution of sibling species with either sympatric, parapatric, or allopatric distributions.

In Australia *Schedorhinotermes* is represented by two species, one of which is made of up to four subspecies. *Schedorhinotermes intermedius intermedius* occurs from New South Wales into southern Queensland. *Schedorhinotermes intermedius actuosus* occurs in all of the mainland states except Victoria. *Schedorhinotermes intermedius breinli* is present in Queensland and the Northern Territory and is abundant in arid inland districts and areas of low rainfall near the coast. *Schedorhinotermes intermedius seclusus* extends from northern New South Wales to north Queensland. *Schedorhinotermes reticulatus* is widely distributed on the mainland but appears to be absent from the Northern Territory (Gay and Calaby 1970, French 1986).

Heterotermes ferox extends from southern Queensland through southeastern and southern areas of mainland Australia across to Western Australia. All four subspecies of *H. paradoxus* are distributed mainly in northern Australia (Gay and Calaby 1970, French 1986).

Coptotermes is represented by at least six species in Australia and is widely distributed throughout the mainland. With the exception of one species, the genus is largely dependent on eucalypts for food; *Coptotermes* species are found in abundance only in eucalypt communities. *Coptotermes acinaciformis* is widely distributed throughout Australia, but is absent from alpine areas of southeastern Australia and from Tasmania. It shows a wide tolerance of climatic conditions and has been collected from localities with annual rainfall ranging from as low as 20 cm (7.9 in.) up to more than 150 cm (59.1 in.). The putative subspecies *Coptotermes acinaciformis raffrayi* occurs only in southwestern Australia. *Coptotermes frenchi* extends from north Queensland to Western Australia in eucalypt communities. *Coptotermes lacteus* is very common in eastern Australia from Victoria to southern Queensland (Gay and Calaby 1970, French 1986).

Microcerotermes species are found all over mainland Australia with the exception of the southeastern portion of the continent. *Microcerotermes boreus* is confined to the northwest of Western Australia and the Northern Territory. *Microcerotermes distinctus* is widely distributed in all mainland states, more particularly in drier inland areas. *Microcerotermes implicadus* is distributed from southern Queensland through Victoria. *Microcerotermes nervosus* is common in the northern parts of Western Australia and the Northern Territory. *Microcerotermes turneri* is restricted to coastal districts from central New South Wales to north Queensland (Gay and Calaby 1970, French 1986).

Nasutitermes, which has 19 currently described species from Australia, is one of the most successful genera in Australia, and one of the few that has penetrated the cool temperate southeastern portion of the continent. *Nasutitermes exitiosus* is the best-known species of the genus. It extends from southern Queensland around the southeastern and southern regions of the continent across to Western Australia. Over most of its range, its northern limit of distribution coincides with the boundary of eucalypt communities. *Nasutitermes exitiosus* is absent from the wetter coastal country and from the colder higher parts of the southern highlands (Gay and Calaby 1970, French 1986).

Summary of natural history and biology of the pest—Subterranean termites must maintain a connection with the ground or soil, unless a supply of water is otherwise available. When free water is available or wood is saturated with water, species in these genera can maintain viable colonies or portions of colonies for extended periods and remain alive during transportation across vast stretches of land or water. They can also establish aerial colonies in buildings. To attack wood above the ground, shelter tubes composed of wood, soil, and termite excrement are constructed to connect the colony from the soil to the source of wood they are exploiting (Mampe 1990, Thorne 1998).

All species of subterranean termites are social insects and live in colonies. Some species of *Coptotermes* are found in discrete nest structures and can construct mounds. *Heterotermes* and *Schedorhinotermes*, as well as some species of *Coptotermes*, live in diffuse nests, a dispersed aggregation of subnests. These subnest units are mobile and allow the entire colony, including the reproductives, to move to areas with the most suitable environmental conditions (Thorne 1998). Generally there are five types of individuals in a colony: immatures or larvae, workers, soldiers, reproductives, and nymphs (Miller 1969). Nymphs will eventually metamorphose into adults with wings (alates) that serve to disperse and establish new colonies a significant distance from the natal colony. Colonies contain a large proportion of wingless workers whose role is the care of the immatures, feeding and foraging, and cleaning, whereas the soldiers defend the colony from predators. The workers are the individuals that damage the wood. Flights of the future reproductives (alates) generally occur during spring, summer, or fall after rain, but can occur anytime during the year in tropical environments.

Mature colonies contain several thousands to millions of individuals (Thorne 1998). Satellite colonies of the larger colonies can also be of a size that is equivalent to an immature or young colony. Workers and nymphs are capable of becoming replacement reproductives and assuming the reproductive role if their satellite colony or subunit is permanently separated from the main colony. It is primarily this capacity for establishing new colonies (by budding) from satellite colonies or subcolonies that makes subterranean termites a threat for introduction into nonendemic sites.

Coptotermes species generally occur in tropical or subtropical areas, and numerous species are known to infest buildings. *Coptotermes formosanus* Shiraki and *C. havilandi* (Sjöstedt) have most frequently been introduced to new localities (Edwards and Mill 1986). Where these species occur in exotic locations, they cause extensive damage to buildings. *Coptotermes formosanus* was first discovered in the Hawaiian Islands in 1907 (Bess 1970) and on the mainland of the United States in 1965 (Weesner 1970) but was likely established many years before both in Hawaii and on the mainland of the United States. *Coptotermes formosanus* has recently become successfully established in La Mesa near San Diego, California (Rust and others 1998), and *C. havilandi* has recently been reported to be established in Florida (Su and Scheffrahn 1997). *Coptotermes acinaciformis* and *C. frenchi* have become established in New Zealand, likely introduced from Australia in imported logs (Bain and Jenkin 1983). *Coptotermes formosanus*, *C. havilandi*, *C. acinaciformis*, and *C. frenchi* often feed on live trees and may eventually kill them or damage the root system and cause the trees to fall in heavy winds. *Coptotermes lacteus* feeds primarily on wood on the ground or wood in contact with the ground. *Schedorhinotermes, Heterotermes, Microcerotermes,* and *N. exitiosus* also feed on wood in contact with the ground but will bridge gaps with foraging tubes to reach wood above ground. For the purposes of this assessment, all species of *Heterotermes* and *Coptotermes* should be considered potentially severe pests if arriving at U.S. ports.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (VC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e, f, g, h)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: b)

   Just about any of the commercial eucalypt species could supply harborage for subterranean termites. The likelihood of association of subterranean termites with freshly cut logs is much greater in natural forests in which silvicultural practices include precommercial thinning and use of prescribed fire. Mature trees with a hollow center are often occupied by subterranean termites. During our visit to logging operations and sawmills in New South Wales, we often saw logs with evidence of live termites inside. Throughout much of the range of *Eucalyptus* harvested for wood chips one species of subterranean termite or another can be found. However, the damage done by these termites is easily detected in logs and should result in redirecting logs to a local chip mill rather than being shipped overseas as whole logs. Termite colonies or subcolonies would not survive the chipping process or the process of moving the chips from the mill to the ship or the ship to the processing plant.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c)
   Chips—*Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Viable colonies of various subterranean termite species would likely survive the 14-day journey to port cities in the United States, although they should be detectable within the moist cavity in the log or by the presence of the packed fecal material, friable carton, or an extensive gallery system. Recently cut logs and the moist fecal material would provide conditions suitable to subterranean termites during transit. The greatest risk exists if logs are shipped from Australia with subterranean species present then remain in storage at the import site, in a suitable habitat such as Hawaii or Puerto

Rico, for extended periods of time. This is how *C. acinaciformis* and *C. frenchi* became established in New Zealand. Wood chips are not likely to harbor viable groups of termites.

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e)

   Coptotermes acinaciformis and *C. frenchi* have become established in New Zealand, and *C. formosanus*, *C. havilandi*, and *C. vastator* Light have become established in exotic locations (Gay 1969, Su and Scheffrahn 1998a). *Nasutitermes* species have been intercepted upon introduction but not yet established (Gay 1969). Not one of the subterranean termites examined in this report is restricted by host. *Coptotermes* can infest numerous species of live trees. Even partial colonies can contain many individuals capable of differentiating into a reproductive caste. If a colony contains alates and they were to fly after arriving in the United States, incipient colonies could easily be established. Because these subterranean termites can infest numerous tree species and wood in service, the presence of an acceptable host is not the critical factor. Rather, a suitable environment with an adequate supply of wood and appropriate temperature and moisture conditions are the key factors. The initiation of a colony is a slow process, but wood in ground contact, moist wood in structures, and suitable host trees with scars or wounds at ports and storage facilities may provide an infestation site. The adults (alates) fly only about 100 m (328 ft) but are capable of moving up to 1 km (0.62 miles), depending on wind conditions and weather. Long-range [>10 km (>6.2 miles)] establishment of colonies from alates has a very low probability. Colonization potential would depend on the genus; warm, moist conditions would be conducive to *Heterotermes, Coptotermes*, and *Schedorhinotermes*, and cool, moist conditions would likely favor *N. exitiosus*.

4. Spread potential: *High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d, e, f, g)

   Termites spread slowly [15 to 300 m (49 to 984 ft) per year], and less than 1% of the alates eventually establish a new colony. However, an important factor concerning subterranean termites is that infested wood (or plants in soil) moved by humans in commerce spreads termites at a much faster rate than their natural spread. Also, once established at the receiving seaport or inland destinations, subterranean termites are often not detected because of their cryptic habits; colonies can be large before the first evidence of their activities is apparent. By this time multiple colonies will already be established adjacent to the invading colony, and additional wood or plants could become infested and distributed within the continental United States or its possessions. Furthermore, exotic subterranean termites could be misdiagnosed or confused with endemic species.

B. Consequences of introduction

5. Economic damage potential: *High* (VC) (Applicable risk criteria, from Ch. 1: a, b, c, f)

   Of the 2,300 species of termites known to exist in the world, only 183 are known to cause damage to structures, and of these, 83 have a significant economic impact. Subterranean termites account for about 80% of the economically important species (Gay 1969, Su and Scheffrahn 1990), and the genus *Coptotermes* contains the largest number of economically important species (Su and Scheffrahn 1998a). Of the 183 species noted for their potential for economic damage, only 17 occur in the United States (Su and Scheffrahn 1990). Control of subterranean termites and repair of their damage in the United States results in a total economic impact of about \$6.0 billion (billion = 10^9) per year (\$1.5 to 2.0 billion for control of subterranean termites and \$4 billion for repair of damage) (Nan-Yao Su, 1999, personal communication, University of Florida, Ft. Lauderdale, Florida).

   Subterranean termites will attack untreated wood and some will attack live trees. None of these termites discussed here would do well in extremely cold climates but could be a problem in moist, warm climates along the western, southern, and southeastern coasts of the continental United States, and subtropical and tropical locations of the United States and its protectorates and possessions. They could pose a significant hazard to the numerous eucalypt trees planted as ornamentals, as windbreaks, or for fiber. Control methods for subterranean termites are available but can be expensive and could be a risk to environmental quality through increased pesticide use. The exotic *Coptotermes formosanus* Shiraki is out-of-control in New Orleans, Louisiana. In some situations it can be controlled or managed with baits, but in the French Quarter it has proven very difficult to control. Given that some of the species of *Coptotermes* in Australia occur in temperate climates, they could easily become established in the United States and perhaps confused with *C. formosanus*.

6. Environmental damage potential: *Moderate* (MC) (Applicable risk criterion from Ch. 1: d)

   These termites would not likely cause large outbreaks or kill an excessive number of trees. Trees at greatest risk would be street trees, such as the ones injured by *C. formosanus* in Honolulu and New Orleans. They could conceivably compete with native termites that degrade and decompose wood in use. In fact, where *C. formosanus* is established in Florida and New Orleans, they successfully compete with the native termite fauna.

7. Social and political considerations: *Moderate* (RC) (Applicable risk criterion from Ch. 1: a)

   These termites generally do not cause aesthetic damage in forests, although most *Coptotermes* species will consume the heartwood of live trees. However, damage to wood in use would cause significant consumer concerns, adding to concerns about other exotic termites species already established in the United States.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *High*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

Termite colonies or subcolonies would not survive the chipping process.

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Reviewers' comments—"Termites are obvious organisms of concern. Australia has a rich fauna, including *Coptotermes lacteus*, a very destructive species. While not ordinarily a problem with chips, importing raw logs is a different matter. We already have introduced species of termites in North America, we do not need others." (Lattin)

Response to comments—Given the success of *Coptotermes formosanus* in the United States and the fact that *C. formosanus* is out-of-control in New Orleans, element "f" was included, which elevates the economic consequences to "*High*", but the pest risk potential for chips remains "*Low*".

Pathogen IPRAs

Foliar Diseases

Assessor—John Kliejunas

Numerous fungi have been described on foliage of eucalypts in Australia and throughout the world (Sankaran and others 1995a). Park and others (2000) provide a review of the taxonomy and pathology of eucalypt foliar fungi. In this assessment, the name of the fungus and its hosts, the distribution, and a summary of natural history and basic biology for six foliar diseases are described. *Aulographina*, *Mycosphaerella*, *Phaeophleospora* (*Kirramyces*), *Cryptosporiopsis*, *Cylindrocladium*, and *Quambalaria* are used as examples. Foliar diseases of eucalypts are then discussed as a group for specific information relating to risk elements.

Aulographina leaf spot (target spot)

Scientific name of pest—*Aulographina eucalypti* (Cooke & Massee) v.Arx & Müller [anamorph *Thyrinula eucalypti* (Cooke & Massee) H.J. Swart] (Dothidiomycetales, Asterinaceae)

Scientific names of hosts—many *Eucalyptus* spp. (see Table 8), *Corymbia maculata*, *Angophora costata*

Distribution—Australia (Australian Capitol Territory, New South Wales, Queensland, South Australia, Tasmania, Victoria), Brazil, Chile, Great Britain, Madagascar, New Zealand, South Africa, Vietnam, and Hawaii

Summary of natural history and basic biology of the pest—*Aulographina eucalypti* is a common leaf pathogen in natural forests and plantations, causing moderate to severe premature defoliation. In addition to characteristic, roughly circular, corky leaf spots, symptoms also develop on petioles, twigs, and sometimes on fruits and bark. Pycnidia, and later elongated thyriothecia with two-celled ascospores, form on the lesions. Rain and low temperatures (15°C to 20°C) predispose trees to infection. Rain and wind-blown spores are the major factors involved in fungal dispersal. Infection occurs mainly in the spring and early summer, primarily in the lower crown (Wall and Keane 1984).

Mycosphaerella leaf spot (leaf blotch, crinkle leaf blight)

Scientific names of pests—Numerous species of *Mycosphaerella* have been described on eucalypt foliage; Crous (1998) lists 28 species in a recent monograph. In Australia, species are common in natural forests, can be destructive in nurseries, and are important in plantations (Park and Keane 1982). *Mycosphaerella nubilosa* (Cooke) Hansf. and *M. cryptica* (Cooke) Hansf. are the most common and damaging in Australian eucalypt plantations (Carnegie and others 1994). (Dothidiales, Dothidiaceae)

Scientific names of hosts—*Eucalyptus* spp. (see Table 8), *Corymbia citriodora*, *C. maculata*

Distribution—The fungal genus is worldwide wherever eucalypts are grown and is common in natural eucalypt forests as well as in plantations.

Summary of natural history and basic biology of the pest—Pathogenicity of the numerous species in the heterogeneous genus *Mycosphaerella* ranges from minor saprophytes to extremely damaging pathogens. They may cause loss of foliage or leaf spots, and reduced growth. Disease symptoms vary greatly among fungal species and hosts. Infection of leaves causes necrotic spots or patches, or crinkled and distorted foliage, and may result in premature leaf drop and reduced growth. Occurrence is most severe in areas with high summer rainfall.

Phaeophleospora leaf spot (sooty blotch)

Scientific names of pests—The name *Phaeophleospora* has recently been resurrected for *Kirramyces* (Crous and others 1997), a genus established for a group of taxa centered on the fungus *Phaeoseptoria eucalypti* Hansford (Walker and others 1992). (Coelomycetes)

Mycosphaerella suttoniae Crous & M.J. Wingf. [anamorph *Phaeophleospora epicoccoides* (Cooke & Massee) Crous, F.A. Ferreira & B. Sutton (syn. *Kirramyces epicoccoides* (Cooke & Massee) Walker, Sutton & Pascoe)];

Phaeophleospora eucalypti (Cooke & Massee) Crous, F.A. Ferreira & B. Sutton [syn. *Kirramyces eucalypti* (Cooke & Massee) J. Walker, B. Sutton & Pascoe];

Phaeophleospora lilianiae (J. Walker, B. Sutton, & Pascoe) Crous, F.A. Ferreira & B. Sutton (syn. *Kirramyces lilianiae* J. Walker, B. Sutton & Pascoe)

Scientific names of hosts—*Eucalyptus* spp. (see Table 8), *Corymbia citriodora*, *C. maculata*

Distribution—*Phaeophleospora epicoccoides* (syn. *Kirramyces epicoccoides*) is found in Australia (Australian Capitol Territory, New South Wales, Queensland, Tasmania, Victoria), Argentina, Bhutan, Brazil, Ethiopia, Hong Kong, India, Indonesia, Italy, Madagascar, Malawi, Myanmar, New Zealand, Philippines, South Africa, Taiwan, Tanzania, Zambia, and in the state of Hawaii; *P. lilianiae* (syn. *K. lilianiae*) in Australia; and *P. eucalypti* (syn. *K. eucalypti*) in Argentina, Australia, Brazil, India, Italy, New Zealand, Paraguay, Peru, Taiwan and Zaire.

Summary of natural history and basic biology of the pests—These pathogens are capable of causing severe premature defoliation, which affects host growth and vigor. *Phaeophleospora epicoccoides* caused damage to nursery seedlings (*Corymbia maculata*, *E. macarthurii*, *E. sideroxylon*) and leaf spots of *E. saligna* in the field (Walker and others 1992). *Phaeophleospora eucalypti* is less common then *P. epicoccoides* in mainland Australia but is common in plantations of *E. globulus* and *E. nitens* in Tasmania (Yuan 1999). *Phaeophleospora lilianae* is known from only two collections of *Corymbia eximia* in New South Wales (Walker and others 1992). Infection results in characteristic purple to brownish-purple amphigenous spots that are angular and marked by veins. Black, globose pycnidia are formed on both leaf surfaces. Infection gradually progresses upward in the crown. Late in the season, spots occur on younger leaves and all infected mature leaves drop. Dispersal is by airborne conidia. Warm weather and heavy dew favor infection.

Cryptosporiopsis leaf spot

Scientific name of pest—*Cryptosporiopsis eucalypti* Sankaran & Sutton (Coelomycetes)

Scientific names of hosts—Numerous species, including *E. camaldulensis*, *E. camphora*, *E. cinerea*, *E. cypellocarpa*, *E. globulus*, *E. grandis*, *E. microcorys*, *E. nicholii*, *E. nitens*, *E. nova-anglica*, *E. robusta*, *E. rostrata*, *E. tereticornis*, and *E. viminalis*

Distribution—On *Eucalyptus* spp. in Australia (Australian Capitol Territory, Queensland), Brazil, India, Japan, New Zealand, Thailand, Vietnam and Hawaii.

Summary of natural history and basic biology of the pest—The pathogen, which occurs mainly in wet, tropical areas, infects leaves and occasionally small twigs (Sankaran and others 1995b). An unidentified species of *Cryptosporiopsis* was associated with root and root collar rot of *E. nitens* in plantations in Tasmania (Yuan 1999). *Cryptosporiopsis eucalypti* and *Coniella fragariae* (Oudem.) B. Sutton were associated with defoliation of *E. camaldulensis* in north Queensland (Old and Yuan 1994). Infection can result in severe defoliation and dieback of young *Eucalyptus* shoots. Infection occurs through stomata or small mechanical wounds. Rain and wind are the major factors involved in localized dissemination of the fungus.

Cylindrocladium leaf spot and blight

Scientific names of pests, hosts, and distribution—*Cylindrocladium reteaudii* (Bugn.) Boesew. (teleomorph *Calonectria reteaudii* (Bugn.) C. Booth) [formerly *Cylindrocladium quinqueseptatum* Boedijn & Reitsma (teleomorph *Calonectria quinqueseptata* Figueiredo & Namekata)]; on *Eucalyptus* spp. Australia (Northern Territory, Queensland), Brazil, India, and Vietnam. (Moniliales, Moniliaceae; teleomorph = Hypocreales, Nectriaceae)

Cylindrocladium scoparium Morgan (teleomorph *Calonectria morganii* Crous, Alfenas & M.J. Wingfield); on *Eucalyptus* spp. in Australia, Argentina, Brazil, Costa Rica, and Florida; cosmopolitan on *Abies*, *Pinus*, and numerous genera of hardwoods (Moniliales, Moniliaceae; teleomorph = Hypocreales, Nectriaceae)

Summary of natural history and basic biology of the pest—Various species of *Cylindrocladium* (teleomorph = *Calonectria*) cause leaf spots and blight to various degrees on *Eucalyptus* spp. and *Corymbia* spp. (see Table 8) throughout the world, primarily in tropical regions (Crous 2002, Crous and Wingfield 1994). Leaf spots range from small, discrete lesions to irregular necrotic areas. Young stems can be infected and girdled, resulting in shoot blight. These species of *Cylindrocladium* occur in soil and litter as mycelia, hyphae, chlamydospores and microsclerotia. Foliage and branches are contaminated with vegetative structures and spores by splashed rain, insects and other microfauna. Frequent precipitation and temperatures ranging between 23°C and 30°C provide favorable conditions for infection.

White leaf and shoot blight

Scientific name of pest—*Quambalaria pitereka* (J. Walker & Bertus) J.A. Simpson [*Sporothrix pitereka* (J. Walker & Bertus) U. Braun & Crous] (syn. *Ramularia pitereka* J. Walker & Bertus) (Hyphomycetes)

Scientific names of hosts—*Corymbia eximia*, *C. ficifolia*, *C. maculata*

Distribution—Found along the east coast of Australia (New South Wales, Queensland). A similar fungus (*Sporotrichum destructor* Pittman *nom. nud.*) on *Corymbia calophylla* and *C. ficifolia* in Western Australia (Cass Smith 1970, Macnish 1963) is considered to be *Sporothrix pitereka* or a close relative (Walker and Bertus 1971).

Summary of natural history and basic biology of the pest—The fungus infects only immature tissue. Infection on new growth occurs in the spring and persists throughout the winter. The pathogen causes severe damage to seedlings and young growth and is associated with cankers of older trees (Bertus and Walker 1974). Infection results in distortion and twisting of young shoots in association with stem lesions, leaf spots, and blight (Walker and Bertus 1971). Repeated infection of new shoots may result in reduced height growth, stunting, and stem distortion. Distinctive necrotic lesions on leaves are brown with reddish to purple margins. The lesions can be small (1 to 2 mm diameter) spots to large irregular areas that distort the leaf. Fruiting consists of masses of white conidiophores that push up and rupture the cuticle, forming white pustules that give a shining white appearance to infected leaves and shoots. A species and provenance trial found all *Corymbia*, but no *Eucalyptus*, species infected by *S. pitereka* (Simpson and others 1997).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential: Logs—*Moderate* (RC) (Applicable risk criteria, from Chapter 1: b, d, e, g)

Chips—*Low* (RC) (Applicable risk criteria, from Chapter 1: b, d, g)

Although most of these fungi are restricted to leaf tissue, some do occur in young shoots and twigs. These leaf fungi are more common in natural forests than in mature plantations, but they are not uncommon in younger plantations in some regions of Australia and are considered serious diseases of these plantations. When present, they may survive for extended time periods. Although some leaf fungi have a wide host range, others are restricted to a few host species. Even though three risk criteria would apply to chips as the commodity, thus making the risk for chips "*Moderate*," the likelihood of propagules of these foliar pathogens being associated with chips is assessed as "*Low.*" The normal chipping process removes most of the young shoots and twigs before chipping. Much of the bark, the crevices of which could contain pieces of infected leaf tissue, is also removed before chipping.

2. Entry potential:
Logs—*High* (RC) (Applicable risk criteria, from Chapter 1: b, d)
Chips—*Low* (VU) (Applicable risk criteria, from Chapter 1: d)

These leaf fungi could survive transit to the United States in infected foliage remaining on any shoots transported with logs, or in leaves lodged in bark crevices. Chipping would reduce chances of survival of these pathogens in the host during transportation. Because some of these fungi survive in soil, propagules may also be transported in any soil adhering to the logs. Because the spores of these leaf pathogens are microscopic and would be undetectable, risk criterion "d" would apply. However the likelihood of propagules of these leaf fungi being both associated with chips and surviving transport is assessed as "*Low.*"

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Chapter 1: a, b, e)

These fungi have spores that are both waterborne and windborne and could be carried for great distances. Colonization would depend on the presence of suitable hosts growing near ports of entry. Favorable environmental conditions, including moisture and temperature, would need to be present for infection and colonization to occur.

4. Spread potential: *Moderate* (RC) (Applicable risk criteria, from Chapter 1: a, b, c)

Most leaf pathogens sporulate prolifically and are easily dispersed by wind or water. However, subsequent colonization would depend on favorable environmental conditions and the presence of susceptible hosts.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RC) (Applicable risk criteria, from Chapter 1: a, c)

Some species of *Cylindrocladium* and *Mycosphaerella* are present in the United States. Some species in other areas of the world have been damaging in young plantations. Infection of eucalypts used in the foliage industry may result in a decrease in value of the affected host, and increased costs due to use of pesticides to control undesirable leaf spotting.

6. Environmental damage potential: *Moderate* (RC) (Applicable risk criteria, from Chapter 1: e)

Establishment of these leaf pathogens would have little direct effect on biodiversity or on the ecosystem as a whole. However, increased use of pesticides in the foliar industry may have the potential to adversely affect the environment.

7. Social and political considerations: *Low* (MC) (Applicable risk criteria, from Chapter 1: none)

Perceived damage potential following successful establishment of the eucalypt leaf diseases in new locations as a result of log importation would be low. Because numerous leaf fungi are already present on eucalypts in the United States, social and political impact would be minimal.

C. Pest risk potential:
Logs—*Moderate* (Likelihood of introduction = *Moderate*; Consequences of introduction = *Moderate*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)

The pest risk potential was reduced from "*Moderate*" with logs to "*Low*" with chips. The removal of bark during the chipping process reduces the likelihood of propagules of these leaf fungi being associated with chips and surviving transport with chips.

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Reviewers' comments—"*Cylindrocladium quinqueseptatum* teleomorph association has been challenged (Kang and others 2001: Can. J. Bot. 79: 1241–1247)." (Margaret Dick)

“*Sporothrix pitereka* has been changed to *Quambalaria pitereka* (J.A. Simpson, 2000. *Quambalaria*, a new genus of eucalypt pathogens. Australasian Mycologist. 19: 57–62).” (Margaret Dick)

“We have recently published a paper in Canadian Journal of Botany 79: 1241–1247 with Pedro Crous that resurrects an older name for *Cylindrocladium quinqueseptatum*, but more importantly, based on phylogeny derived from DNA sequences, suggest the *Cylindrocladium quinqueseptatum* is not the anamorph of *Calonectria quinqueseptata* (based on the type cultures of these species). So we now have *Cylindrocladium reteaudii* and *Calonectria reteaudii* as the names for *C. quinqueseptatum* and its anamorph.” (Dudzinski)

“*Cryptosporiopsis eucalypti* also in New Zealand. Gadil, P.D.; Dick, M. 1999. Fungi Silvicolae Novazelandiae: 2. New Zealand Journal of Forest Science 29: 440–458.” (Dudzinski)

“Pest with host-commodity at origin potential. Statement that these fungi are rarely present in mature plantations but are more common in native forests is misleading. This ignores the situation in younger plantations in Australia where *Mycosphaerella* spp., *Sporothrix pitereka* and *Cylindrocladium quinqueseptatum* are not uncommon in some regions and are considered serious diseases in some of the plantations.” (Dudzinski)

“Foliar pathogen assessments seem to be good. The ability of the fungi to infect woody tissue makes them something to be aware of and some type of sampling, monitoring would be justified.” (Jacobi)

“Individual IPRAs. In the foliar diseases and gumleaf skeletonizer moth IPRAs, the assessors provide a third risk rating (assessor’s judgment) for the risk elements pest-with-host-at-origin-potential and entry-potential. A criterion should be assigned to a risk element if supported by current data. If there are no data to support the criterion, it should not be assigned. Providing a third risk rating instead only confuses the reader.” (Osterbauer and Johnson)

“Likelihood of introduction: Infection by fungal leaf pathogens is concentrated in the younger age classes. It is very rare to find leaf infection within the crown of regrowth trees (ca 30 years-old +) and older plantations. This would not alter the risk rating.” (Wardlaw)

“Entry potential: The combined risk of low likelihood of infected leaves or shoots in the crowns of older trees (at harvesting age) and low likelihood of bark crevices in debarked logs would make a b rating marginal for eucalypt logs (this could downgrade the overall risk rating to moderate for logs).” (Wardlaw)

“Pest risk potential: Would not change despite the above comments.” (Wardlaw)

Response to comments—The recent taxonomic changes pointed out by Margaret Dick and Dudzinski, and the addition of New Zealand to the distribution of *Cryptosporiopsis eucalypti*, were made. The statements concerning the prevalence of foliar fungi in plantations versus natural forests were clarified to reflect Dudzinski’s concerns. Although these fungi are relatively uncommon in plantations older than 30 years as stated by Wardlaw, they do occur and can cause problems in younger plantations.

The team agreed with the comment about a third risk rating, the “assessor’s judgment,” and eliminated this from the rating. Instead, the assessor explained why a rating that was not entirely consistent with the rating criteria was assigned.

Botryosphaeria Canker

Assessor—Gregg DeNitto

Scientific name of pest—*Botryosphaeria ribis* (Tode.:Fr.) Grossenb. & Dugger (anamorph = *Fusicoccum* sp. ?) (Dothidiales, Botryosphaeriaceae)

Scientific names of hosts—Table 9 lists eucalypt hosts by geographic location. In addition to *Eucalyptus* spp. and *Corymbia calophylla*, *B. ribis* has been identified on a wide range of woody plants, including forest and agricultural trees (including *Acer*, *Betula*, *Carya*, *Citrus*, *Picea*, *Malus*, *Prunus*, *Pinus*, *Quercus*, *Salix*).

Distribution—Reported on eucalypts in Australian Capital Territory, Tasmania, Western Australia, and in Florida; on numerous other hosts in most states of Australia and the United States (Farr and others 1989).

Summary of natural history and basic biology of the pest—*Botryosphaeria ribis* causes a stem canker and may also cause a twig canker and dieback of woody plants (Smith and others 1994). Economically important diseases that it causes include bot rot of apple and peach gummosis. *Botryosphaeria ribis* tends to be associated with weakened or stressed hosts and is considered an opportunist. It infects both bark and sapwood through fresh wounds and natural openings. *Botryosphaeria* cankers in eucalypts usually are swollen with bark cracks and exudation of black kino. Canker development by *Botryosphaeria* may take many months from the time of infection, suggesting an endophytic relationship (Smith and others 1996, Bettucci and Alonso 1997). Dispersal of conidia of the anamorph of *B. ribis* (unknown but believed to be a species of *Fusicoccum*) is by rainsplash. Ascospores are dispersed by wind and water. Conidia probably initiate most infections.

The botryosphaeriaceous fungi are difficult to separate into species because of the difficulty of distinguishing morphological characteristics, the absence of the teleomorph often on natural substrates, and the inconsistent association with an anamorph. *Botryosphaeria dothidea* and *B. ribis* have been considered by some to be the same species. Jacobs and Rehner (1998) examined ITS sequences between the putative species and found incongruencies between the data and traditional taxonomic characters. They considered them subspecific variants of *B. dothidea* sensu lato until more data supporting separation became available. Recent genetic work within *Botryosphaeria* using ITS and rDNA sequencing have supported the separation of *B. ribis* from *B. dothidea* (Zhou and Stanosz 2001). Smith and Stanosz (2001) examined RAPD markers and nuclear rDNA ITS sequencing of isolates identified as *B. ribis* and *B. dothidea.* They were able to separate two distinct groups based on these analyses and compared morphological characteristics of the groups that separated. The anamorphs of *B. dothidea* and *B. ribis*, *Fusicoccum aesculi* and an unnamed species, respectively, have also been debated with uncertainty about the relationships without further studies (Morgan–Jones and White 1987, Rayachhetry and others 1996). Smith and Stanosz (2001) found significant differences in conidium shape between *F. aesculi* (anamorph of *B. dothidea*) and anamorphs in the other two groups identified, including *B. ribis*. This morphological distinction plus the genetic separation led them to separate *B. ribis* and *B. dothidea* as two distinct species. Because of the morphological similarities between the two species, reliance on collector's identifications must be done with care and one must be cautious in accepting the identification based on morphology alone. Reported hosts and localities must be viewed with question.

Table 9—Geographical distribution and species of major eucalypt hosts of *Botryosphaeria ribis*

Location	Host(s)	Reference
Argentina	*Eucalyptus* spp.	Gibson 1975
Australia	*E. accedens*, *E. blakelyi*, *E. caesia*, *E. diversicolor*, *E. globulus*, *E. leucoxylon*, *E. marginata*, *E. megacarpa*, *E. nitens*, *E. radiata*, *E. saligna*, *E. wandoo*; *Corymbia calophylla*	Davison and Tay 1983, Fraser and Davison 1985, Old and others 1990, Shivas 1989
Brazil	*E. grandis*, *E. urophylla*	Keane and others 2000
India	*E. globulus*	Sankaran and others 1995
New Zealand	*E. botryoides*, *E. cypellocarpa*, *E. delegatensis*, *E. regnans*, *E. saligna*	Keane and others 2000
Solomon Islands	*E. grandis*, *E. urophylla*	Keane and others 2000
South Africa	*E. andrewsii*, *E. camaldulensis*, *E. cladocalyx*, *E. coriacea*, *E. dalrympleana*, *E. elata*, *E. fastigata*, *E. gigantea*, *E. globoidea*, *E. globulus*, *E. grandis*, *E. hemiphloia*, *E. macarthurii*, *E. maidenii*, *E. muelleriana*, *E. obliqua*, *E. oreades*, *E. pilularis*, *E. quadrangulata*, *E. regnans*, *E. resinifera*, *E. saligna*, *E. viminalis*	Farr 1989, Keane and others 2000, Smith and others 1994
United States	*E. camaldulensis*, *E. grandis*	Barnard and others 1987, Webb 1983
Zimbabwe	*E. grandis*	Keane and others 2000

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d, e, g, h)
Chips—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d, e, g, h)

Botryosphaeria ribis has been reported in western and eastern states of Australia and therefore is likely to occur in at least some of the intermediate states. It is generally considered to be worldwide in distribution on a wide range of woody hosts and is likely present in most Australian states, although not necessarily on *Eucalyptus*. Infections can occur on both branches and main stems. Chipping would not affect the likelihood of *Botryosphaeria* being present on product intended for export.

2. Entry potential:
Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)
Chips—*Moderate* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)

As with most canker fungi, this organism can likely survive on host material as long as the material is kept under conditions that are not harmful to the organism, notably high temperatures or moisture conditions that are not favorable. It is likely *B. ribis* can survive transport either on logs or chips. The cankers that are produced could be small and virtually invisible on logs. Following transport in a container or hold of a ship, it is probable that fructifications would have developed and would be ready for spore dispersal. There would not be anything readily detectable in chips. Its potential as an endophyte suggests its ability to be present in host material without symptom expression. Removal of bark prior to chipping would reduce the number of reproductive structures and potential for entry. The rating for chips was reduced to "*Moderate*" because of the fewer number of reproductive structures expected to be produced on chips compared with logs due to the lack of bark.

3. Colonization potential: *High* (RC) (Applicable risk criteria, from Ch. 1: b, c, e)

The colonization potential for *B. ribis* is "*High*" because of its wide host range, range of suitable environments it could encounter upon entry, and potential for new hosts. It has been noted on new hosts several times. There is a report of *B. dothidea* on Bradford pear (*Pyrus calleryana* Decne.) in Alabama, a previously unknown host (Mullen and Hagan 1985). A significant disease of pistachio (*Pistachia vera* L.) was identified in 1984 in northern California, also caused by *B. dothidea* (Rice and others 1985, Michailides 1991). Although Michailides (1991) attributed the disease to *B. dothidea*, he stated that the pycnidial stage identified on pistachio fit the description of *B. ribis*. This suggests the continuing difficulty of the taxonomy of these two species. Both of these new hosts were likely a result of the introduction of the host to a new area where *Botryosphaeria* was already present, but it does indicate that unknown hosts may still be present. Following transport in a container or hold of a ship, it is probable that fructifications would have developed and would be ready for spore dispersal when material is moved for processing.

4. Spread potential: *High* (VC) (Applicable risk criteria, from Ch. 1: a, c, d, e, f, g)

Most canker fungi that are aerially dispersed have a great capability for long-distance spread over short periods of time. Limiting factors include availability of suitable hosts and adequate environmental conditions. The broad host range of *Botryosphaeria* would minimally limit its spread. Survival of these fungi in harvested material could allow for increased spread through human-assisted transport to areas with hosts and suitable climate.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: a, c, f)

Botryosphaeria ribis is present in the United States. It tends to affect all tree sizes, depending on the particular host. Considerable damage occurs from *B. ribis* on apple (*Malus pumila*). Additional economic damage is dependent on the introduction of new strains or genetic variants that may be more pathogenic or have new hosts in the United States. *Botryosphaeria* spp. normally cause symptoms in plants that are under some type of environmental stress. In agricultural situations, they usually cause adverse impacts only where the crop is not well managed or maintained.

6. Environmental damage potential: *Low* (RC) (Applicable risk criteria, from Ch. 1: none)

Because of the lack of information on pathogenicity of genetic variants, the environmental damage is unknown. Most known hosts of *B. ribis* are only seriously affected when they have been weakened by other factors. Exposure to new hosts could result in significant levels of damage in the United States. The introduction of new strains could increase the level of damage to existing hosts. Research into the differences in the strains and species and their hosts must be completed before firm conclusions regarding the actual impact can be stated.

7. Social and political considerations: *Low* (RU) (Applicable risk criteria, from Ch. 1: none)

   Based on the presence of *Botryosphaeria* in many areas of the United States, further introductions may not cause major impacts. Therefore, social and political impacts would be minimal. However, if new, more virulent strains are introduced that significantly affect United States resources, especially ornamental and high value plantings, then social and political considerations could increase to at least a moderate rating.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)
Chips—*Moderate* (Likelihood of introduction = *Moderate*; Consequences of introduction = *Moderate*)

The pest risk potential was lowered from "*High*" with logs to "*Moderate*" with chips. It is expected that lower numbers of fruiting structures and spores would be present on chips because of the lack of bark. Although reproductive structures may still be present with chip transport, the expected reduced number would lower the likelihood of entry of the organism into the United States.

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Reviewers' comments—"Entry potential. Chip piles heat up and are colonized by competing microorganisms. What is excessive heating and drying? Are there references to support the statements 'As with most canker fungi, these organisms can readily survive in a reproductive state on host material as long as there is not excessive heating or drying. It is likely they can survive transport either on logs or chips.'? Additional research may be needed." (Cameron)

"The assumption that canker fungi are limited to branches may be in error. Some may well be in the main stem causing little damage or symptoms but still capable of surviving a lengthy trip and establishing themselves in a new land." (Cobb)

"With the recent papers by Zhou and Stanosz, and Smith and Stanosz, I am at a loss as to the best way to handle this section. Based on these papers, I don't believe that it is correct to attribute all the published papers of *Botryosphaeria* on eucalypts to *B. ribis*, especially since many people, including myself, have considered the two species as synonyms, usually, but not always, with *B. dothidea* as the correct name. I certainly agree with the last few sentences under the biology section. You might want to consider using both *Botryosphaeria* species as the cause of Botryosphaeria canker on eucalypts, and explain that because of the reasons already set forth, previous identifications of this group of fungi on eucalypts must be considered suspect. It's probably a moot point, since both fungi undoubtedly have similar biologies." (Hodges)

"Cankers assessment does acknowledge that chips can harbor pathogens. This is good. I found these assessments well thought out and well written." (Jacobi)

"Table 9: *E. calophylla* should be *C. calophylla*." (Robinson)

"NB. Has been recorded on *E. nitens* in Tasmania." (Wardlaw)

"*Likelihood of introduction*: Have only recorded *B. ribis* associated with top dead in young drought stress *E. nitens* plantations in Tasmania. No evidence of this disease in older trees targeted for harvesting. Assigning the 'f' criteria is dubious. However, the overall risk rating would not change." (Wardlaw)

Response to comments—Excessive heating and drying is that which is harmful to the organism of concern. This was changed in the IPRA to reflect nonfavorable environmental conditions rather than excessive. Published literature on fungal survival in wood chips and logs is minimal, but surveys of *Pinus radiata* chips from New Zealand and Chile indicate that fungi can survive in chips under conditions of long-distance transport (H. Burdsall, 2002, personal communication). The fungi that were recovered from this monitoring were not pathogens, however. Kiln drying is known to kill resident fungi when appropriate temperatures and humidities are applied. These conditions are not experienced throughout ship's holds, although parts of shipments may attain these conditions. The text was changed to more accurately reflect that the fungus likely could survive transport, but not necessarily with reproductive structures present. Additional research is needed in the survival of pest organisms on woody materials, but that is beyond the scope of this PRA.

The IPRA references that *B. ribis* causes a stem canker, as well as twig and branch cankers. Entry potential assessment includes the possibility that *B. ribis* could be introduced on logs and that the size and visibility of cankers may preclude them from being observed.

The reason for including *B. ribis* as a potential organism of concern and doing an IPRA is the uncertainty about the genetics of the species and genus. The fact that there is continuing disagreement, as noted by Dr. Hodges, as researchers more closely evaluate the taxa and use newer technologies may be justification in itself for the IPRA. One point of discussion on the taxonomy of the *Botryosphaeria* in Australia was to indicate that there may or may not be more than one taxa in Australia that may or may not be similar to the United States taxa.

Table 9 has been updated to reflect the current eucalypt taxonomy and the addition of other eucalypt hosts.

The Rating criterion for Element 1 was corrected from 'f' to 'h' because of a typographical error. Although the occurrence of *B. ribis* in Tasmania has been noted only as topkill of stressed trees, it is possible that fungal inoculum could be present on logs and chips and that this type of material could be harvested.

Cryphonectria eucalypti Canker

Assessor—Gregg DeNitto

Scientific name of pest—*Cryphonectria eucalypti* M. Venter & M.J. Wingfield (Diaporthales, Valsaceae)

Until recently, the causal organism of this disease in Australia and South Africa has been referred to as *Endothia gyrosa* (Schwein.:Fr.) Fr., the same organism that causes pin oak blight in North America. Recent studies of isolates from North America, South Africa, and Australia using DNA sequencing, RFLPs, and colony morphology indicate that the fungus on *Eucalyptus* is a different species from *E. gyrosa* that causes pin oak blight in North America (Venter and others 2001). A new species, *Cryphonectria eucalypti*, has been described (Venter and others 2002).

Scientific names of hosts—Table 10 lists eucalypt hosts by geographic location. It is assumed that eucalypt hosts of *E. gyrosa* reported in Australia and South Africa are hosts of *C. eucalypti.* Reported eucalypt hosts of *E. gyrosa* in other parts of the world have not been analyzed as to actual species, but they are reported here as being possible *C. eucalypti* because of the host relationship. Further study is needed to determine the actual species in other parts of the world.

Distribution—*Endothia gyrosa* has been reported on eucalypts in Australian Capital Territory, New South Wales, Tasmania, Victoria, and Western Australia, and in Brazil, Portugal, and South Africa. It is assumed these are all *C. eucalypti*, although isolates from Brazil and Portugal have not been examined to determine if they are the same organism. Only an anamorphic stage, *Endothiella gyrosa*, has been observed in Western Australia.

Summary of natural history and basic biology of the pest—The causal organism of this disease on eucalypts has been attributed to *E. gyrosa*, also the cause of pin oak blight in the United States. As stated above, this has now been proposed to be a new species, *Cryphonectria eucalypti. Endothiella gyrosa* was identified as the anamorph of *Endothia gyrosa*. An anamorph of *C. eucalypti* has not been described. Only the anamorph has been found in Western Australia.

This fungus causes an annual and perennial canker on stems and branches of *Eucalyptus.* It kills the bark, cambium, and sapwood. It is usually considered a nonaggressive pathogen of healthy trees in Australia, but it has reached damaging levels in some situations (Wardlaw 1999). Infections are initiated through bark cracks and wounds by either ascospores or conidia. Wardlaw (1999) found an association of infection with mechanical wounds but not with pruning or dead branches of *E. nitens*. He thought a possible infection court was longitudinal cracks that developed in the new bark of rough-barked trees.

Ascospores of *C. eucalypti* are airborne. Insects are implicated in the transmission of conidia of *C. parasitica*, a related species (Sinclair and others 1987) and may be involved in transmission of this disease on *Eucalyptus*. Both pycnidia and perithecia are present throughout the growing season and disperse spores when conditions are proper. *Cryphonectria eucalypti* appears to tolerate relatively wide environmental conditions (Van der Westhuizen and others 1993). Old and others (1986) found variation among isolates of *Endothiella* in seedling pathogenicity, length of kino veins, and recovery of the fungus from inoculated trees.

Table 10—Geographical distribution and species of major eucalypt hosts of *Cryphonectria eucalypti*

Location	Host(s)	Reference
Australia (ACT)	*E. blakelyi*, *E. pauciflora*, *E. rossii*, *E. viminalis*	Davison and Coates 1991, Old and others 1986
Australia (NSW)	*Corymbia maculata*, *E. delegatensis*, *E. saligna*	Davison and Coates 1991, Old and others 1986
Australia (TAS)	*E. amygdalina*, *E. delegatensis*, *E. globulus*, *E. nitens*, *E. nitida*, *E. obliqua*, *E. pulchella*, *E. regnans*, *E. tenuiramis*, *E. viminalis*	Old and others 1986, Yuan and Mohammed 1997
Australia (VIC)	*E. viminalis*	Old and others 1986
Australia (WA)	*Corymbia calophylla*, *E. marginata*	Davison and Coates 1991
Brazil[a]	*Eucalyptus* sp.	Farr 1989
Portugal[a]	*E. diversicolor*	Spaulding 1961
South Africa	*E. grandis*, *E. nitens*, *E. urophylla*, *E. grandis* x *camaldulensis*, *E. grandis* x *urophylla*	Van der Westhuizen and others 1993

[a]Not determined to be *C. eucalypti*, but included to show worldwide distribution of possible *C. eucalypti*, based on reports of *E. gyrosa* on eucalypts.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
Logs—*High* (RC) (Applicable rating criteria, from Ch. 1: b, c, d, e, h)
Chips—*High* (RC) (Applicable rating criteria, from Ch. 1: b, c, d, e, h)

Cryphonectria eucalypti has been identified in native stands and plantations of *Eucalyptus* in most of the potential export states of Australia. Surveys in plantations and natural stands in Tasmania identified *C. eucalypti* 50 times from more than 60 locations, and it was the most common fungus found. It appeared to be ubiquitous throughout Tasmania on *Eucalyptus* (Yuan and Mohammed 1997). Surveys of native forests, woodlands, and plantations in southeastern Australia, including Australian Capital Territory, New South Wales, Victoria, and Tasmania, found *C. eucalypti* in 33 locations. Of 177 trees sampled, *C. eucalypti* was recovered 34 times (Old and others 1986). Chipping would not affect the likelihood of *Cryphonectria* being present since the fungus occupies the sapwood.

2. Entry potential:
Logs—*High* (RC) (Applicable rating criteria, from Ch. 1: b, c, d)
Chips—*High* (RC) (Applicable rating criteria, from Ch. 1: b, c, d)

Cryphonectria eucalypti produces small annual cankers to larger perennial cankers on stems and branches of *Eucalyptus*. Many of these cankers, especially annual, are barely discernible and would be unlikely to be detected through routine quarantine inspections. *Cryphonectria eucalypti* survived up to 12 months after inoculation in wounded, living *E.* (*Corymbia*) *maculata* (Old and others 1986). Seedlings inoculated with *C. eucalypti* developed cankers that were open (not callused over) more than 2 months after inoculation, and none had callused over after 7 months, indicating continued survival in tissue (Yuan and Mohammed 1999). Both perithecia and pycnidia have been found in eastern Australia, sometimes in the same canker (Yuan and Mohammed 1999). Fruiting bodies of *C. eucalypti* were observed 2 months after inoculation of seedlings (Yuan and Mohammed 1999). As with most canker fungi, these organisms appear to readily survive and develop reproductive structures on host material as long as there is not excessive heating or drying. Removal of bark prior to chipping would reduce the number of reproductive structures and potential for colonization. Chipping would reduce the likelihood of the development of reproductive structures, but pycnidia might develop on peeled logs and chips, as happens with *C. parasitica* (Boyce 1961). It is likely they can survive transport either on logs or chips. The pathogen was isolated from discolored wood for at least 2 years after wounding of *E. sieberi* and *E. globoidea* (Keane and others 2000).

3. Colonization potential: *High* (RC) (Applicable rating criteria, from Ch. 1: a, b, e)

Two life stages of *C. eucalypti* have been observed associated with cankers on *Eucalyptus* from eastern Australia (Yuan and Mohammed 1999). It has also been identified as being associated with *Eucalyptus* in South Africa likely as an introduction since a host native to South Africa has not been identified. Inoculations done at different times of the year have been successful (Yuan and Mohammed 2000), indicating that season of infection may not be a critical factor. *Cryphonectria eucalypti* has a number of *Eucalyptus* hosts, but it is unknown how many other hosts this new species from Australia may have. The broad geographic distribution and host range of eucalypts in Australia and the limited pathogenicity of *C. eucalypti* suggest it is native to the country and hosts.

4. Spread potential: *High* (MC) (Applicable risk criteria, from Ch. 1: a, b, c, e, f)

Most canker fungi that are air dispersed have a great capability for spreading long distances over short periods of time. Limiting factors include availability of suitable hosts and adequate environmental conditions.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RU) (Applicable risk criteria, from Ch. 1: a, f)

Cryphonectria eucalypti is not a major damaging agent to eucalypts in Australia or South Africa. It has caused significant damage in one area, however, in Tasmania (Wardlaw 1999). The reason for this level of damage has not been fully explained (Yuan and Mohammed 2000). It has also caused significant damage to seedlings of *E. globulus* in Western Australia (Yuan and Mohammed 1998). It is closely related to two other *Cryphonectria* species: *C. cubensis* and *C. parasitica*. *Cryphonectria cubensis* sometimes limits the commercial cultivation of susceptible *Eucalyptus* spp. in tropical areas. *Cryphonectria parasitica*, the chestnut blight fungus, has caused extensive mortality of American chestnut (*Castanea sativa*) in the eastern United States. *Cryphonectria parasitica* was not known as a major damaging agent in its Asian homeland. The reaction of *C. eucalypti* to new hosts and the potential for damage cannot be readily predicted.

6. Environmental damage potential: *Low* (VU) (Applicable risk criteria, from Ch. 1: none)

The potential environmental damage if the canker pathogen became established in the United States is unknown. If its host range is limited to eucalypts, then the damage would be minimal, even if it is more virulent than in Australia. However, if unknown hosts exist in the United States, it is possible that it could cause considerable damage, as happened with the closely related *C. parasitica* that eliminated American chestnut as a functional component of eastern hardwood ecosystems.

7. Social and political considerations: *Low* (VU)
(Applicable risk criteria, from Ch. 1: none)

As stated for environmental damage, the social and political considerations are dependent on the hosts that may be present in the United States. If they are limited to eucalypts, then the considerations would be low. If, however, other hosts are discovered, then social and political impacts could be sizable.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)
Chips—*High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)

Chipping eucalypt logs would not have a significant effect on the survival, transport, and colonization of *C. eucalypti* to the United States.

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Reviewers' comments—"When eucalypt pathologists worldwide talk of Cryphonectria canker, they are generally referring to canker associated with *Cryphonectria cubensis*, which is considered to be a serious disease. Your analysis possibly has insufficient coverage of *C. cubensis*. Although it was generally thought to be absent from Australia the work of Davison E.M. and Coates D.J. (1991) *Australasian Plant Pathology* 20: 157–160 indicated that isolates from a small number of *E. marginata* roots in WA were identical to *C. cubensis* in isozyme analysis. These records, which have also been authenticated outside Australia, are curious because the fungus has not been recorded elsewhere in Australia and there is no suggestion that the WA incidences represent an introduced organism. The fungus is still considered to be a quarantine organism in Australia regardless of these records." (Dudzinski)

"Old K.M. & Kobayashi (1988) Australian Journal of Botany 36: 599–603 showed that *C. parasitica* occurred on eucalypts in Japan." (Dudzinski)

"Distribution. Suggest '*Cryphonectria eucalypti* (as *Endothia gyrosa*) has been reported on *Eucalyptus* in …, and in South Africa. Reports of *Endothia gyrosa* on *Eucalyptus* in Brazil and Portugal have not been confirmed to be *C. eucalypti*." (Hodges)

"I have been corresponding with Marieka (Venter) Gryzenhout recently (one of Mike Wingfield's student who is working on *Cryphonectria*). She says there is no good evidence at this time that *Cryphonectria eucalypti* occurs anywhere except South Africa and Australia. I have mixed feelings about the new name (*Cryphonectria*). I would have preferred to see it as a new species of *Endothia*, even if the DNA evidence eventually meant moving all the *Cryphonectria* names back to *Endothia*." (Hodges)

"Summary of natural history, first paragraph. Suggest this be deleted since the information is already given in section on Scientific Name. If the anamorph of *C. eucalypti* has not been named, and the fungus (as the anamorph) found in WA is truly *C. eucalypti*, there is no need to mention the anamorph of *E. gyrosa*." (Hodges)

"Will the fungus sporulate on decorticated wood?" (Hodges)

"Spread potential, line 1. Generally water dispersal of spores results in slow spread." (Hodges)

"Consequences, line 5. '*Cryphonectria cubensis* sometimes limits…' (There are many resistant provenances and clones)." (Hodges)

"In the IPRA for Cryphonectria canker, the economic damage potential is listed as "*Low*" when it should be "*Moderate*" based on the guidelines presented in Ch. 1." (Osterbauer and Johnson)

"Table 10: *E. calophylla* should be *C. calophylla*; *E. maculata* should be *C. maculata*." (Robinson)

"Under entry potential, *E. maculata* should be *C. maculata*." (Robinson)

"P. 178 (3rd paragraph). *E. gyrosa* is not a significant pathogen of *E. globulus* saplings in Western Australia. It can be present on stressed sites that are copper deficient, but then the impact is less than 1% (G. Hardy, Murdoch University, pers. comm.). Note also that only the anamorph (*Endothiella*) has been recorded in Western Australia." (Robinson)

"In selected bibliography, the correct journal reference for Yuan and Mohammed 1997 is Australian Plant Pathology 26: 78–84." (Robinson)

"*Colonisation potential*. Cankers that penetrate the entire depth of bark and cause cambial damage are very rare, particularly in plantations (*E. nitens* and *E. globulus*) in Tasmania. Debarking would greatly reduce the inoculum potential in logs and I would suggest the 'f' criterion that differentiated logs from chips is unlikely. However, the overall risk rating would not change if the 'f' criteria was deleted for logs." (Wardlaw)

Response to comments—A common name for the disease caused by *C. eucalypti* has not been determined. To reduce possible confusion between this fungus and *C. cubensis*, the disease caused by *C. eucalypti* is being referred to as *Cryphonectria eucalypti* canker in this IPRA. *Cryphonectria cubensis* is recognized as occurring in Western Australia (see Table 9). An IPRA was not completed for this species because of the single report from Western Australia, the existence of an IPRA for the pathogen in the South American *Eucalyptus* PRA (Kliejunas and others 2001), and the occurrence of this pathogen in the United States. The pathway for entry and spread of *C. cubensis* is likely similar to that of *C. eucalypti*, a more commonly encountered fungus in Australia, although *C. cubensis* at this time has a wider host range. The assessor is aware of the Old and Kobayashi record of *C. parasitica* in Japan, however that does not influence this assessment. There is no record of this fungus in Australia requiring consideration.

It is understood that isolates of *E. gyrosa* from Brazil and Portugal have not been examined to determine if they are the same as *C. eucalypti*. Reference was made because of the possibility that this is the same fungus. The IPRA was changed to make this clearer.

It is not known if *C. eucalypti* sporulates on decorticated wood. However, a relative, *C. parasitica*, does, as is mentioned in the IPRA. The IPRA was changed to reflect that *C. cubensis* affects only susceptible species and variants of eucalypt species. Under spread potential the reference to water dispersal was deleted and only airborne was retained. This did not affect the rating. The economic damage potential rating was incorrectly identified as "*Low*" and has been changed to "*Moderate.*" Corrections were made to the PRA to reflect the separation of *Corymbia* from *Eucalyptus.*

As stated in this IPRA and in other parts of the PRA, measuring significance on a native host in its native environs may not be a good predictor of how an insect or pathogen will react when introduced to a new situation. Although the incidence of this canker in Western Australia may be limited, that may only influence the Pest with host-commodity at origin potential. We do not have significantly reliable and wide-ranging data to justify decreasing that risk potential.

The Yuan and Mohammed 1997 citation was corrected.

The IPRA recognizes that debarking will reduce the number of fruiting structures produced. However, it is possible that decorticated wood could develop fructifications that could allow for entry of *C. eucalypti* into the United States.

Seiridium Cankers

Assessor—Gregg DeNitto

Scientific names of pests—*Seiridium eucalypti* Nag Raj; *Seiridium papillatum* Z.Q. Yuan (Coelomycetes)

Scientific names of hosts—*S. eucalypti*: *E. amygdalina*, *E. botryoides*, *E. cypellocarpa*, *E. delegatensis*, *E. globulus*, *E. grandis*, *E. nitens*, *E. obliqua*, *E. regnans*, *E. saligna*, *Eucalyptus* sp.; *Corymbia maculata*

S. papillatum: *E. delegatensis*, *E. globulus*, *E. nitens*, *Eucalyptus* sp.

Distribution—*S. eucalypti*: South Australia, Tasmania; *S. papillatum*: Tasmania

Summary of natural history and basic biology of the pest—*Seiridium eucalypti* and *S. papillatum* have only recently been described and identified as pathogens of eucalypts. Both species have been associated with stem and branch cankers and on leaves in natural stands and plantations in Australia. Artificial inoculations of *Eucalyptus* seedlings identified *S. eucalypti* as a pathogenic species (Yuan and Old 1995, Yuan and Mohammed 1999) and *S. papillatum* as a weak pathogen (Yuan and Mohammed 1999). Surveys of *Eucalyptus* plantations and natural stands in Tasmania found *S. eucalypti* across the state and it comprised over 20% of the fungi isolated (Yuan and Mohammed 1997b).

These fungi produce abundant acervuli with conidia on canker lesions (Yuan and Old 1995). Seedling inoculations with both species caused lesions larger than controls, but lesions caused by *S. papillatum* callused over after 2 months (Yuan and Mohammed 1999). Lesions from both species had fruiting bodies develop within 2 months of inoculation of *E. nitens* (Yuan and Mohammed 1999). Inoculations have only been done with fungal mycelium, but it is assumed that rain-splashed conidia are the principal means of spread.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
Logs—*Moderate* (MC) (Applicable risk criteria, from Ch. 1: d, e, h)
Chips—*Moderate* (MC) (Applicable risk criteria, from Ch. 1: d, e, h)

Seiridium eucalypti is a relatively common pathogen identified on a variety of eucalypt species in Tasmania. *Seiridium papillatum* was less frequently encountered (Yuan and Mohammed 1997b). *Seiridium papillatum* has not been found in other states, and *S. eucalypti* occurred only on leaves in South Australia. *Seiridium eucalypti* produces a canker that may lead to stem or branch mortality distal to the infection. This may be less likely with *S. papillatum*. In either case, infected woody tissue could be harvested and chipped without recognition of the presence of either of these fungi.

2. Entry potential:
Logs—*High* (MC) (Applicable risk criteria, from Ch. 1: b, c, d)
Chips—*Low* (RU) (Applicable risk criteria, from Ch. 1: b, c, d)

As with many Coelomycetes, these fungi will likely survive in harvested logs and chips for several months as long as the wood retains moisture and temperatures do not become too high. Optimum growth of *S. eucalypti* and *S. papillatum* in culture were 20°C and 25°C, respectively. Growth dropped to almost zero for both species at 30°C (Yuan and Mohammed 1997b). It is not known how the temperature affects fungal survival in woody tissue, however. Lesions formed by these two fungi are visible when close observations are made of individual stems, but many infections would likely be missed in a load of logs and certainly in chips. Chipping would have no effect on fungal survival during transit. However, the lack of bark on chips may limit the production of reproductive structures and the inoculum present for establishment of the fungus in the United States.

3. Colonization potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: b, e)

Both of these fungi appear to be restricted to temperate conditions. More moist environments likely encourage spread. The only known hosts are species of *Eucalyptus* and *Corymbia*. If these factors hold true, then the likelihood of colonization in the United States will be limited.

4. Spread potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: a, c, e, f)

This group of fungi readily spreads when hosts are available, either by movement of rain-splashed conidia or on infected material. The extent of eucalypts in the United States is limited and would limit spread of these fungi to California, Arizona, Hawaii, and Florida. If other Myrtaceous species are potential hosts, then spread in Hawaii could become more significant.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: c, f)

Eucalypts are of relatively minor economic value in the United States. Plantations for biomass are limited and do not appear to be increasing. Eucalypts do not have a role in traditional forest products in the United States. The most significant economic value is in the floriculture trade. If either of these fungi were introduced, that is the area likely to be most impacted. Because they cause branch mortality, infection would result in reduced yield and, therefore, reduced economic return to growers. Although eucalypts are present as ornamental trees, the impact of the fungi would primarily be top kill in small trees.

6. Environmental damage potential: *Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Environmental damage would be minimal since eucalypts are not native species and do not have an established role in ecosystems in the United States.

7. Social and political considerations: *Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Impacts on the floriculture trade and ornamental trees could result in some political and social effects. However, except for some instances on ornamentals in California, existing introduced pests of *Eucalyptus* in the United States are having little such effects.

C. Pest risk potential:
Logs—*Moderate* (Likelihood of introduction = *Moderate*; Consequences of introduction = *Moderate*)
Chips—*Moderate* (Likelihood of introduction = *Low*; Consequences of introduction = *Moderate*)

Although survival of these fungi in transit will not be influenced whether it is on logs or chips, it is believed that the reproductive potential will be less on chips. The production of pycnidia is less on wood than bark and the amount of inoculum produced in a load of chips will be considerably less than from a load of logs.

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Reviewers' comments—"Entry potential. Are there references to support the statement 'As with many Coelomycetes, these fungi will likely survive in harvested logs and chips for several months as long as the wood retains moisture and temperatures do not become high.'?" (Cameron)

Response to comments—There are no specific references for *Seridium* species on survival in wood other than the temperature studies mentioned in the IPRA, which were done on growth medium. It is assumed that these fungi have growth and survival requirements within certain ranges of temperature and moisture. The temperature studies suggest that these are temperate organisms, similar to many other fungi. Either of these species can survive for the period necessary for processing and transit of the export product because the environmental conditions encountered during this period should be favorable.

Stain and Vascular Wilt Fungi

Assessor—Jessie A. Micales

Scientific names of pests—*Ceratocystis eucalypti* Z.Q. Yuan & Kile (anamorph = *Chalara eucalypti* Z.Q. Yuan & Kile). *Ceratocystis moniliformis* (Hedgc.) C. Moreau. *Ceratocystis moniliformopsis* Z.Q. Yuan & C. Mohammed. *Ophiostoma pluriannulatum* (Hedgc.) Syd. & P. Syd. (or closely related species). *Ceratocystis* spp. *Ophiostoma* spp. [Plectomycetes, Microascales, Ophiostomataceae (Upadhyay 1993) or Xylariales, Ophiostomataceae (Samuels, 1999) or Microascales, Ceratocystidiaceae (Kirk and others 2002)]. *Chalara* spp., *Graphium* spp., *Leptographium lundbergii* Lagerberg & Melin (anamorphic stages of Ophiostomataceae).

Scientific names of hosts—Cosmopolitan fungi on a broad array of hardwood hosts. Specific reports on *E. delegatensis*, *E. gigantea*, *E. globoidea*, *E. goniocalyx*, *E. obliqua*, *E. regnans,* and *E. sieberi.* Most probably on all species of *Eucalyptus* and *Corymbia* post-harvest.

Distribution—*Ceratocystis eucalypti* and its anamorph have been reported from Tasmania and Victoria (Kile and others 1996). *Ceratocystis moniliformopsis* and a *Chalara* anamorph have been recently reported from Tasmania (Yuan and Mohammed 2002). *Ceratocystis moniliformis*, *O. pluriannulatum* (or a closely related species), and unidentified specimens of *Ophiostoma* and *Graphium* species have been isolated from log yards in Victoria and wounded trees near Canberra and Melbourne (M.J. Wingfield, University of Pretoria, Republic of South Africa, 2002, personal communication; Snow, 1996, 1999). Sapstained wood chips were observed in Eden, New South Wales. *Ceratocystis moniliformis* has been reported from North America, Africa, and the West Indies; *Ophiostoma pluriannulatum* has been reported from eastern North America and Europe (Farr and others 1989). *Leptographium lundbergii* has been found in platypodid ambrosia beetle galleries (*Platypus subgranosus*) in the Central Highlands of Victoria (Hogan 1948). It has also been reported on conifers in North America, United Kingdom, Europe, South Africa, and Japan (Jacobs and Wingfield 2001).

Summary of natural history and basic biology of the pest—"Blue stain" or "sapstain" is caused by a group of ascomycetous fungi in the Ophiostomaceae, primarily belonging to the genera *Ophiostoma* and *Ceratocystis* and their accompanying anamorphs. The fungi produce pigmented hyphae that grow throughout the sapwood column of the living tree or harvested log, resulting in discoloration that decreases grade and results in economic loss in both logs and chips. The physical properties of the wood are unaffected, although porosity is usually increased. Sapstain fungi are frequently associated with beetles, including ambrosia beetles and powderpost beetles, and mites. The fungi usually grow in insect galleries and produce sticky masses of ascospores or conidia that adhere to the insects prior to emergence. The infested insects disperse the spores when feeding or constructing galleries in other trees or logs that are not immediately processed. When introduced into a living host, the fungi invade the sapwood, occlude the vessels, and contribute to the death of the tree. Debarking the logs does not remove the fungi, because the entire sapwood column can be colonized. Rain splash may also be an important dispersal mechanism (Kile 1999, Malloch and Blackwell 1999, Seifert 1999, Tkacz and others 1998). There is no documented study comparing the prevalence of sapstain fungi in natural forests versus plantations, but one might expect greater insect infestation and fungus transmission within natural forests rather than among young, relatively healthy plantation trees. Upon harvest, wood from both plantation-grown trees and natural forests should be equally susceptible to colonization.

None of the sapstain fungi are thought to be major pathogens by themselves, but they can contribute to the death of healthy trees in association with bark beetle attacks (Hansen and Lewis 1997). The sapstain fungi are also closely related to other species of *Ophiostoma* and *Ceratocystis* that cause disastrous wilt diseases in hardwoods, including oak wilt [caused by *Ceratocystis fagacearum* (T.W. Bretz) J. Hunt] and Dutch elm disease [caused by *Ophiostoma ulmi* (Buisman) Nannf.]. Some unidentified isolates of the *Ophiostoma quercus* (Georgev.) Nannf. complex that colonize hardwoods have been identified in Australia, and there may also be some *O. ulmi*-type pathogens there (T.C. Harrington, Iowa State University, 2002, personal communication). Very little research has been done on Australian sapstain fungi, and little is known of their biosystematics or pathogenicity. Initial tests on *C. eucalypti* have shown that it has at least two mating types and can colonize a number of *Eucalyptus* species (Kile and others 1996). Closely related fungi that cause sapstain and disease, primarily in conifers but also in *Nothofagus* and *Laurelia*, have been previously discussed as potential pests on imported logs from New Zealand (USDA Forest Service 1992), Chile (USDA Forest Service 1993), and Mexico (Tkacz and others 1998).

The lack of research and published information about Australian sapstain fungi is a primary consideration in this analysis. Only a few sporadic reports of sapstain on eucalypts appear in the literature. Expert mycologists who have spent time in Australia confirm that virtually nothing is known about these fungi. Many organisms have been isolated but few have been identified. Such a paucity of information requires significantly more caution in evaluating the risks than if more data were available. Much of the analysis is based on research from other *Ceratocystis* and *Ophiostoma* species. Caution is especially required since many species of *Ceratocystis* and *Ophiostoma* can colonize hosts from different families; some sapstain species have been reported from both hardwoods and softwoods (Farr and others 1989).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d, e, f, g, h)
   Chips—*High* (RC) Applicable risk criteria, from Ch. 1: b, c, d, e, f, g, h)

   Sapstain fungi can develop in eucalypt logs that sit for lengthy periods of time in the bush or in log yards before processing. These fungi can also be introduced into the sapwood of the living tree through basal wounds, as in thinning operations, or by insect vectors. Extensive regions of the sapwood can become extensively colonized. Both perfect and imperfect forms of the fungi can sporulate, thus building up large-scale population increases. The fungi can survive for extensive periods in the wood as long as moisture is available. Because the fungi are intimately associated with the sapwood, they cannot be dislodged during harvesting procedures. The lack of research on the specific identities of these fungi makes it impossible to establish host ranges, but initial studies on *C. eucalypti* suggest that this fungus can colonize numerous hosts and that it is widely distributed in southeastern Australia (Kile and others 1996). Sapstain fungi can grow on either logs or chips, either within the living tree or post-harvest, so the assigned ratings did not vary with the commodity.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)
   Chips—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)

   Sapstain fungi can survive in logs for more than a year with favorable temperature and moisture regimes (Tkacz and others 1998). The conditions under which logs are transported can often facilitate fungal growth due to the moist, warm environment during transit through the tropics and the close proximity of host material. Bark removal would not prevent survival in transit, because the entire sapwood cylinder can be colonized. The fungi can fruit prolifically in insect galleries, bark, or wood cavities, and on the undersides of logs, bark, or wood scraps. The likelihood of spore development on or in untreated colonized logs is high once they have been delivered to ports.

   The elevated temperatures associated with chip piles and the transport of chips should retard fungal growth but might not kill the organisms, allowing subsequent growth and sporulation upon re-exposure to air and moderate temperatures. The increased surface area of wood chips might allow greater numbers of fruiting bodies to form, resulting in increased spore production if temperature and oxygen are no longer limiting at the port of entry. Isolates of *Graphium* sp., a common imperfect stage of *Ophiostoma*, were obtained from *Pinus radiata* chips that had traveled from Chile to Washington state (Micales and Burdsall 2002), demonstrating that sapstain fungi can survive lengthy transport on chips, albeit at very low frequencies (less than 1% of fungi isolated). There is no direct evidence to suggest a difference in entry potential between logs and chips.

3. Colonization potential: *High* (RC) (Applicable risk criteria from Ch. 1: b, c, d, e)

   Under the conditions of transport of logs, substantial inoculum in the form of conidia or ascospores can be expected to be present at the port of entry. There is a high probability that these fungi could be transported to suitable hosts, probably by nonspecific insect vectors. The planting of ornamental eucalypt species in California and the southern United States could provide suitable host material for establishment. An initial inoculation study with *C. eucalypti* has shown that the fungus is not host specific (Kile and others 1996). Sapstain fungi grow best in wood at temperatures between 22°C and 30°C and can thrive under a variety of climates. Serious staining can also occur at wood stored at lower temperatures (3°C to 8°C) (Seifert 1993). This broad temperature range suggests that the dispersal of sapstain fungi would not be limited by climates encountered at most U.S. entry ports.

4. Spread potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, d, e, f, g)

   Inoculation studies with *C. eucalypti* have shown that it is not host specific (Kile and others 1996). The mild temperatures of California and the wet climates of the Pacific Northwest and the southern United States should facilitate fungal survival and dispersal from many U.S. ports. The ability of generalized insect vectors, which are not host or fungal specific, to transport the spores of the fungi greatly increases the possibility of dispersal. Established fungi could be further dispersed by human-assisted transport through sales of ornamental hardwood nursery plants or through the transport of hardwood firewood. These fungi could go undetected for many years, especially among ornamental plantings, because most hardwoods are not commercially harvested and examined for stain during the grading process.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RC)
(Applicable risk criteria, from Ch. 1: a, c)

Sapstain fungi decrease the value of wood products by discoloring the wood. Hardwood lumber is often quite high-value material, and any discoloration greatly decreases its value and marketability. Many sapstain fungi already exist in the United States and will colonize wood products if they are not dried in a timely manner. In addition, some species of *Ceratocystis* cause "sapstreak" in living trees, primarily maple and yellow poplar. The introduction of another hardwood-staining organism would probably not greatly affect the market. The close relationship of the saprophytic sapstain fungi with highly pathogenic, tree-killing wilt pathogens is more of a concern. Although no serious wilt pathogens have been reported on eucalypts, very little is known about Australian species of *Ceratocystis* or *Ophiostoma*, and many species remain undescribed. It is possible that one of these fairly harmless saprophytes could find highly susceptible hosts in the United States and cause another devastating hardwood disease reminiscent of oak wilt or Dutch elm disease. Some species of *Ceratocystis* and *Ophiostoma* are known to have multiple hosts from different plant families, so economic damage might not be confined to genera of the Myrtaceae (Farr 1989).

6. Environmental damage potential: *Moderate* (RC)
(Applicable risk criterion from Ch. 1: f)

Although there is no documentation of tree-killing species of *Ceratocystis* or *Ophiostoma* from Australia, the introduction of an unknown fungal species to the United States could result in significant mortality among susceptible hardwood trees. Loss of trees in ornamental plantings and in commercial species, such as oak, would cause considerable impact. Because most of these fungi have not been identified to species and other species of *Ceratocystis* and *Ophiostoma* are known pathogens, the potential of introducing virulent species, biotypes, or strains needs to be considered. Because of this possibility, an assessment of moderate risk is supported.

7. Social and political considerations: *Moderate* (RC)
(Applicable risk criteria, from Ch. 1: a)

The accidental introduction of another sapstain or sapstreak fungus into the United States would not cause social or political impacts beyond those caused by native species. There is a potential for a high level of mortality in a highly susceptible U.S. host from a currently unknown species of *Ceratocystis* or *Ophiostoma.* The death of large numbers of urban trees would result in public concerns for aesthetic and recreational reasons, thus resulting in an elevated rating of moderate risk.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)
Chips—*High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)

Sapstain fungi can grow and survive on chips as well as on logs. Therefore, the assigned ratings do not change with commodity.

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Reviewers' comments—"Entry potential. These are important statements! Cite original research, not a previous PRA. May need additional research to substantiate these statements." (Cameron)

"A new species from eucalypt logs in Tasmania, *Ceratocystis moniliformopsis*, has just been published. The etymology alludes to similarity to *C. moniliformis*. Ref. Yuan, Z.Q. and Mohammed, C. (2002) *Ceratocystis moniliformopsis* sp. nov., an early colonizer of *Eucalyptus obliqua* logs in Tasmania. Australia. Australian Systematic Botany 15: 125–133." (Dudzinski)

"Summary of natural history and basic biology of the pest. I think Australian pathologists might be surprised to learn that *O. ulmi*-type pathogens may exist in Australia, and although anything is possible there is no evidence of this from symptoms on trees. Dutch elm disease is known in New Zealand, of course, although now at very low levels. What exactly is meant by *O. ulmi*-type?" (Dudzinski)

"The summary of natural history and basic biology section on stain and vascular wilt fungi seems to ignore completely their very important roles as tree killing associates of bark beetles." (Hansen)

"Scientific names: *Leptographium lundbergii* is listed; include with scientific names of pests." (Hodges)

"Summary of natural history, lines 6–12. This is pretty much the story on conifers; is it also true for hardwoods?" (Hodges)

Response to comments—The references to *Ceratocytstis moniliformopsis* and *Leptographium lundbergii* have been added. A reference to the ability of sapstain fungi to kill healthy trees in association with bark beetles (Solheim 1997) has also been added. Much of the information on life cycle is taken from Kile (1999) that specifically discusses the vascular wilts and vascular stain diseases of hardwoods. The reference to *O. ulmi*-type fungi refers to a group of fungi that are similar to *O. ulmi* morphologically, not necessarily pathologically.

Armillaria Root Rot

Assessor—Harold H. Burdsall, Jr.

Scientific names of pests—*Armillaria fumosa* Kile & Watl., *Armillaria hinnulea* Kile & Watl., *Armillaria luteobubalina* Watl. & Kile, *Armillaria novae-zealandiae* (G. Stev.) Herink, *Armillaria pallidula* Kile & Watl. (Agaricales, Marasmiaceae)

Scientific names of hosts—Many *Eucalyptus* spp., many *Corymbia* spp., occasional conifers, understory hardwood species

Distribution—Tasmania, nearly all parts of mainland Australia

Summary of natural history and basic biology of the pest—Australia is home to at least six *Armillaria* species. Of these, four have been reported on *Eucalyptus* spp. *Armillaria pallidula* is known only from pine, but because pine is not native to Australia, this species almost certainly occurs in native eucalypt forests as well. Only *A. luteobubalina* has been demonstrated to be a primary pathogen in the native forests (Kile 1981). Other species are known as secondary pathogens, attacking stressed trees in native forests. Armillaria root rot is found in very young plantations but is not a problem once the trees are established. Because of the short rotation (10 to 20 years) of most plantations, Armillaria root rot does not become a problem. It is only seen on older trees. All species examined to date have the ability to cause disease in some situations, frequently in a broad range of host species. They are also adept at surviving as saprophytes in dead wood or root tissues for long periods of time (Kile 1980, Kile 1986, Rishbeth 1972, Shaw 1975). *Armillaria luteobubalina* is also well known for pathogenic capability in plantations on many species of *Eucalyptus* and several species of *Corymbia*. An example of damage caused by *Armillaria* spp. (probably *A. luteobubalina*) was seen during the site visit to old growth stands of *Eucalyptus* spp. in both the Dandenong Range, near Melbourne, Victoria, and near Manjimup, southern Western Australia. Triangular shaped lesions (up to several feet wide at the bottom) in the sapwood extended from the base of the tree up to 20 ft (6.1 m) up the bole. Trees thus affected continued to appear healthy but would probably not be considered for harvest because of the obvious saprot. Less obvious (incipient) decay might easily go unnoticed. Under the right conditions the fungus in the infected root, or in the case of the more saprophytic species, in the infested wood, produces mushrooms, the source of the reproductive basidiospores. These spores are discharged and are carried by air currents to wounds in uninfected trees. *Armillaria* species are known for the production of rhizomorphs in the soil that grow out from a nutrient source and infest another substrate. There seems to be a correlation between the saprophytic nutritional state and the production of rhizomorphs. Most pathogenic species, such as *A. luteobubalina*, produce limited rhizomorphs. They spread to a new host plant through root-to-root contact. This characteristic leads to a slower spread rate than would be attained by aerial spread, but it appears that the importance of the basidiospores in dissemination varies among species (Kile 1986, Smith and others 1992). However, in the establishment of new infection foci, whether in native forests of Australia or in a foreign ecosystem, basidiospores would be very important. How these species would function in the North American ecosystem is, of course, not obvious, but to date, all are known to have some pathogenic capability and a rather broad host range that would accompany them. Chipping logs will have no impact on whether *Armillaria* is present. Incipient infections in the sapwood will be carried in the chips into the chip piles. However, how long it would remain viable would depend on the conditions in the pile. The production of basidiomes in *Armillaria* spp. is expected to be very unlikely on such a small woody substrate, and the North American species are extremely difficult to get to fruit outside the natural system. It is very unlikely that fruiting would occur on chips.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: c, d, e, g, h)
   Chips—*High* (RC) (Applicable risk criteria, from Ch. 1: c, d, e, g, h)

   In logs harvested from native forests, the chances of an *Armillaria* species (probably *A. luteobubalina*) being present is probably no greater than in logs from plantations. The plantations are often on poorly adapted sites and thus predispose the young trees to attack by an *Armillaria* species, often not *A. luteobubalina* but rather *A. novae-zealandiae* or *A. hinnulea*, the less pathogenic species. The adaptability of these species to different conditions and to other host species is of concern when considering log imports. The fact that decayed butt sections are cut off during harvesting (personal observation during site visit) is comforting but incipient attack is not obvious enough that it would be noticed in the field.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)
   Chips—*Low* (RU) (Applicable risk criteria, from Ch. 1: b, c, d)

   Armillaria species are capable of surviving well in wood for extended periods of time. Being in the sapwood and deeper in the wood tissues of the butts of infested logs, the fungus would be protected from desiccation. The ability of *Armillaria* species to maintain themselves in chips and chip piles is not known**.** However, the drying of chips in piles and the heat generated in the depths of piles may be detrimental to the fungus's survival. Decay tests performed on *A. mellea* (Burdsall, unpublished data) demonstrated that it was not well adapted to decaying small pieces of wood, although the fungus did not die during the decay test. This demonstrates that survival in small pieces of wood is possible in some conditions. However, the conditions under which the chips are maintained and treated—mixing, drying, heating—might select against an *Armillaria* species surviving in chips. Although it is not certain that *Armillaria* species would not survive well in transported chips, and criterion b (survival during transportation) may not apply, two criteria still apply, resulting in a high rating according to the formula. However, because of the treatment that the chips receive and the probable impact on the fungus, the likelihood of survival seems much reduced, so the rating has been reduced to "*Low*."

3. Colonization potential: *Low* (RC) (Applicable risk criteria, from Ch. 1: b, c)

   To produce basidiospores, these fungi would have to develop basidiomes (mushrooms) after arrival in the United States. The effectiveness of the basidiospores in establishing the fungus would depend on that event, on favorable environmental conditions including moisture and temperature, and on the presence of suitable hosts growing near ports of entry. The likelihood of this combination of conditions occurring is low. With regard to chips, the production of basidiomes, if the fungus actually survived the chipping, storage conditions, and transport on the ships, is very unlikely given the difficulty in obtaining them in other than natural conditions. The host range of the *Armillaria* species in question comes into play here as well. The extent of host range for the Australian *Armillaria* species is of concern when considering importing logs, and hosts would need to be present for infection and colonization to occur.

4. Spread potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, c, d, e, f, g)

   The spread of these fungi would depend on the presence of hosts near the ports or the place where the logs are being stored. Once spores are produced, susceptible hosts within miles are within range of the spore dissemination. Just as in Australia, these propagules would be effective in inciting new infection centers at a great distance.

B. Consequences of introduction

5. Economic damage potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, f)

   The broad host range noted for *Armillaria* species is of considerable concern. Several of the species are known to attack both hardwood and conifer hosts. If one of the species were particularly pathogenic to some of the conifers in the western United States, the introduction could wreak havoc in the western forests. Introduction of an exotic *Armillaria* species could also be a major concern to both cities and homeowners with *Eucalyptus* ornamental plantings, and because there is no information regarding the virulence to other host species the potential damage could be very significant. In addition, infection of *Eucalyptus* spp. used in the foliage industry may result in a significant economic impact to that industry.

6. Environmental damage potential: *Moderate* (MC) (Applicable risk criteria, from Ch. 1: none)

   If a species of *Armillaria* were introduced that was pathogenic to conifers in the United States, the environmental impact would depend on the virulence and the host range of the pathogen. Such an introduction would have the potential of having a major impact through causing root rot in numerous conifer species. With effective basidiospore dispersal, new infection centers might arise rapidly and spread could be rapid. *Armillaria* species tend not to spread rapidly, but in a new ecosystem where the host species are not adapted, how the new pathogen would progress is unknown.

7. Social and political considerations: *Low* (MC) (Applicable risk criteria, from Ch. 1: none)

   Perceived damage potential following successful establishment of an *Armillaria* on eucalypts as a result of log importation would be low. However, if that fungus was pathogenic and particularly virulent on other hosts, especially western conifers, the resulting damage could be much greater.

C. Pest risk potential:
Logs—*Moderate* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)
Chips—*Low* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

The low likelihood of *Armillaria* spp. surviving in chips in transport reduces Entry potential from "*High*" with logs to "*Low*" with chips and reduces the pest risk potential from "*Moderate*" with logs to "*Low*" with chips.

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Reviewers' comments—"Entry potential. These are important statements and need citations. Research is needed for survival in chips." (Cameron)

"Entry potential, general. I don't agree that chips carry a high risk of entry for Basidiomycetes in general unless they produce a conidial state. Even if a log with active decay is chipped, the chips containing the fungus are likely to be widely dispersed among fungus-free chips in the process, and the fungus is unlikely to achieve the mass of mycelium necessary to support production of basidiomes. For this reason, and as mentioned below about *Armillaria* not well-adapted to decaying small pieces of wood, I don't believe that *Armillaria* or the conk-producing Basidiomycetes are likely to produce basidiomes on chips, and thus result in entry of the organism." (Hodges)

"Chapter 4, Factors Influencing Risk Potential, first paragraph. I still have a problem with basidiomes being produced on chips, as mentioned. Also, mycelia and rhizomorphs of decay fungi shouldn't result in entry even if they survive." (Hodges)

"Pest risk. I don't think this should be High for chips. See above." (Hodges)

"Likelihood of introduction. The only cases of enhanced Armillaria root rot in Tasmania that could be associated with poor site adaptation are two outbreaks in *E. nitens* plantations on deep sands in coastal areas of northwestern Tasmania. *Armillaria* mortality is very rare in plantations (generally <0.1% incidence) and probably not different for native forests. Basal cankers (i.e., extending into the merchantable stem) caused by *Armillaria luteobubalina* are very rare in Tasmania—I have seen such cankers in only one native forest (an older regrowth forest of *E. regnans* in northeastern Tasmania) and one plantation (a young, off-site *E. nitens* plantation on deep sands near the coast in northwestern Tasmania). I have only encountered butt rot (a white rot of the heartwood) in regrowth forests on sites where *A. novae-zelandiae* would be expected. However, none of these observations would affect the assigned risk rating." (Wardlaw)

Response to comments—Two of the reviewers (Hodges, Cameron) commented that the rating for entry potential for these pathogens was rated too high, believing that the formation of mushrooms, needed before dispersal could occur, would be unlikely in chips. The rating given in the draft document was a result of the strict adherence to the rating scale as presented in risk criteria in Chapter 1. Because of the unique nature of these fungi, factors not evident in those criteria have been applied to reach a more reasonable evaluation of the risk. The ability of *Armillaria* species to survive in chips is still in question, but the ability to produce basidiomes on chips is certainly unlikely. Thus, the likelihood of introduction rating has been reduced.

The lack of importance of *Armillaria* spp. as forest pathogens in Australia was addressed in other comments (Wardlaw). During the site visit, Dr. Kile also stressed the role of *Armillaria luteobubalina* as a secondary pathogen with the other species being saprophytic. However, as mentioned in his comments, Dr. Wardlaw states, "However, none of these observations would affect the assigned risk rating," indicating his realization that, as an exotic in the United States, the pathological impact might be much more serious.

Root-, Sapwood-, and Heart-Rots

Assessor—Harold H. Burdsall, Jr.

Numerous root-, sapwood-, and heart-rot fungi have been described on eucalypts in Australia (Kile and Johnson 2000). In this assessment, the name of the fungus and its hosts, the distribution, and a summary of natural history and basic biology for several of the groups of decay fungi are used as examples. The groups include species that are considered root-rots as well because these fungi are often found a short distance up into the trunk and in their incipient stages could be overlooked in the culling process during harvesting. These rots of eucalypts are then discussed as a group for specific information relating to risk elements.

1. *Phellinus* and *Inonotus* incited rots

Scientific names of pests—*Phellinus gilvus* (Schw.) Pat., *P. noxius* (Corner) G.H. Cunn., *P. rimosus* (Berk.) Pilát, *P. robustus* (P. Karst) Bourd. & Galz., *P. wahlbergii* (Fr.) D.A. Reid; *Inonotus albertinii* (Lloyd) P.K. Buchanan, *I. chondromyeluis* Pegler, *I. rheades* (Pers.) Bond. & Singer (Hymenochaetales, Hymenochaetaceae)

Scientific names of hosts—*Corymbia calophylla*, *C. maculata*, *Eucalyptus delegatensis*, *E. diversicolor*, *E. globulus*, *E. grandis*, *E. obliqua*, *E. ovata*, *E. regnans*, *E. saligna*, *E. viminalis*

Distribution—New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia. The *Phellinus* and *Inonotus* species have some of the widest host ranges and distributions of any of the basidiomycetous decay fungi in Australia.

Summary of natural history and basic biology of the pest—It will be noted that the species of *Phellinus* and *Inonotus* listed are for the most part found in the United States. Such may not be reality. Species concepts in these genera are extremely difficult to define and at present are questionable. Most species distinctions today are still based on morphological characters but such distinctions have been demonstrated to be undependable for some species, for example, *P. gilvus*, *P. wahlbergii* (Larsen and Cobb 1990, Rizzo and others 1995). Other *Phellinus* and *Inonotus* species concepts are certainly equally suspect. These fungi are variable in their biology, with some species attacking heartwood, while others attack the roots and/or butt of the trees. Still others are saprots. As such they might be found in different parts of the tree from the butt to the upper branches. Their association with older trees will make them much less likely to occur in plantation logs, but in the older logs from native forests butt-rot associated with members of these genera is not uncommon (Burdsall, 2001, site visit observation) and requires the elimination of a portion of the bottom of the log. These species grow as mycelium in their substrate before producing basidiomes (conks), the source of basidiospores. The discharge of basidiospores into the wind currents allows for the dissemination to a new infection site. Whether the spores of root- and butt-rot fungi are very effectively transported by air is questionable. Root-to-root contact is a more effective means for such fungi. However, long distance transport and the establishment of new infection centers requires such a mode of transport at some level of effectiveness. *Phellinus* and *Inonotus* species are known for having among the widest host range and geographical distributions of any root- or stem-rot fungi in Australia (Kile and Johnson 2000). For this reason they are of primary concern.

2. Hymenochaete stem rot

Scientific name of pest—*Hymenochaete* sp. (Hymenochaetales, Hymenochaetaceae)

Scientific names of hosts—*Eucalyptus* spp., especially *E. diversicolor*; also saprophytic on power poles

Distribution—Western Australia

Summary of natural history and basic biology of the pest—This is an undescribed species of *Hymenochaete* that is known to produce a white-rot in young plantation stock (E. Davison, Curtin University, Perth, 2001, personal communication). Its biology is yet unknown, but Koch's postulates have been performed successfully. It apparently infects through wounds and branch stubs, thus would be found in the upper portion of the logs harvested from plantations. Because it attacks young trees, it is of concern when considering the import of plantation logs. It can quickly infect the heartwood (Castro and Krugner 1984). Its ability to survive once a log is harvested is obvious because it is also found as a decay in power poles (E. Davison, Curtin University, Perth, 2000, personal communication), which causes additional concern.

3. Stereum stem rot

Scientific name of pest—*Stereum hirsutum* (Willd.:Fr.) Gray (Russulales, Stereaceae)

Scientific names of hosts—*Eucalyptus diversicolor*, *E. delegatensis* (?), *E. regnans* (?)

Distribution—Western Australia, possibly Tasmania

Summary of natural history and basic biology of the pests—Reports of *Stereum hirsutum* are common in Western Australia, where it occurs on *E. diversicolor* stumps and infects the coppice stems with a brown heart-rot (Davison and Tay 1990). It is known to occur in *E. globulus* plantations as well (E. Davison, Curtin University, Perth, 2000, personal communication). Thus the smaller timber from plantations may have heart-rot that is not obvious in the butt log. In continual infections from stumps into new stems the butt log will certainly show attack by the fungus. This method of plantation reestablishment is rarely used today because of the desire to grow improved genetic stock. Thus stump reinfections and butt log infections should be much reduced in the future.

4. General stem- and butt-rots

Scientific names of pests—*Fistulina spiculifera* (M.C. Cooke) D.A. Reid (Agaricales, Fistulinaceae);

Ganoderma lucidum (M.C. Curtis) P. Karst.(Polyporales, Ganodermataceae);

Gymnopilus junonius (Fr.) P.D. Orton [= *G. spectabilus* (Fr.:Fr.) A.H. Smith, = *G. pampeanus* Speg.] Singer (Agaricales, Cortinariaceae);

Omphalotus nidiformis (Berk.) O.K. Miller, Jr. (Agaricales, Marasmiaceae); *Perenniporia medulla-panis* (Jacq.:Fr.) Donk (Polyporales, Polyporaceae);

Piptiporus australiensis (Wakef.) G.H. Cunn., *P. portentosus* (Berk.) G.H. Cunn. (Polyporales, Polyporaceae)

Scientific names of hosts—Numerous species, including *Corymbia calophylla*, *Eucalyptus camaldulensis*, *E. camphora*, *E. cinerea*, *E. cypellocarpa*, *E. globulus*, *E. grandis*, *E. microcorys*, *E. nicholii*, *E. nitens*, *E. maculata*, *E. nova-anglica*, *E. robusta*, *E. saligna*, *E. tereticornis*, and *E. viminalis*

Distribution—New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia

Summary of natural history and basic biology of the pest—Of this group of species causing root- and stem-rot, *Piptoporus portentosus* has the widest host and geographic range, closely followed by *P. australiensis* (Kile and Johnson 2000). The other most common organisms are species of *Phellinus* and *Inonotus* species (Kile and Johnson 2000). These species are similar in their biology. All require the production of a basidiome before the production of basidiospores. The basidiospores are then the infective propagules for the spread of the fungus. Little is known regarding the exact mode of infection by these fungi. They are all probably dependent on wounds of some sort as an inoculation court in long-distance dispersal, but those causing root-rots can certainly spread by root-to-root contact. Most of these species are not of concern in plantations because they are more associated with older trees in the native forests. Where plantations are reproduced by coppice, species such as *Gymnopilus junonius* are of some concern. However, coppicing is being little used today because of the increased use of improved genetic stock (Ian Smith, Victoria State Department of Natural Resources and Environment, 2001, personal communication during site visit).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host-commodity at origin potential:
   Logs—*Moderate* (RC) (Applicable risk criteria, from Ch. 1: c, d, e, h)
   Chips—*Moderate* (RC) (Applicable risk criteria, from Ch. 1: c, d, e, h)

   The root- and stem-rot fungi have a good chance of being present at harvest. In harvesting observed during the site visit, rotted butt logs were cut off and discarded from the log pile. Whether the logs are cut above the extent of the incipient decay is the determining factor with respect to whether the pathogens accompany the exported logs. Chipping may well have little effect on the survival of these fungi. All these fungi are well adapted to a saprophytic existence and might well survive the chipping process.

2. Entry potential:
   Logs—*High* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)
   Chips—*Moderate* (RC) (Applicable risk criteria, from Ch. 1: b, c, d)

   The fungi discussed in this section are all capable of surviving as saprophytes. This ability would allow them to remain viable during extended transport to an exotic location. Unless the chips are soon dried or are deposited in a hot part of the chip pile, these fungi can probably survive in chips. Most of these species have not been well studied, so their ability to survive in chips is somewhat speculative. However, it is reasonably certain that some fungi in infested chips might be able to retain viability.

3. Colonization potential: *Moderate* (RC) (Applicable risk criteria, from Ch. 1: b)

   This is the weak link in the transmission of these species to the United States. To become established in the United States, all these species must have correct conditions for fruiting in order to produce the infective basidiospores. Once formed, the basidiospores can be carried by the wind to susceptible hosts. The presence of susceptible hosts within a short distance of the port of entry is critical to the colonization by these fungi. The further distant the susceptible hosts, the less the chance they will be infected.

4. Spread potential: *Moderate* (RC) (Applicable risk criteria, from Ch. 1: a, e, f)

   Although all the species discussed here produce basidiospores under the appropriate conditions, many of them are more adept at spreading by root-to-root contact. The spread of these root-rots is expected to be rather slow.

B. Consequences of introduction

5. Economic damage potential: *High* (RC) (Applicable risk criteria, from Ch. 1: a, b, c, f)

   Because the spread of the species is normally rather slow, the economic damage potential is expected to be less than if they tended to be more effectively windborne. In a new ecological system, predicting virulence and spread is somewhat speculative, but such an introduction would not be expected to have a major impact economically. An impact on the eucalypt floral industry is unlikely because these fungi are adapted to older trees and to native forests rather than plantation or nursery situations.

6. Environmental damage potential: *Low* (RC) (Applicable risk criteria, from Ch. 1: none)

   Many root-rot and stem-rot fungi are already present in the United States. However, the introduction of a polyphagous exotic species that could infect conifers could be of great importance. The impact on hardwoods is more likely because of the low likelihood of one of these species making the jump in host preference from *Eucalyptus* to a conifer.

7. Social and political considerations: *Low* (MC) (Applicable risk criteria, from Ch. 1: none)

   Perceived damage potential following successful establishment of the *Eucalyptus* root-, sapwood-, and heart-rots as a result of log importation would be low. Especially if restricted to *Eucalyptus* spp., social and political impact would be minimal.

C. Pest risk potential:
Logs—*High* (Likelihood of introduction = *Moderate*; Consequences of introduction = *High*)
Chips—*High* (Likelihood of introduction = *Moderate*; Consequences of introduction = *High*)

Because these decay fungi can survive the chipping process and may retain viability in chips during transit, the pest risk potential does not change with commodity.

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Reviewers' comments—"Pest with host-commodity at origin potential, and entry potential. Much speculation about survivability in chips; research is needed." (Cameron)

"Colonization potential by decay fungi is said to be only moderate because they must have 'correct' conditions for fruiting. Yet, nothing is presented regarding correct conditions. Maybe conditions in the U.S. are more favorable than in Australia." (Cobb)

"Regarding the rate of spread of a decay fungus, even if it is 'rather slow,' it can cause major losses when the host is a long lived tree and, when established it can disrupt an ecosystem for millennia." (Cobb)

"Title. How do you differentiate between 'stems' and 'trunks'?" (Hodges)

"Entry potential. See comments for Armillaria root rot (don't agree that chips carry a high risk of entry for Basidiomycetes in general unless they produce a conidial state)." (Hodges)

"Spread potential. If this section is on stem and trunk rots, why the discussion of root rots?" (Hodges)

"Pest risk potential. See comments for *Armillaria*." (Hodges)

"The decay fungi assessment is well written and assumptions seem good based on our knowledge base." (Jacobi)

"I find that lumping all the stem and trunk decay organisms together is not the right way to go. Some of these organisms are cosmopolitan (*S. hirsutum* is by no means restricted to Western Australia, and is also present throughout North America, as is *Gymnopilus junionus*/*spectabilis*) while others are restricted to certain states and certain tree species. This makes it very difficult to accurately assess the import risk for individual species of trees from individual States.

Most of these organisms are not associated with *E. globulus* plantations. (Robinson)

"Summary of natural history section. Keane and others 2000 should be Kile and Johnson 2000." (Robinson)

"General stem and butt rots. *Omphaloyus nitiformis* is incorrectly spelt, should be *Omphalotus nidiformis*; *E. maculata* should be *C. maculata*." (Robinson)

"*Stereum* discussion. The method of coppicing needs to be explained. It is explained at the bottom of the page, but the reference to coppicing in the top paragraph is not obvious. Also it is not 'certain' that *S. hirsutum* will infect coppice." (Robinson)

Response to comments—Comments regarding the need for research on the survivability of stem and butt rot fungal pathogens in chips (Cameron) and questions regarding the ability of the decay fungi to fruit on chips if they arrive into the United States (Hodges) are well taken. The survivability of the basidiomycetes in chips is in question, and the ability to produce basidiomes on chips is equally questionable. However, unlike *Armillaria* spp. in which the production of basidiomes is difficult (or impossible) on small-dimension wood, many other organisms that cause decay in living trees (for example, some *Phellinus* spp.) fruit much more easily. The assessor's experience with culturing these types of fungi for more than 30 years prompts him to believe that fruiting on such a substrate may be possible for at least some of these species. Thus, the potential for spore production once in the United States is much greater than in the case of fungi such as *Armillaria* spp. Conversely, other reviewers believe that the rating placed on the colonization potential for the establishment of these organisms is too low (Cobb). In spite of the fact that there is a potential for the development of basidiomes and basidiospores, the potential is probably not very high. The conditions leading to such fruiting and basidiospore production are unlikely to occur. This reduces the colonization potential. The rating therefore seems appropriate.

A comment was offered regarding the inaccuracy of the title of this IPRA, which did not include mention of root-rot fungi that were covered in the text (Hodges). The comment is correct, and a change in title of the IPRA was made. The intent of this IPRA was to cover decays in living trees from the ground up. The title now is all-inclusive.

Another reviewer (Robinson) disagreed with "lumping" the decay organisms together because some have a restricted host range while others are supposedly distributed worldwide, and still others are not associated with *E. globulus* plantations. It is certainly true that there are differences among the "decays," but in the broad picture as viewed in the importation of exotic species, these organisms would be found in the wood of logs and chips and their life cycles are generally similar. Also, the worldwide distribution of most of these species mentioned is not unqualified. Unfortunately, the species concepts in these fungi are not well known and whether *Stereum hirsutum* from Australia is truly conspecific with that in the United States is still questionable. The same applies to *Gymnopilus junionus*/*spectabilis*.

Because the IPRA must take into account the natural forests as well as plantations, the pathogens are not always separated. Plantation-grown trees will certainly be less likely to possess some of the pathogens, especially those of shorter rotations, and with the reduced use of coppicing as a means of reproduction the impact of several of the root-inhabiting species will lessen. However, poorly maintained or off-site plantations could well be more susceptible to these pathogens if left to grow longer for higher production, thus predisposing them to infection by these agents.

Chapter 4. Summary and Conclusions

Background

Several forest industries propose to import logs and chips of eucalypts from Australia for processing in various localities in the United States. Current regulations require that unprocessed logs from temperate areas of Australia must be fumigated with methyl bromide or heat-treated to eliminate pests. Logs must be stored and handled to exclude access by pests after treatment [Title 7, CFR part 319.40-5(d), 319.40-6 (a)]. Chips are required to be of tropical origin from healthy, plantation-grown, tropical species or must be fumigated with methyl bromide, heat-treated, or heat-treated with moisture reduction [Title 7, CFR part 319.40-6 (c)(2)]. The Animal and Plant Health Inspection Service (APHIS) requested that the Forest Service prepare a pest risk assessment that identifies the potential insects and pathogens of 18 species of eucalypts (*E. amygdalina*, *E. cloeziana*, *E. delegatensis*, *E. diversicolor*, *E. dunnii*, *E. globulus*, *E. grandis*, *E. nitens*, *E. obliqua*, *E. ovata*, *E. pilularis*, *E. regnans*, *E. saligna*, *E. sieberi*, *E. viminalis, Corymbia calophylla, C. citriodora*, and *C. maculata*) throughout Australia, estimates the likelihood of their entry on logs or chips of the eucalypt species into the United States, and estimates the potential for these pests to establish and spread within the United States. The pest risk assessment also evaluates the economic, environmental, social, and political consequences of any introduction. This risk assessment includes the conterminous United States and Hawaii as potential ports of entry. The assessment and conclusions are expected to be applicable to these areas.

Pest Risk Assessment

The Wood Import Pest Risk Assessment and Mitigation Evaluation Team, a group of pest specialists from various USDA Forest Service offices, compiled this pest risk assessment. The team of specialists provided technical expertise from the disciplines of forestry, entomology, plant pathology, and mycology. Most team members worked on previous pest risk assessments related to log imports. Representatives from APHIS, the USDA Forest Service, and the government of Australia assisted the team. In September 2001, eight members of the team and two APHIS representatives traveled to Australia. Biosecurity Australia coordinated the site visit. The team split into smaller sub-groups and visited numerous plantings and natural forests of eucalypts in various parts of the country. They also visited processing mills and ports. The team spoke with various government officials, industry representatives, and academia to discuss the risk assessment and conditions in Australia.

The team began the risk assessment process by compiling a list of organisms reported to be associated with 18 selected eucalypt species in Australia. From this list, insects and pathogens having the greatest risk potential as pests on logs or chips were identified using risk analysis procedures recommended by APHIS (Orr and others 1993). This pest risk assessment expanded two of the five criteria for identifying potential pests of concern (Table 6). Criterion 2a includes pests that are present in both Australia and the United States but with restricted distribution in the United States and little chance of being internally spread within the United States because of the lack of reason for movement of contaminated material from the restricted area. Imports of such materials could well traverse and break these barriers. Criterion 4 was expanded to include 4a, native species that have reached the probable limits of their range but may differ in their capacity for causing damage, based on the genetic variation exhibited by the species. The team used a set of criteria to determine the level of risk associated with each risk element.

Twenty-two individual pest risk assessments (IPRAs) were prepared for pests of the 18 eucalypt species, 15 dealing with insect pests and seven with pathogens. The organisms from these assessments are grouped in Tables 11 and 12 according to the substrate they are likely to occupy (on bark, in or under bark, inside wood). Table 11 summarizes the pest risk potential with logs as the commodity, while Table 12 summarizes the pest risk potential with chips as the commodity. The team recognizes that these organisms may not be the only ones associated with logs or chips, but they are representative of the diversity of insects and pathogens that inhabit logs. The lack of biological information on a given insect or pathogen should not be equated with low risk (USDA Forest Service 1993). However, by necessity, this pest risk assessment focuses on those insects and pathogens for which biological information is available. By developing IPRAs for known organisms that inhabit a variety of niches on logs, APHIS can subsequently identify effective mitigation measures to eliminate the recognized pests and any similar unknown organisms that inhabit the same niches.

Table 11—Summary of risk potentials for Australian pests of concern for unprocessed eucalypt logs (on bark, in or under bark, or in wood)[a]

	Likelihood of introduction				Consequences of introduction			
Common name (*Scientific name*)	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environmental damage	Social/ political	Pest risk potential
On bark								
Insects								
Pergid sawflies (*Perga affinis affinis*, *P. affinis insularis*, *P. dorsalis*, *P. schiodtei*)	L	L	M	M	M	L	L	L
Leaf beetles (*Chrysophtharta* and *Paropsis* species, including *C. agricola, C. bimaculata*, *P. atomaria*, *P. charybdis*, *P. delittlei*)	M	M	H	M	H	L	L	H
Lerp psyllids (*Cardiaspina* and *Glycaspis* species, including *C. albitextura*, *C. bilobata*, *C. fiscella*, *C. maniformis*, *C. retator*, *C. squamula*, *G. baileyi*, *G. nigrocincta*)	L	L	H	M	H	L	L	L
Gum tree scales (*Eriococcus* species, especially *E. coriaceus* and *E. confusus*)	L	L	H	M	M	L	L	L
Walking sticks (*Ctenomorphodes tessulatus*, *Didymuria violescens*, *Podacanthus wilkinsoni*)	L	M	M	L	M	M	M	L
Gumleaf skeletonizer moth (*Uraba lugens*)	H	H	H	M	M	M	M	M
Pathogens								
Foliar diseases (*Aulographina eucalypti*, *Cryptosporiopsis eucalypti*, *Cylindrocladium* spp., *Phaeophleospora* spp., *Mycosphaerella* spp., *Quambalaria pitereka*)	M	H	H	M	M	M	L	M
In or under bark								
Insects NONE								
Pathogens								
Botryosphaeria canker (*Botryosphaeria ribis*)	H	H	H	H	M	L	L	H
Cryphonectria eucalypti canker (*Cryphonectria eucalypti*)	H	H	H	H	M	L	L	H
Seiridium cankers (*Seiridium eucalypti*, *Seiridium papillatum*)	M	H	M	M	M	L	L	M
In wood								
Insects								
Ambrosia beetles and pinworms (*Austroplatypus incompertus*; *Platypus australis, P. subgranosus*, *P. tuberculosus*; *Amasa truncatus;* *Ambrosiodmus compressus*; *Xyleborus perforans*; *Xylosandrus solidus*; *Atractocerus crassicornis*, *A. kreuslerae*, *Atractocerus* sp.)	H	H	M	H	H	M	M	H
Round-headed wood borers [*Callidiopsis scutellaris*, *Coptocercus rubripes*, *Coptocercus* sp.; *Epithora dorsalis*; *Hesthesis cingulata*; *Macrones rufus*; *Phlyctaenodes pustulosus*; *Phoracantha* (=*Tryphocaria*) *acanthocera*, *P.* (=*Tryphocaria*) *mastersi*, *P. odewahni,* *P. punctipennis*, *P.* (=*Tryphocaria*) *solida,* *P. tricuspis*; *Scolecobrotus westwoodi*; *Tessaromma undatum*; *Zygocera canosa*)]	H	H	H	H	H	L	H	H

Table 11—Summary of risk potentials for Australian pests of concern for unprocessed eucalypt logs (on bark, in or under bark, or in wood)[a]—con.

	Likelihood of introduction				Consequences of introduction			
Common name (*Scientific name*)	Host association	Entry potential	Colonization potential	Spread potential	Economic damage	Environmental damage	Social/ political	Pest risk potential
In wood—Insects con.								
Ghost moths and carpenterworms [*Abantiades latipennis*; *Aenetus eximius*, *A. ligniveren*, *A. paradiseus*; *Zelotypia stacyi*; *Endoxyla cinereus* (=*Xyleutes boisduvali*), *Endoxyla* spp. (=*Xyleutes* spp.)]	M	H	M	M	H	M	M	H
True powderpost beetles (*Lyctus brunneus*, *L. costatus*, *L. discedens*, *L. parallelocollis*; *Minthea rugicollis*)	H	H	H	H	H	L	M	H
False powderpost or auger beetles (*Bostrychopsis jesuita*; *Mesoxylion collaris*; *Sinoxylon anale*; *Xylion cylindricus*; *Xylobosca bispinosa*; *Xylodeleis obsipa*, *Xylopsocus gibbicollis*; *Xylothrips religiosus*; *Xylotillus lindi*)	H	H	H	H	M	L	L	H
Dampwood termite (*Porotermes adamsoni*)	H	H	H	H	H	M	H	H
Giant termite (*Mastotermes darwiniensis*)	H	H	H	H	H	M	H	H
Drywood termites (*Neotermes insularis*; *Kalotermes rufinotum*, *K. banksiae*; *Ceratokalotermes spoliator*; *Glyptotermes tuberculatus*; *Bifiditermes condonensis*; *Cryptotermes primus*, *C. brevis*, *C. domesticus*, *C. dudleyi*, *C. cynocephalus*)	H	H	H	H	M	L	M	H
Subterranean termites (*Schedorhinotermes intermedius intermedius*, *S. i. actuosus*, *S. i. breinli*, *S. i. seclusus*, *S. reticulatus*; *Heterotermes ferox*, *H. paradoxus*; *Coptotermes acinaciformis*, *C. frenchi*, *C. lacteus*, *C. raffrayi*; *Microcerotermes boreus*, *M. distinctus*, *M. implicadus*, *M. nervosus*, *M. turneri*; *Nasutitermes exitiosis*)	H	H	H	H	H	M	M	H
Pathogens								
Stain and vascular wilt fungi [*Ceratocystis eucalypti, C. moniliformis*, *C. moniliformopsis*, *Ophiostoma pluriannulatum* (or closely related species), *Ceratocystis* spp., *Ophiostoma* spp.; *Chalara* spp., *Graphium* spp., *Leptographium lundbergii* (anamorphic stages of Ophiostomataceae)]	H	H	H	H	M	M	M	H
Armillaria root rot (*Armillaria fumosa*, *A. hinnulea*, *A. luteobubalina*, *A. novae-zealandiae*, *A. pallidula*)	H	H	L	H	H	M	L	M
Root-, sapwood-, and heart-rots [*Phellinus gilvus*, *P. noxius*, *P. rimosus*, *P. robustus*, *P. wahlbergii*; *Inonotus albertinii, I. chondromyeluis*, *I. rheades*; *Hymenochaete* sp.; *Stereum hirsutum*; *Fistulina spiculifera*; *Ganoderma lucidum*; *Gymnopilus junonius* (= *G. spectabilus* = *G. pampeanus*); *Omphalotus nidiformis*; *Perenniporia medulla-panis*; *Piptiporus australiensis*, *P. portentosus*]	M	H	M	M	H	L	L	H

[a]H=high rating; M=moderate rating; L=low rating.

Table 12—Summary of risk potentials for Australian pests of concern for unprocessed eucalypt chips[a]

Common name (*Scientific name*)	Likelihood of introduction: Host association	Likelihood of introduction: Entry potential	Likelihood of introduction: Colonization potential	Likelihood of introduction: Spread potential	Consequences of introduction: Economic damage	Consequences of introduction: Environmental damage	Consequences of introduction: Social/Political	Pest risk potential
On bark								
Insects								
Pergid sawflies (*Perga affinis affinis*, *P. affinis insularis*, *P. dorsalis*, *P. schiodtei*)	L	L	M	M	M	L	L	L
Leaf beetles (*Chrysophtharta* and *Paropsis* species, including *C. agricola, C. bimaculata*, *P. atomaria, P. charybdis*, *P. delittlei*)	L	L	H	M	H	L	L	L
Lerp psyllids (*Cardiaspina* and *Glycaspis* species, including *C. albitextura*, *C. bilobata, C. fiscella, C. maniformis*, *C. retator*, *C. squamula*, *G. baileyi*, *G. nigrocincta*)	L	L	H	M	H	L	L	L
Gum tree scales (*Eriococcus* species, especially *E. coriaceus* and *E. confusus*)	L	L	H	M	M	L	L	L
Walking sticks (*Ctenomorphodes tessulatus*, *Didymuria violescens*, *Podacanthus wilkinsoni*)	L	L	M	L	M	M	M	L
Gumleaf skeletonizer moth (*Uraba lugens*)	M	L	H	M	M	M	M	L
Pathogens								
Foliar diseases (*Aulographina eucalypti*, *Cryptosporiopsis eucalypti*, *Cylindrocladium* spp., *Phaeophleospora* spp., *Mycosphaerella* spp., *Quambalaria pitereka*)	L	L	H	M	M	M	L	L
In or under bark								
Insects NONE								
Pathogens								
Botryosphaeria canker (*Botryosphaeria ribis*)	H	M	H	H	M	L	L	M
Cryphonectria eucalypti canker (*Cryphonectria eucalypti*)	H	H	H	H	M	L	L	H
Seiridium cankers (*Seiridium eucalypti*, *Seiridium papillatum*)	M	L	M	M	M	L	L	M
In wood								
Insects								
Ambrosia beetles and pinworms (*Austroplatypus incompertus*; *Platypus australis*, *P. subgranosus*, *P. tuberculosus*; *Amasa truncatus; Ambrosiodmus compressus*; *Xyleborus perforans*; *Xylosandrus solidus*; *Atractocerus crassicornis*, *A. kreuslerae*, *Atractocerus* sp.)	M	M	M	H	H	M	M	M
Round-headed wood borers [*Callidiopsis scutellaris*; *Coptocercus rubripes*, *Coptocercus* sp.; *Epithora dorsalis*; *Hesthesis cingulata*; *Macrones rufus*; *Phlyctaenodes pustulosus*; *Phoracantha* (=*Tryphocaria*) *acanthocera*, *P.* (=*Tryphocaria*) *mastersi*, *P. odewahni*, *P. punctipennis*, *P.* (=*Tryphocaria*) *solida*, *P. tricuspis*; *Scolecobrotus westwoodi*; *Tessaromma undatum*; *Zygocera canosa*]	L	L	H	H	H	L	H	L

Table 12—Summary of risk potentials for Australian pests of concern for unprocessed eucalypt chips[a]—con.

Common name (*Scientific name*)	Likelihood of introduction: Host association	Entry potential	Colonization potential	Spread potential	Consequences of introduction: Economic damage	Environmental damage	Social/Political	Pest risk potential
In wood—Insects, con.								
Ghost moths and carpenterworms [*Abantiades latipennis*; *Aenetus eximius*, *A. ligniveren*, *A. paradiseus*; *Zelotypia stacyi*; *Endoxyla cinereus* (=*Xyleutes boisduvali*), *Endoxyla* spp. (=*Xyleutes* spp.)]	L	L	M	M	H	M	M	L
True powderpost beetles (*Lyctus brunneus*, *L. costatus*, *L. discedens*, *L. parallelocollis*; *Minthea rugicollis*)	H	H	H	H	H	L	M	H
False powderpost or auger beetles (*Bostrychopsis jesuita*; *Mesoxylion collaris*; *Sinoxylon anale*; *Xylion cylindricus*; *Xylobosca bispinosa*; *Xylodeleis obsipa*, *Xylopsocus gibbicollis*; *Xylothrips religiosus*; *Xylotillus lindi*)	H	H	H	H	M	L	L	H
Dampwood termite (*Porotermes adamsoni*)	L	L	H	H	H	M	H	L
Giant termite (*Mastotermes darwiniensis*)	L	L	H	H	H	M	H	L
Drywood termites (*Neotermes insularis*; *Kalotermes rufinotum*, *K. banksiae*; *Ceratokalotermes spoliator*; *Glyptotermes tuberculatus*; *Bifiditermes condonensis*; *Cryptotermes primus*, *C. brevis*, *C. domesticus*, *C. dudleyi*, *C. cynocephalus*)	L	L	H	H	M	L	M	L
Subterranean termites (*Schedorhinotermes intermedius intermedius*, *S. i. actuosus*, *S. i. breinli*, *S. i. seclusus*, *S. reticulatus*; *Heterotermes ferox*, *H. paradoxus*; *Coptotermes acinaciformis*, *C. frenchi*, *C. lacteus*, *C. raffrayi*; *Microcerotermes boreus*, *M. distinctus*, *M. implicadus*, *M. nervosus*, *M. turneri*; *Nasutitermes exitiosis*)	L	L	H	H	H	M	M	L
Pathogens								
Stain and vascular wilt fungi [*Ceratocystis eucalypti*, *C. moniliformis*, *C. moniliformopsis*, *Ophiostoma pluriannulatum* (or closely related species), *Ceratocystis* spp., *Ophiostoma* spp.; *Chalara* spp., *Graphium* spp., *Leptographium lundbergii* (anamorphic stages of Ophiostomataceae)]	H	H	H	H	M	M	M	H
Armillaria root rot (*Armillaria fumosa*, *A. hinnulea*, *A. luteobubalina*, *A. novae-zealandiae, A. pallidula*)	H	L	L	H	H	M	L	L
Root-, sapwood-, and heart-rots [*Phellinus gilvus*, *P. noxius*, *P. rimosus*, *P. robustus*, *P. wahlbergii*; *Inonotus albertinii*, *I. chondromyeluis*, *I. rheades*; *Hymenochaete* sp.; *Stereum hirsutum*; *Fistulina spiculifera*; *Ganoderma lucidum*; *Gymnopilus junonius* (= *G. spectabilus* = *G. pampeanus*); *Omphalotus nidiformis*; *Perenniporia medulla-panis*; *Piptiporus australiensis*, *P. portentosus*]	M	M	M	M	H	L	L	H

[a]H=high rating; M=moderate rating; L=low rating.

Major Pests of Eucalypts on Imported Logs or Chips

Eucalypt Logs as Commodity

Some of the organisms of concern on eucalypts [for example, Pergid sawflies (*Perga affinis affinis, P. affinis insularis, P. dorsali, P. schiodtei*), leaf beetles (*Chrysophtharta agricola, C. bimaculata, Paropsis atomaria, P. charybdis, P. delittlei*), lerp psyllids (*Cardiaspina albitextura, C. bilobata, C. fiscella, C. maniformis, C. retator, C. squamula, Glycaspis baileyi, G. nigrocincta*), gum tree scales (*Eriococcus coriaceus, E. confusus*), walking sticks (*Ctenomorphodes tessulatus, Didymuria violescens, Podacanthus wilkinsoni*), gumleaf skeletonizer moth (*Uraba lugens*), and foliar pathogens (*Aulographina eucalypti, Cryptosporiopsis eucalypti, Cylindrocladium* spp., *Phaeophleospora* spp., *Mycosphaerella* spp., *Quambalaria pitereka*)] would be associated only with logs as hitchhikers, most likely confined to the bark surface. Although these hitchhiking organisms are generally not considered likely to be found on logs, the foliage-feeding leaf beetles were rated a high risk potential because they have a high colonization potential and they are serious pests in eucalypt plantations. The gumleaf skeletonizer moth and foliar fungi were identified in the risk assessment as a moderate risk potential. Both merit a moderate rating because of their possible association with bark and not because of high consequences once introduced.

Insects and pathogens that inhabit the inner bark and wood have a higher probability of being imported with logs than do organisms on the bark, particularly in the absence of mitigation measures. Three canker-causing fungi were identified as occurring in or under the bark. *Botryosphaeria ribis* and *Cryphonectria eucalypti* were rated as a high risk potential. *Botryosphaeria ribis* is of concern because of its wide host range and genetic variability. The concern arises from the genetic diversity of this organism and the potential for this diversity to be reflected in varying levels of virulence on different hosts. *Cryphonectria eucalypti* is a recently identified fungus similar to one that causes chestnut blight and to a second pathogen that is native to the United States that causes pin oak blight. Probable long-distance transport to South Africa and potential unknown hardwood hosts in the United States led to its high rating. The two species of *Seiridium* (*S. eucalypti, S. papillatum*) were rated as a moderate risk potential, primarily because known hosts of these pathogens are restricted to eucalypts and consequences of introduction would be limited.

Of 12 groups of insects and pathogens that occur in the wood, 11 were rated as a high risk potential. Ambrosia beetles and pinworms (*Austroplatypus incompertus; Platypus australis, P. subgranosus, P. tuberculosus; Amasa truncatus; Ambrosiodmus compressus; Xyleborus perforans, Xylosandrus solidus; Atractocerus crassicornis, A. kreuslerae, Atractocerus* sp.) infestations result in degrade caused by their galleries and, in the case of the ambrosia beetles, by the localized staining from the associated symbiotic fungi. As controls are not currently available and costs of quarantine enforcement would be high, economic damage potential could be significant. Round-headed wood borers [such as *Callidiopsis scutellaris*; *Coptocercus rubripes*, *Coptocercus* sp.; *Epithora dorsalis*; *Hesthesis cingulata*; *Macrones rufus*, *Phlyctaenodes pustulosus*; *Phoracantha* (=*Tryphocaria*) *acanthocera*, *P*. (=*Tryphocaria*) *mastersi*, *P. odewahni*, *P. punctipennis*, *P*. (=*Tryphocaria*) *solida*, *P. tricuspis*; *Scolecobrotus westwoodi*; *Tessaromma undatum*; *Zygocera canosa*] are commonly intercepted in U.S. ports in connection with trade involving various forms of solid unprocessed wood. Two introduced species of *Phoracantha* have successfully established on *Eucalyptus* in California, and one species (*P. semipunctata*) has established in Hawaii. Some genera have either demonstrated adaptability to new hosts or already have hosts outside the genus *Eucalyptus*. Ghost moths and carpenterworms [*Abantiades latipennis; Aenetus eximius, A. ligniveren, A. paradiseus; Zelotypia stacyi; Endoxyla cinereus* (=*Xyleutes boisduvali*), *Endoxyla* spp. (=*Xyleutes* spp.)] are significant plantation pests in three Australian states, causing reduced value of infested wood. Controls for these wood-infesting insects are generally ineffective. The wood-inhabiting true powderpost beetles (*Lyctus brunneus, L. costatus, L. discedens, L. parallelocollis; Minthea rugicollis*) and the false powderpost or auger beetles (*Bostrychopsis jesuita; Mesoxylion collaris; Sinoxylon anale; Xylion cylindricus; Xylobosca bispinosa; Xylodeleis obsipa, Xylopsocus gibbicollis; Xylothrips religiosus; Xylotillus lindi*) were rated as a high risk potential. These polyphagous insects would likely be associated with logs or chips, would survive during transit, and attack most hardwood species in use. The dampwood termite (*Porotermes adamsoni*) and the giant termite (*Mastotermes darwiniensis*) will attack untreated wood and live trees of numerous hardwood and softwood species and could cause significant damage in moist, warm climates. Drywood termites (*Neotermes insularis; Kalotermes rufinotum, K. banksiae; Ceratokalotermes spoliator; Glyptotermes tuberculatus; Bifiditermes condonensis; Cryptotermes primus, C. brevis, C. domesticus, C. dudleyi, C. cynocephalus*) damage untreated wood in structures and result in considerable economic loss. Subterranean termites (*Schedorhinotermes intermedius intermedius, S. i. actuosus, S. i. breinli, S. i. seclusus, S. reticulatus; Heterotermes ferox, H. paradoxus; Coptotermes acinaciformis, C. frenchi, C. lacteus, C. raffrayi; Microcerotermes boreus, M. distinctus, M. implicadus, M. nervosus, M. turneri; Nasutitermes exitiosis*) attack untreated wood and some attack live trees. They could compete with native termites that degrade and decompose wood in use and could pose a significant hazard to street trees. The stain and vascular wilt fungi [*Ceratocystis eucalypti, C. moniliformis, C. moniliformopsis, Ophiostoma pluriannulatum* (or closely related species), *Ceratocystis* spp., *Ophiostoma* spp.; *Chalara* spp., *Graphium* spp., *Leptographium lundbergii* (anamorphic stages of Ophiostomataceae)] were given a high risk potential because the lack of information on Australian species of *Ceratocystis* and *Ophiostoma* raises concern. The high risk potential is based on the possibility that a species in this group that is saprophytic in Australia could find highly susceptible hosts in the United States, and the potential of introducing virulent species, biotypes, or strains exists. The root-, sapwood-, and heart-rot fungi [*Phellinus gilvus, P. noxius, P. rimosus, P. robustus, P. wahlbergii*; *Inonotus albertinii, I. chondromyeluis, I. rheades*; *Hymenochaete* sp.; *Stereum hirsutum; Fistulina spiculifera*; *Ganoderma lucidum*; *Gymnopilus junonius* (= *G. spectabilus* = *G. pampeanus*); *Omphalotus nidiformis; Perenniporia medulla-panis*; *Piptiporus australiensis, P. portentosus*] received a high rating because the taxonomy of these deep wood fungi is in flux, and named species are questionable. An organism with the same name in Australia and the United States may in fact differ in virulence. All are capable of surviving as saprophytes in wood for long periods of time, increasing the opportunity for transport. A limiting factor in their establishment in the United States may be their restricted dissemination ability once they arrive.

The deep-wood Armillaria root-rot fungi (*Armillaria fumosa*, *A. hinnulea, A. luteobubalina, A. novae-zealandiae, A pallidula*) were rated as moderate risk potential rather than high because of the low likelihood of these fungi producing basidiomes and basidiospores needed for colonization upon arrival in the United States.

In assessing the risk of potential pests, the fact that insects and microorganisms invade logs in a predictable temporal sequence, dictated by the condition of the host, is important. At the time of felling, logs will contain any pathogens and borers present in the bole of the living tree. Certain life stages of defoliating insects may be attached to the bark. Within the first several weeks after felling, beetles and borers may colonize logs. Also, certain wood borers may deposit eggs on the bark of logs shortly after harvest. Whether bark- and wood-boring insects will be common on export logs will depend in part on how rapidly the logs are removed from harvest sites and loaded onto ships, trains, or trucks for transport to the United States.

Eucalypt Chips as Commodity

When chips rather than logs are considered as the commodity, the risk potential changes for several of the groups of organisms (Table 12). Of the seven groups of organisms occurring on the bark, the rating for the leaf beetles changes from high to low, whereas the rating for gumleaf skeletonizer moth and for foliar diseases changes from moderate to low. The risk potential for the four remaining groups (Pergid sawflies, lerp psyllids, gum tree scales, and walking sticks) remains as low. The reduction in ratings is generally due to the reduced levels of bark present in chips compared with logs.

Of the three groups of canker fungi on or in the bark, the rating for *Botryosphaeria ribis* is reduced from high to moderate, the rating for *Cryphonectria eucalypti* remains high, and the rating for the Seiridium canker fungi remains as moderate. The change in rating for Botryosphaeria canker is because of the suspected reduction in fruiting body production related to the lack of bark with the commodity. This causes a lowering of rating for entry potential. It is suspected that this reduction will not be as significant in *Cryphonectria* because of its possible ability to fruit directly on wood.

Of the 12 groups of organisms occurring in the wood, the high risk potential for the true powderpost beetles, false powderpost (auger) beetles, the stain and vascular wilt fungi, and the root-, sapwood-, and heart-rot fungi remain high because of the likelihood of these organisms surviving the chipping process. Ratings for the remaining eight groups of deep wood organisms change considerably. The risk potential for ambrosia beetles and pinworms dropped from high to moderate. The risk potential for the round-headed wood borers, the ghost moths and carpenterworms, the dampwood termite, the giant termite, the drywood termites, and the subterranean termites dropped from high to low. For host material infested with those insects before chipping, it was thought unlikely that any life stage that would pass successfully through the chipping process could subsequently survive in chips due to altered moisture and temperature. The risk potential for the deep wood Armillaria root-rot fungi dropped from moderate to low because of the low likelihood of survival in chip piles.

The changes in risk potentials for the two commodities, logs and chips, are compared directly in Table 13.

We recognize that other potential pathways exist for the introduction of forest pests. Though deserving of examination, these pathways may be difficult if not impossible to predict and are not a focus of this assessment.

Factors Influencing Risk Potential

During site visits, we were informed of and observed differences in harvesting and processing practices among regions of Australia. These differences, such as debarking efficiency, can influence the risk potential for certain pests, especially hitchhikers and those that invade the inner bark. In addition to harvesting practices, some differences were noted among regions of Australia in the occurrence and extent of certain pest organisms. These differences are noted in the individual pest risk assessments. They may influence the risk potential for certain organisms from specific regions. This is compounded by the fact that certain species of eucalypts are preferentially planted in different areas.

Table 13—Summary of risk potentials for Australian pests of concern, eucalypt logs versus chips as the commodity[a]

Organisms	Logs	Chips
On bark		
Pergid sawflies	L	L
Leaf beetles	H	L
Lerp psyllids	L	L
Gum tree scales	L	L
Walking sticks	L	L
Gumleaf skeletonizer moth	M	L
Foliar diseases	M	L
In or under bark		
Botryosphaeria canker	H	M
Cryphonectria eucalypti canker	H	H
Seiridium cankers	M	M
In wood		
Ambrosia beetles & pinworms	H	M
Round-headed wood borers	H	L
Ghost moths and carpenter-worms	H	L
True powderpost beetles	H	H
False powderpost (auger) beetles	H	H
Dampwood termite	H	L
Giant termite	H	L
Drywood termites	H	L
Subterranean termites	H	L
Stain and vascular wilt fungi	H	H
Armillaria root rot	M	L
Root-, sapwood-, and heart-rots	H	H

[a]H=high rating; M=moderate rating; L=low rating.

Effects of Chipping on Insects and Pathogens

Other practices, such as chip production, can also influence the likelihood of pest occurrence and transport. The risk rating of potential pest species was based on the concept of whole log importation and on chip importation. Clearly, debarking and reducing logs to chips will seriously impact the survival and hence the risk of importation of certain pests. Some pests, primarily insects, will be adversely affected by chipping because of the actual destruction of living organisms or disruption of host material so that life stages cannot be completed. Thus, of the insects for which IPRAs were done, all except the true powderpost beetles and the false powderpost beetles would be rated at moderate or low risk of surviving chipping and transport. The extent of insect population reduction due to chipping would vary from virtual elimination to various levels of reduction, depending on insect size and life stage, operating characteristics of the chipping machinery, and other factors.

Other organisms, such as fungi, may not be affected by chipping or could be positively or negatively affected. The production of chips will result in considerably more surface area on which fructifications could develop. It would also make it impossible to visually inspect for certain defects, such as cankers and decay. The smaller the size of the wood chips, the quicker they would dry out, and the less the risk of potential pests surviving. Smaller size chips would probably not provide an adequate food base to permit fruiting of decay fungi, but these fungi could survive as mycelia or rhizomorphs. On the other hand, large piles of chips will generate heat internally and possibly have large areas under anaerobic conditions that may be damaging to fungal pathogens, either directly or through the encouragement of thermophilic fungi that may be antagonistic to the pathogens. Internal temperatures of hardwood chip piles have been reported to reach 49°C to 82°C after 5 to 7 days (Fuller 1985), temperatures sufficiently high to inhibit or kill most fungal pathogens. Heat treatments ranging from 65.6°C for 75 min to 100°C for 5 min generally have been regarded as the minimal times and internal wood temperatures required for wood sterilization. Some fungi isolated from woodchip piles have been found to survive exposure to temperatures of 65°C or greater for times ranging from 8 to 72 h (Zabel and Morrell 1992). Chips on the surface of undisturbed chip piles will be unaffected by heating. While chipping, piling, storage, and transporting eucalypts may alter the risk of pest importation, there is little or no information on the magnitude of risk reduction. Other risks, such as insect hitchhikers on transport vehicles, would remain unchanged.

The temperature, moisture, and air content in wood chip piles vary with the pile volume and with time. Although the piles may rest undisturbed for extended periods, they also undergo repeated mixing during transportation, storage, and distribution. These dynamics may affect insect and pathogen survival, reproduction, and population levels, as well as community composition. Heat generated during the decomposition process favors thermotolerant and thermophilic organisms over mesophilic organisms. Dwinell (1986) found that in piled southern pine chips, the pinewood nematode [*Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickel] primarily inhabits fresh chips and chips located in the outer shell of the pile due to heat generated during the decomposition process, whereas chips in the interior of the pile do not harbor the nematode when oxidative processes cause spontaneous heating to 60°C (140°F). Dwinell (1987) and Leesch and others (1989) investigated the population dynamics of the pinewood nematode in southern pine chips stored in the hold of ships during transport from Georgia to Sweden.

Chips in the bottom of holds averaged temperatures of 35°C (95°F) and contained high levels of the pinewood nematode. Few pinewood nematodes were found in the middle of holds, where temperatures averaged 48°C (118°F). Dwinell concluded that the bottom of the holds served as an incubator for the nematode during the 17 to 19 day voyages. In laboratory studies, population densities of the pinewood nematode declined rapidly at temperatures above 45°C (113°F), and the nematode was not recovered after 1 and 3 days at 50°C and 48°C (122°F and 118°F), respectively (Dwinell 1990).

In a study of Monterey pine infected with the pitch canker pathogen *Fusarium circinatum* Nirenber and O'Donnell, chipping branches reduced the emergence of twig beetles (*Pityophthorus* spp. and associates) by about 95%, compared with emergence from intact branches (McNee and others 2002). The frequency of pathogen isolation from branch chips was highly variable and increased with increasing severity of disease symptoms. Pathogen isolation frequencies from 1-year-old chips were lower than in fresh chips, but the reduction was not significant in chips with low initial isolation frequencies.

Micales and Burdsall (2002) analyzed samples from 16 shipments of unprocessed *Pinus radiata* chips exported from Chile to Bellingham, Washington. Six fungal genera (*Geotrichum*, *Gloeocladium*, *Paecilomyces*, *Penicillium*, *Phanerochaete*, and *Trichoderma*) were consistently recovered and represented nearly 90% of the isolates. Species of *Trichoderma* accounted for nearly half the total species isolated. *Graphium*, a genus of potential bluestain or vascular wilt pathogens, was recovered from only 0.32% of the specimens. They concluded that species of *Trichoderma* appear to competitively inhibit other fungi in woodchip shipments.

Conclusions

There are numerous potential pest organisms found on eucalypts in Australia that have a high likelihood of being inadvertently introduced into the United States on unprocessed logs or chips. Some of these organisms are attracted to recently harvested logs, whereas others are affiliated with logs in a peripheral fashion but nonetheless pose serious threats to eucalypts or other hosts in the United States. Thus, the potential mechanisms of log and chip infestation by nonindigenous pests are complex.

Eucalypts are not native to the United States and occur in limited locations, notably California, Hawaii, and Florida. Thus, any introductions of pest organisms, if limited to eucalypts, would have limited environmental consequences. However, the potential for crossovers of eucalypt pests from Australia to native hosts in the United States exists and could result in more significant adverse effects. The array of potential hosts in the United States is not fully known. Until more specific information is available, caution seems prudent. The consequences to Hawaii could be considerable because of the extent of endemic species, especially Myrtaceae, that are present there. Most previous log import risk assessments did not include Hawaii as a potential port of entry. Because of the elevated risk to Hawaii, we included it in this assessment.

For those organisms of concern that are associated with the 18 species of Australian eucalypts considered in this PRA, specific phytosanitary measures may be required to ensure the quarantine safety of proposed importations. Detailed examination and selection of appropriate phytosanitary measures to mitigate pest risk is the responsibility of APHIS as part of the pest risk management phase (Orr and others 1993) and is beyond the scope of this assessment.

Chapter 5. Bibliography

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Appendix A—Team's Site Visits to Australia

Canberra: September 12–15, 2001

WIPRAMET team members Borys Tkacz, John Kliejunas, Gregg DeNitto, Harold Burdsall, Jessie Micales, Dennis Haugen, Michael Haverty, and Andris Eglitis traveled to Australia with APHIS representatives Jane Levy and Edward Podleckis. The entire team met in Canberra for 2 days of discussions with Australian officials and then divided into three sub-teams that visited two states each for several days. Once the state visits were concluded, the Team gathered again in Canberra for a closeout session before returning to the United States.

The Team departed the United States from San Francisco on September 10, 2001, and arrived in Sydney, Australia, on September 12.

September 12

The Team arrived in Canberra, Australian Capital Territory.

September 13

The Team met with officials from Australia's Department of Agriculture, Fisheries and Forestry (AFFA). The AFFA Department includes the Australian Quarantine and Inspection Service (AQIS) and an area called Market Access and Biosecurity (MAB) that contains the Plant and Animal Quarantine Policy Division. Also present at the meeting was USDA–APHIS Area Director for Oceania, Dennis Hannapel, who is an APHIS attaché in Australia. We were welcomed by Dr. Simon Hearn, Executive Manager of Market Access and Biosecurity. Dr. Hearn described the roles of AQIS (inspections) and Biosecurity Australia (scientific aspects of policy). His office has carried out a number of risk assessments for imports coming to Australia. Dr. Hearn pointed out that they have the same debates in Australia as in the United States over the issue of what constitutes "reasonable risk."

Dr. Hearn also discussed forestry in Australia, pointing out that there are 1.5 million hectares (3.7 million acres) of plantations in the country (70% softwoods and 30% hardwoods, mostly *Eucalyptus*). The emphasis on forestry is based on economic, environmental, and recreational reasons. Currently, the management of forest plantations is mostly at the State level, with a number of common agreements regarding planting and harvesting developed across the tiers of government in Australia. Forestry is seen as being very important for the future of Australia.

Dr. Hearn explained the origin of the capital city of Canberra. The Federation of Australia was formed in 1901 and they could not decide between Sydney and Melbourne as a site for the capital, so they planned and built a city in between the two. The Australian Capital Territory (ACT) is similar to the District of Columbia in the United States. There is not much industry in ACT, and about 70% of the area has not been heavily developed.

We met Dr. Sharan Singh, a plant pathologist and head officer for Quarantine in Biosecurity Australia. Dr. Singh works on import risk assessments (IRAs), helps develop international import standards, and manages the Americas Group (one of six geographical areas under Biosecurity Australia). Dr. Singh introduced the other participants at the meeting, including Dr. Emmanuel Mireku, a plant pathologist who works with Dr. Singh and who coordinated our site visit in Australia, Ann Gardner from the Asia Team, Doug Walsh from the Americas Team, Bill Magee, Senior Manager for Biosecurity Australia, Dr. Paul Pheloung, Office of the Chief Plant Protection Officer, and several other staff members from Biosecurity Australia.

Team leader Borys Tkacz introduced the members of WIPRAMET and the APHIS representatives, discussed how the Team was formed and how it functions, and talked about the importance of invasive species as a high priority for the United States. Citing the work of David Pimentel at Cornell University, Borys pointed out that the impacts of non-native forest pests are placed at $4.2 billion per year in reduced yields, control costs, and other factors. Non-native invasives produce ecological impacts as well, including the loss of wildlife habitat, reduced biodiversity, increased fuel loading, and increased damage by native pests. The increased interest in importing wood from all over the world has led to the work of WIPRAMET. Borys then gave a presentation on the pest risk assessment (PRA) process. He described the "pests of concern" list, which is not a quarantine list but does provide a starting point for identifying organisms that could be the subject of detailed individual pest risk assessments (IPRAs). Organisms are grouped into one of five categories, ranging from "non-indigenous plant pest not present in the United States" to "native plant pest but may differ genetically from its counterpart in the United States." There were some questions on how our qualitative assessment arrives at a pest risk potential by combining all seven elements of risk that are evaluated. Borys answered that we still follow the Generic Risk Assessment process described by Orr and others (1993), with some modifications that grew out of the application of that process for the PRA on solid wood packing material that also had WIPRAMET participation.

There was additional discussion on topics such as risk reduction, rules, appeals, and litigation.

The team listened to a presentation by Dr. Mary Harwood, Executive Manager of Biosecurity Australia. She provided an overview of Australia's Import Risk Assessment (IRA) process and pointed out that her office will soon produce an IRA handbook that will come out for public comment. Some changes being made to the existing handbook include the following:

1. Adopting a single approach to risk assessment, combining the routine and non-routine assessments (the IRA team may be small or large depending on the complexity of the assessment)
2. Transparency in the process (the handbook will describe every step along with guiding instructions and a series of scientific templates)
3. Contact with stakeholders early in the process
4. Establishing a "scientific front," where a scientific assessment panel will be formed to judge if good science is applied to the assessment and if a balanced conclusion is reached.

Dr. Harwood presented a flow chart describing the proposed revised IRA framework. The Australian IRA process follows the standards of the IPPC (International Plant Protection Convention) in determining whether organisms are quarantinable or not. In contrast to our IPRA process, the IRA process includes mitigation measures. One of our APHIS advisors, Ed Podleckis, pointed out that in the Safeguarding Review, one group dealing with pest risk assessments had remarked that we look at the Australian example as to how to proceed with risk assessments. Ed pointed out that we in the United States are also looking at early involvement of stakeholders in the PRA process and that our two systems of risk assessment are beginning to look similar.

Bill Magee, Senior Manager for Plant Biosecurity within MAB, discussed current timber trade and some of the associated pest issues. Australia now imports very few logs; almost all the imported wood is in the form of sawn lumber with bark removed. Coniferous sawn timber trade from the United States has declined; most of the Douglas-fir now comes to Australia from Canada. New Zealand also supplies kiln-dried lumber to Australia. Other significant wood importers into Australia are Malaysia and Indonesia. There is a concern about ambrosia beetles for Australian *Pinus radiata* D. Don and hoop pine (*Araucaria cunninghamii* Aiton ex D. Don). Bark removal has been the only mitigation measure applied for pathogens. Biosecurity Australia has received a pest list from California and is obtaining one from New Zealand as well. The question was asked if a pest list from the United States could be considered to include pests from Canada as well. We replied that there was considerable overlap but there may be some pests in Canada that do not occur in the United States. Biosecurity Australia is currently working on an IRA for sawn wood but is still importing it at the same time.

John Caling, database administrator for Plant Biosecurity, discussed the database for interception records associated with wood products imports. The reporting module tracks interceptions associated with 22 commodities, including dunnage. Queries from the database are made through the Microsoft Access program (Microsoft Corporation, Redmond, Washington). We were shown the interception records of pests identified on bulk timber from the United States for the period between January 1990 and December 2000. Interceptions were high in the early 1990s (564 in 1992) but have declined steadily to a low of 26 in 2000. (A number of these interceptions include silvanid stored grain beetles because native grain may be transported in the same ships.)

The Team listened to a presentation by David Heinrich, Manager of Operations Review for AQIS, the Australian Quarantine and Inspection Service. Mr. Heinrich discussed how his Cargo Management Branch clears commodities including timber for entry into the country. When bulk timbers arrive, a sample is laid out and held for 24 h, then inspected, treated (if necessary), and released. When inspections reveal that a treatment is necessary, some of the available options include fumigation with methyl bromide, sulphuryl fluoride (applied offshore), ethylene oxide, heat, gamma radiation, and permanent timber preservatives (offshore). Timber dimensions may be restricted to <200 mm (<7.9 in.) due to limits on the penetrability of fumigants. Quarantine items for imported timber include plant material, animal residues, seeds, soil, bark, and live pests. Inspectors do not look for staining or mold. Equipment used for inspection includes list manifests, crayons, chisels, handsaws, mallets, sledges, tools to enable the inspector to look for insect frass. Some examples of variations from the standard inspection procedure include accredited lumber from California and conifer lumber coming from New Zealand between November and April. These New Zealand shipments are inspected specifically for the longhorn borer *Arhopalus tristis* (New Zealand begins fumigation during the flight period of the beetle). Some issues for AQIS inspectors include the appropriate level of sampling to be done and the breaking up of bundles of wood for more thorough inspection. Generally there is a dramatic increase in detecting the level of infestation when bundles are broken for inspection (3% to 45% increase in infestation). There are safety concerns with breaking bundles and moving material around, and industry personnel are not always available to assist in this process. AQIS has developed a reference guide of timber pests for industry to use so that they can help out with the inspection process.

Judith Downey, manager of AQIS Cargo Business Systems, discussed offshore timber co-regulatory systems and how they relate to import regulations. She pointed out that Canada has an arrangement whereby they carry out a quality check during the grading process and inspect for pinholes and other problems before shipping lumber to Australia. As a further move to improve conditions on their end, the Canadians provide a list of mills that have been accredited. The result has been that the rate of fumigation has dropped from 30% in 1999 to 17% in 2000, although the number of interceptions has not changed. AQIS keeps records on compliance and on the relative "cleanness" of shipments; if five consecutive shipments are clean, then the rate of inspection goes down. Some big improvements have been noted with this approach. (A shipment is considered infested only if a timber pest is present; hitchhikers are not considered). Contamination (for example, weed seeds, soil) is unacceptable, and Canadian exporters are working hard at providing cleaner shipments to Australia.

Mellissa Wood, Database Manager for the National Forest Inventory, Bureau of Rural Sciences (AFFA), gave the Team a presentation on the forest and plantation resources of Australia. The National Forest Inventory (NFI) collects and communicates information about Australia's forests. This is a collaborative effort between the governments of the Commonwealth and the individual States and Territories. NFI has been in existence for 12 years and provides a framework for the States to report information on their native forests and plantations. The data gathered, collated, and reported by NFI include the extent of native forest cover and changes in cover over time, the extent, location, and species involved in plantations, the extent and representation of forest types in conservation reserves, and the tenure of forests by region. The National Forest Inventory makes information available through GIS maps, tables, and graphs. NFI defines a forest as being dominated by trees greater than 2 m (6.6 ft) tall with existing or potential crown cover of at least 20%. This definition is close to the international standard (trees >5 m (>16.4 ft) tall), but the minimum tree height in Australia is set at 2 m (6.6 ft) in order to capture the vast extent of the country's mallee forests that are very significant yet would fall below the international standard of "forest." NFI has 64 broad forest formations that form the basis of mapping units. Collectively, these formations comprise 166 million hectares (410 million acres) of forest cover in Australia, 73% of which is classified as "woodland" (20% to 50% cover), 23% as "open forest" (51% to 80% cover), and 3% as "closed forest" (>80% cover). The 64 forest formations are grouped into 17 broad classes, several of which include eucalypts. In total, there are 124 million hectares (306.4 million acres) of eucalypt forest and 16 million hectares (39.5 million acres) of *Acacia* forest. The next most abundant forest types include *Melaleuca* [4 million hectares (9.9 million acres)] and rainforest [3.5 million hectares (8.6 million acres)]. Nearly 70% of this forested land is in private holdings, which includes 45% in leasehold lands. Public multiple use (State) lands include 7% of the native forest, with other Crown land at 11%. Nature conservation reserves make up 12.3% of the remaining natural forest. About 17% of the native forest is considered commercial, and plantations represent less than 1% of the commercial forest land base.

Plantations, at 1.5 million hectares (3.7 million acres), represent 0.8% of the country's total forest cover. Data from this resource is managed by the National Plantation Inventory (NPI), a component of the NFI that tracks ownerships greater than 1,000 hectares (2,471 acres) in size. Data from plantation holdings smaller than 1,000 hectares are tracked through the National Farm Forest Inventory, a subset of NPI. Farm forestry represents about 5% of the current plantation total. Although 66% of the current area in plantations is in softwoods, there has been a dramatic increase recently in hardwood plantations. Sixty-two percent of the current hardwood plantation resource is Tasmanian blue gum, *Eucalyptus globulus*, grown for short-rotation pulp production. *Pinus radiata*, mostly in southern Australia, represents about 74% of the softwood plantation resource. Most new plantations are now being established on cleared agricultural land rather than on cleared forest land. The plantation resource has increased dramatically in recent years, with 30,000 hectares (74,131 acres) planted in 1995; 55,000 hectares (135,900 acres) in 1997, and 120,000 hectares (296,500 acres) planted in 2000. Ninety-two percent of the plantations were established since 1970; 47% have been planted since 1990. About 46% of the plantations are privately owned, including cases where the land is owned by one party but the trees are owned by another through a lease arrangement. The recent dramatic trends in plantations are toward private ownership and toward hardwood species. Much of the hardwood plantation resource is owned by Japan, and the wood will go directly there as chips once the trees are harvested.

Dr. Mike Cole, Deputy Chief Plant Protection Officer from AFFA, spoke to the Team about Incursion Management, including preparedness and response plans for certain key organisms of concern to Australia. Specifically, response plans are being developed for pitch canker and gypsy moth. Dr. Cole advocated the development of cooperative strategies for preparedness (including cooperative diagnostics) with the United States. He also proposed cooperative strategies for research on pests such as gypsy moth, which finds many eucalypts to be palatable. He plans to run an Asian gypsy moth trapping program in cooperation with State agencies and to develop general awareness programs. A new government agency is being formed, called Plant Health Australia, which will also have industry and State involvement and will focus on Incursion Management. Sources of funding are currently being sought for this new agency. Plant Health Australia will establish a network of key diagnostic centers and emphasize the importance of developing linkages with other scientists in order to maximize efficiency. A general discussion followed Dr. Cole's remarks where Borys emphasized the importance of sharing information at the international level for early detection of pests.

September 14

The Team met with forest pathologists Dr. Glen Kile and Mark Dudzinski at the offices of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Division of Forestry and Forest Products in Yarralumla, ACT. Mr. Dudzinski has worked on *Phytophthora cinnamomi* in the jarrah (*E. marginata*) forests, banksia woodlands, and native heath lands in southwestern Australia; on foliar pathogens of eucalypts and acacias in Australia and Southeast Asia; and on issues relating to stem defect in residual trees following stem wounding during mechanized thinning of regrowth eucalypt forests in southeastern Australia. Dr. Kile, Chief of this research division of CSIRO (Forestry and Forest Products), has many responsibilities, including serving as Chairman of the National Forest Health Committee. This Committee is currently focused on developing a generic incursion management strategy for Australia. An important issue regarding incursion management is that of cost sharing and compensation, determining who should pay. We discussed risks associated with timber imports with Dr. Kile. He stated that even though Australia has been trading with the Pacific Northwest for 100 years, there have not as yet been any introductions of foreign pests from there. He is very concerned about the solid wood packing commodity and felt that global action is needed to address this issue.

An avenue of research in the CSIRO Forest Products Division involves forestry germplasm. Due to increasing interest in fast-growing trees, the Division is investigating the use of *Eucalyptus* brought back to Australia from other parts of the world.

Dr. Kile discussed some foreign organisms that are of concern to Australia. He expressed an interest in pine pitch canker from California. Current pest problems of concern in Australia include some mysterious nematodes in *Pinus radiata* near Melbourne and a fire ant problem in Queensland that is the subject of an eradication program. These recent problems have led to increased funds to manage the country's borders for pest introductions. Another problem of significance in forestry is Dothistroma needle disease [caused by *Dothistroma septospora* (Dorog.) Morelet] in *Pinus radiata*. This disease is a periodic problem that limits *P. radiata* in high rainfall areas. *Dothistroma* has not yet spread to Western Australia or New South Wales, and a program is now underway to breed for resistance to the disease. In February of 2000, *Bursaphelenchus*-like nematodes were found in a dying tree in the suburbs of Melbourne. These have not yet been identified and a *Monochamus* vector has not been found either, although there have been some *Monochamus* interceptions associated with solid wood packing material from China. An interception unrelated to the nematode is of a new species of the wood-boring beetle *Arhopalus*. Australia is very concerned about Asian gypsy moth and is carrying out pheromone trapping near ports and high-risk areas. In addition, a post-barrier surveillance program is in place for the Asian gypsy moth.

Team Leader Borys Tkacz gave a presentation on the PRA process that WIPRAMET is following for this *Eucalyptus* risk assessment and a discussion followed. Dr. Kile felt that insects were probably more likely to be introduced from Australia than pathogens. He also mentioned a new book that has come out on diseases and pathogens of Australian eucalypts. The Team then reviewed the list of pathogens of concern with Dr. Kile and Mr. Dudzinski. Dr. Kile pointed out that there are no mistletoes in Tasmania and that he does not see *Armillaria* as a concern. *Armillaria luteobubalina* is the only pathogen and could be in the sapwood of trees killed by other agents. It is not found in wet forests (for example, *Eucalyptus regnans*) but could be in drier forests. Mark Dudzinski discussed leaf pathogens associated with *Eucalyptus*. The main leaf pathogens are in the genera *Mycosphaerella* (30 species) and *Aulographina*. Dr. Kile believes that the *Aulographina* species are widely distributed and may already be in the United States. *Aulographina eucalypti* is common in Hawaii on *E. globulus* and *E. robusta*. *Harknessia* spp. are widespread wherever *Eucalyptus* occurs. Many of these are leafspot pathogens and can be important defoliators. Both Mr. Dudzinski and Dr. Kile stated that these leaf pathogens are fairly restricted to host species, without much crossover.

Dr. Kile discussed wood decay fungi and pointed out that most of the work on these organisms is old, being derived when old trees were being harvested. Not much has been updated now that the emphasis is on harvesting younger trees. Some species names (for example, in the genus *Ganoderma*) have not been updated.

Dr. Kile pointed out that since 1971 there have been 5 to 6 million tonnes of chips exported to Japan and no pathogens have been reported during that time period. Dr. Kile felt that wood decay fungi would be even less of an issue in plantations than in regrowth, especially in light of the fact that coppice regrowth is likely to be less common than replanting with genetically improved material. He informed us that Tim Wardlaw is working on wood decay fungi associated with regrowth in Tasmania.

Mark Dudzinski discussed canker fungi associated with *Eucalyptus*. *Cryphonectria eucalypti* in Australia is distinct from the North American *Endothia gyrosa* and is associated with dieback, usually as a complex of pathogens and insects. Some young trees have died from this pathogen. *Botryosphaeria* (probably a species different from *B. ribis* and *B. dothidea*) can cause severe cankers especially on trees stressed by drought. The pathogen causes dieback in the tops of trees. *Botryosphaeria* sp. is associated with *Eucalyptus* in other parts of the world and may or may not occur on other hosts (possibly on some Proteaceae). *Cryphonectria* *cubensis* has been isolated once in Australia, from roots of *Eucalyptus* in native forest, but is still considered a quarantine pest. Some work has been done on canker fungi by Dr. Caroline Mohammad and other scientists in Tasmania. Dr. Kile discussed *Ceratocystis eucalypti*, suspected to be a saprophyte, but stated that the distribution of this genus is poorly known in Australia. Mark Dudzinski said that *Cytospora eucalypticola* is very common, but it is not known if the organism occurs in genera other than *Eucalyptus*.

Hal Burdsall inquired about *Laetiporus* and *Polyporus* and was told that the taxonomy of this group is poorly understood in Australia. *Phytophthora cinnamomi* is very important in Western Australia, Tasmania, and Victoria. Some other species of *Phytophthora*, including *P. cryptogea* and *P. drechsleri*, are also associated with tree dieback by causing infections through the roots. Mark mentioned an undescribed foliar *Phytophthora* on *Eucalyptus* in New Zealand.

We learned that many exotic tree species have been planted in Canberra since 1913 and that some have experienced pest problems. Some dieback has been noted on *Pinus ponderosa,* and *Botryosphaeria* has been found on *Sequoia* sp. Other significant exotics include the elm leaf beetle (*Pyrrhalta luteola*) in Victoria and a canker fungus on *Platanus* street trees. An aphid native to California, *Essigella californica*, has become widely established on *Pinus radiata* and is problematic in the Mt. Gambier area where pines are under stress. We learned that Rob Floyd (CSIRO) has a student working on this aphid.

The Team inquired about other organisms that have adapted to *Pinus radiata* in Australia. Dr. Kile responded that Australia's situation is comparable to that in New Zealand, where all the organisms associated with *P. radiata* are ones that have been introduced. He listed the aphid *Essigella californica*, *Ips grandicollis*, *Sirex noctilio,* and *Dothistroma septospora* as the agents of greatest concern on Monterey pine. Of all these organisms, Mark Dudzinski felt that Dothistroma needle blight was the most important. *Armillaria* has not been found on *P. radiata*. Although *A. luteobubalina* may occur where *P. radiata* has been planted, there have been no problems thus far.

We discussed the chipping process for eucalypts and possible pest risks associated with that commodity. Dr. Kile stated that there are tight quality criteria on contaminants, decay, and other factors, and that we can look at the many years of shipping chips to Japan without incident in order to better understand the associated pest risks. We inquired about the survival of fungi on eucalypt chips and were told that studies on chip piles have primarily been done on softwoods and that information was not as readily available for eucalypts.

We inquired about viruses that might be associated with eucalypts and were told about an unusual condition that resembles viral infection, called Mundulla Yellows. A causal agent has not yet been identified for this interveinal discoloration, although the condition does appear to be infectious, particularly in disturbed ecosystems. Mundulla Yellows has been around for about 20 years and seems to be expanding. The condition is found in Western Australia and South Australia and is primarily distributed along roadsides. A broad range of plants is affected by Mundulla Yellows, but thus far there has been no evidence of infection in commercial plantations. Two important eucalypt hosts showing the symptom are river red gum (*Eucalyptus camaldulensis*) and jarrah (*E. marginata*).

Dr. Kile described the structure and function of CSIRO, the largest government research organization in the country. CSIRO has 6,000 employees and an annual budget of AUD800 million. Some of the funding comes from outside sources. There are 21 operating units or divisions. The Division of Forestry and Forest Products (headed by Dr. Kile) has 230 employees.

In the afternoon, the Team traveled to the Australian National University where we were met by Dr. Brian Turner from the Department of Forestry in the School of Resource Management and Environmental Science. The school has a 4-year undergraduate program in forestry with 20 to 30 graduates per year. The school also has a wildlife program but does not offer programs in entomology or pathology.

We had the opportunity to talk with Mr. Ross Florence, native forest silviculturist and eminent forest ecologist who recently authored a book entitled "Ecology and Silviculture of *Eucalyptus* in Australia." Mr. Florence explained that an understanding of the insects and diseases associated with *Eucalyptus* needs to begin with an understanding of the host tree species and the relationships of their communities. He explained why eucalypts are able to dominate all but the driest parts of the Australian continent. As the continents began to separate 50 to 60 million years ago, the rainforests of Australia began to break up and nutrient availability in soils declined. As the continent drifted further north, there was an increase in drought conditions, and fire became an important ecological factor. *Eucalyptus* was the only taxon with the ability to adapt to these three changes from the rainforest environment: (1) decline in soil fertility, (2) greatly reduced available moisture, and (3) influence of fire. As a result of this adaptability, *Eucalyptus* now occurs in all kinds of settings, from coastal rainforests to dry interior sites. Some attributes, or adaptations, that eucalypts possess to make them successful include a woody mass that develops at the junction of the wood and the root. Buds are formed at this woody mass and enable the plant to regenerate when the main plant has been killed. On particularly poor soils, these woody masses contain phosphatase, which enables the eucalypts to take advantage of nutrients not available to other plants. A key process that eucalypts possess for adaptation to low-fertility soils is the ability to conserve nutrients in the sapwood and phloem. There is low sapwood production (only 10 years), and in addition, trees are able to withdraw nutrients from leaves before they fall (2 to 3 years). Fire is an important agent for releasing nutrients in poor soils. Accumulated low-nutrient litter has a high C/N ratio and requires fire as a partial sterilizing agent to flush out the nutrients. (Not all eucalypts respond to increased nutrients.) Another important adaptation possessed by eucalypts is drought tolerance (not the same as "drought avoidance" through stomatal closure, which is the adaptation to drought that is associated with *Acacia* spp.). In the western dry regions of Australia, the lignotuber is an adaptation that allows root systems to go to greater depths before shoot growth begins.

According to Mr. Florence, *Eucalyptus* is an extremely large taxonomic group and is now regarded as eight genera. There may be as many as 600 species (235 just in New South Wales), which represent a complex mosaic under environmental control. The environments where they occur are quite variable, including the rainforest, the wet sclerophyll forests (where eucalypts merge with the rainforest), and sites where eucalypts are maintained in the overstory by periodic fire and the understory is composed of rainforest species.

Mr. Florence discussed management practices in eucalypt forests and how there have been some departures from natural systems as a result of even-aged management. In the native forests, there was a balance of high-demand and low-demand species and stresses on a site were on a small scale. Now, stands often stagnate with weak expression of dominance and can have extensive dieback. In some cases, Mr. Florence felt that dieback in overstocked stands is actually gap-phase replacement. Other changes, such as waterlogging of soils, led to massive mortality of jarrah (*Eucalyptus marginata*) due to infection by *Phytophthora cinnamomi*. Individual eucalypts are very site-sensitive and managers are now experiencing problems with matching species to the appropriate site. Mr. Florence cited the occurrence of *Armillaria* root disease in some regrowth stands as a problem that would have been less likely in a natural forest having a mixture of species with different requirements. Another example of a pest problem arising from management is the bulls-eye borer, *Phoracantha acanthocera*. Since the 1960s, karri (*Eucalyptus diversicolor*) forests have been clearcut, burned, and replanted, and the bulls-eye borer is now becoming more important, especially on the poorest sites. In other areas, a destabilized forest has led to an increase of the rainforest element, with better litter production and better nutrition but with an increase in psyllids and in branch dieback in eucalypts.

Currently, an important management issue is planting the appropriate species on the appropriate site. This issue presents a problem because sites in Australia are very patchy and broken, and with the needs for different species on different sites, the economies of scale become extremely difficult to manage. In addition, most soils are not very good for producing a high growth rate of eucalypts. *Eucalyptus* is a great competitor for water. In many areas, species that have a high water demand have been cut and water and salt have subsequently risen through the soil profile to create problems. (Most of these salt problems are occurring in the woodland zone.) In Western Australia, *E. globulus* is being planted extensively with Japanese funding because eucalypts are seen as an important resource for export.

Following the presentation by Mr. Florence, the team met with personnel from CSIRO in their offices near the campus of the Australian National University. We met with Dr. Rob Floyd, entomologist and Program Leader of Natural Resource and Biodiversity; Michael Lenz, Project Leader for Termite Research; Dr. Mike Hodda, nematologist; and Jan Viljoen, Research Scientist with the Stored Grain Research Laboratory. Team leader Borys Tkacz gave the CSIRO personnel an overview of our team and the process we are following for pest risk assessment. Dr. Floyd (who has also been active with pest risk assessments in Australia) led a discussion on the status of the "Insects of Concern" that we had identified for the *Eucalyptus* PRA. We discussed the wood borers, particularly from the genus *Phoracantha*. Dr. Floyd stated that *P. semipunctata* is less of a problem in Australia than it seems to be in California, where apparently healthy trees are attacked. In Australia, only drought-stressed trees are affected. For example, there were some problems in Western Australia with *P. semipunctata* last year when the rainfall was less than 600 mm (23.6 in.). Dr. Floyd mentioned two other species of *Phoracantha* that may be of greater importance in Australia (*P. acanthocera* and *P. mastersi*). There has been a recent taxonomic revision that synonymized two important genera, *Phoracantha* and *Tryphocaria*, but Dr. Floyd commented that the synonymy is not widely supported. (Later in our travels, we learned that there is a significant behavioral separation between beetles of the two "genera," with those called *Tryphocaria* being borers that infest only standing trees, whereas the *Phoracantha* beetles infest logs as well as stressed trees). Dr. Floyd stated that few wood borers are economically important in Australia. He named three entomologists who are very familiar with wood borers in Australia [Janet Farr (Western Australia), Dick Bashford (Tasmania), and Charlma Phillips (South Australia)].

We discussed a number of other Australian insects on our list with Dr. Floyd and the other specialists present at the meeting. Dr. Floyd pointed out that the insects selected for inclusion on the list appear to be based on the amount of literature available rather than on potential risk. *Trachymela* is a chrysomelid that has been found in low numbers in South Africa but is rare in Australia. *Porotermes* is a common termite in some areas and has been introduced into New Zealand via whole logs. Mike Lenz felt that *Porotermes* could survive long-distance shipment in logs. *Coptotermes* could also survive shipment in logs, and possibly *Glyptotermes* and *Kalotermes* could survive as well. Dr. Floyd felt that several of our listed species could be handled as groups, including many of the leaf beetles such as *Paropsis* spp., *Chrysophtharta* spp., and *Cadmus* spp. The lerp psyllids could be grouped as well. Dr. Floyd felt that the walking sticks were not important enough to warrant an IPRA, but that the cup moth (*Doratifera vulnerans*) probably could, even though he felt it is less important than *Uraba lugens*, the widely distributed gumleaf skeletonizer moth. Dr. Floyd stated that scale insects of the genus *Eriococcus* can be very serious and that the species *E. coriaceus* is a particularly important one. Dr. Floyd mentioned two important genera of scarabs that he felt should be added to the list—*Heteronyx* spp., beetles associated with young seedlings, and various species of *Liparetrus*, spring beetles that are important defoliators of young eucalypts. The scarab Christmas beetles *Anoplognathus* spp. are also important defoliators of some eucalypts. *Mnesampela privata*, the autumn gum moth, was mentioned as being worthy of an IPRA and the *Endoxyla* wood moths are also considered important pests.

We had previously not been aware of a recently published book entitled "Insect Pests of Australian Forests—Ecology and Management" (1998), by H. J. Elliott, C. P. Ohmart, and F. R. Wylie, that Rob Floyd felt was the definitive work on Australian forest insects.

We also briefly discussed pests of *Pinus radiata* and were told of the aphid *Essigella californica* introduced from California. Nematodes are probably of no concern on *Eucalyptus*. The nematode found near Melbourne may be an undescribed species of *Bursaphelenchus* from Asia; apparently the vector is not established.

As a conclusion to our meeting with CSIRO, Dr. Floyd led a discussion about the broad aspects of pest risk assessments and inquired as to the possibility of establishing a database that everyone could use for PRA purposes. Currently, given the absence of such a database and inability to share information, there is considerable duplication of effort in carrying out pest risk assessments.

September 15

The team spent a day off in Canberra.

September 16

Each of the three sub-teams began their State site visits. Borys Tkacz, Mike Haverty, and Jessie Micales departed for Queensland and New South Wales; Harold Burdsall, Jane Levy, and Andris Eglitis traveled to Victoria and Western Australia; and Dennis Haugen, Gregg DeNitto, John Kliejunas, and Ed Podleckis traveled to Tasmania and South Australia.

New South Wales, Queensland: September 16–25, 2001

The team that traveled to New South Wales and Queensland was composed of Dr. Jessie Micales, Dr. Michael Haverty, and Mr. Borys Tkacz.

September 16 Canberra to Eden

In the morning, we met Jack Simpson, a plant pathologist with the Research Division of the State Forests of New South Wales (SFNSW). Emmanuel Mireku from Biosecurity Australia accompanied us. We drove south from Canberra to Cooma, ESE to Bega, then south to Merrimbula and Eden.

The first part of the trip between Canberra and Cooma took us through woodlands and grasslands with many sheep and cattle. *Pinus radiata* was being grown as shelterwood for livestock refuge. Many old, large *Eucalyptus* trees in pastures had *Amyema* mistletoe infestations, an indication of tree stress. We also saw signs of *Eucalyptus* dieback. The etiology of dieback is not entirely understood but involves a complex of different factors involving herbivory, drought, and generally poor growth conditions that predispose the tree to colonization by a number of different fungi, including *Botryosphaeria* and *Cryphonectria*, as well as leaf-sucking insects, such as aphids and psyllids. Leaves are often colonized by Aulographina leaf spot, caused by *Aulographina eucalypti*, and sooty molds that grow on the deposits of aphids and other leaf-sucking insects.

In the mountains, we stopped to view the activities of an ambrosia beetle, *Austroplatypus incompertus*. We were able to see only one "pitch tube" in an alpine ash (*Eucalyptus delegatensis*). There was a large flight of termites, likely a species of *Coptotermes*, but we took no samples. There were several mounds about 1 m (3.3 ft) high and 0.6 m (2 ft) in diameter with a nasute in them, indicating termites in the family Termitidae, subfamily Nasutitermitinae, and probably a species of *Nasutitermes*. Mike Haverty also found foragers of rhino termitid species under bark with the nasutes on a fallen log. In the same area and in log decks, there was plentiful evidence of *Porotermes adamsoni*. In this short amount of time and after minimal driving, we saw evidence of four species of termites spanning three families! We also saw frass and circular holes of cerambycid beetles in logs of *E. delegatensis* and an unidentified homopteran on a eucalypt leaf.

Many eucalypts put out coppice shoots after harvest. Injuries from fire expose the base of the coppice shoot and allow heartrot fungi to colonize the tree. *Laetiporus portentosis* is the most common brown-rot fungus. It will colonize many different genera of trees, especially exotics in arboretums and ornamental plantings. Many white-rot fungi also colonize eucalypts.

We stayed overnight in Eden along the southern coast of New South Wales.

September 17 Eden to Cooma

We first went to the offices of SFNSW in Eden and met Phil Goldberg, a staff forester. He guided us to the Nadgee State Forest outside of Eden. Because of danger from wildfire, the native forests are highly managed by thinning and prescribed burning. Eucalypts stand up well to fire damage, so thinning and hazard reduction burns are conducted throughout the rotation. The conservationists object to this practice and would rather see little to no management. There are currently heavy restrictions on logging, including a ban on logging within 50 m (164 ft) of a stream or known endangered species. Logging permits involve approval from three different agencies and are expensive to obtain. Thinnings are generally sent to chip mills and are done by private contractors.

We then visited the Timbillica State Forest and met Ray Cox, also with the SFNSW. The forest was composed of large [60 to 100 cm (23.6 to 39.4 in.) dbh], native 80- to 100-year old *E. sieberi* (silvertop ash) and messmate (*E. obliqua*) trees. The good quality logs (about 33% to 50%) were cut into 8-ft (2.4-m) lengths for saw timber, while the lower quality material with decay and termite damage in the central core was crushed (to conserve space) and sent to the chip mill. The bark is removed easily in the spring due to the wet weather. It appeared that just picking up the logs and dropping them repeatedly was removing all of the bark. Debarking is much more difficult when harvesting in the fall and some bark may be left on the logs after a fall harvest.

About 50% of the logs had a defect called “pipe” that is caused by *Coptotermes*. The termites feed on the heartwood and pack the open space with digested wood, called “mud,” a condition that is called “mudgut.” The termite enters the tree trunks through the bark, and they must get to the heartwood of the log by the spring or they will die. These wounds result in the formation of “volcanoes” of gum pockets, or “kino,” which are a good indication of termite infestation. Termites frequently eat into the base of epicormic branches, and we also observed termite activity on the debarked logs. In the native forests, the loss to termites and decay in these older trees appeared extreme, but we would later learn that wood from the central core is routinely discarded due to its poor quality and tendency to warp.

A few of the logs were brown-rotted, probably by *Laetiporus portentosis*, the principal brown-rot fungus of *Eucalyptus*. The logs are graded by the amount of deterioration in the bole. Often the butt end is removed because this is the area that shows the most damage. The extent of decay and termite damage is measured to determine the grade of the log. Those with extensive decay or termite damage are considered salvage. At least 4 in. of good wood or half the diameter of the log is needed to be sound in order to chip the log for pulp. The logs are marked so that their species, grade, length, and diameter are indicated.

Gum pockets, or “kino,” are an indication that there is some sort of damage in the log. They can be indicative of termites or mechanical wounding. Red bloodwood, *Corymbia gummifera*, is very prone to these resin pockets. It is a very durable wood that is used for fence posts rather than sawlogs.

During the harvest, a certain number of old trees are left as “habitat trees,” especially those that show defects, are obviously hollow, or will form hollows in the near future. These are good for wildlife. Fruiting bodies of *Laetiporus portentosis* are a good indication of a habitat tree. We observed one of these trees that also had a large wound at the base.

We then traveled to a poorer quality site of young *E. sieberi* where harvesting was being conducted with automated equipment. These trees had lots of epicormic branching and they were being thinned for better growth. The planting goal is to have the trees 10 m (32.8 ft) apart with 100 trees per hectare (about 40 trees per acre). The logs harvested during the thinning operation will all be chipped. The harvester can handle logs up to a diameter of 40 cm (16 in.), but the trees we saw harvested were much smaller. The harvester cuts the tree, removes the branches, debarks the log, measures it, and cuts it to proper size. It is shipped to the mill the same day with minimal delay. The machines for this operation cost $1.2 million (Australian), and the contractors expect to be able to harvest 80 tonnes of wood per day.

At this site we saw large mounds of *Coptotermes lacteus*, the most destructive of termites, with living termites inside. We also saw brown rot in the sapwood of wounded trees, probably introduced from wounds left by fallen branches. White-rot decay was observed in the heartwood of some trees. Many different fungi cause white rot in *Eucalyptus*. Many of the small-diameter trees have decay at their base, so the butt ends are cut off at harvest.

We then traveled to the Harris–Daishowa (Aust.) Pty Ltd chipmill in Eden, NSW, where we met with Vince Phillips, Corporate Affairs Manager. He described the operation to us. Logs arrive at the mill from state forests in NSW and Victoria, up to 250 km (160 miles) away. Most of the wood is brought in from a 150-km (93-mile) radius. Approximately 94,000 hectares (232,279 acres) are available for harvest from public land, which accounts for about 15% of the government reserves. From the northern management area of NSW, they receive about 60,000 tonnes of wood and 20,000 tonnes of chips from sawmills. From the immediate area around Eden, they obtain approximately 280,000 tonnes of wood from older trees and 50,000 tonnes from younger thinnings. They also receive some material from Victoria, including 130,000 tonnes of older material and 30,000 tonnes of thinnings.

In a year, they export 680,000 tonnes of chips to Japan. Earlier in 2001, they also sent chips to Indonesia, but this does not seem to be continuing. The Japanese prefer chips from the younger thinnings rather than from mature trees because the pulp makes much better paper.

For the future, they are looking into obtaining wood from plantations rather than native forests due to environmental concerns. In Victoria, there are about 25,000 hectares (61,776 acres) of eucalypt plantations, and plans are being made to put in another 25,000 hectares over the next few years. The mill is examining the prospect of using wood from radiata pine plantations. There are currently about 60,000 hectares (148,263 acres) in radiata pine in the vicinity, and they would need about 200,000 to 250,000 tonnes per year, depending on the Japanese economy. Plantations near Bombala are fairly close to the port; logs from these plantations would be easy to transport to the mill.

The logs are usually processed within a day of cutting. They are debarked and delimbed in the bush, and this material is left on the forest floor. A small amount of bark might be left on the logs, but this is minimal because only a very small amount is permitted in the pulp chips. Sawmills usually leave the wood on the ground for a longer period of time because they must accumulate a certain number of logs to process. This probably does not exceed 3 to 4 weeks and is more commonly kept to 3 to 5 days. They are planning on accumulating about 40,000 tonnes of thinnings before Christmas so that they will have a good supply to use over the holidays.

Logs are often covered with soil particles or they might have large quantities of mud gut in the center. Sawmills will often send the center of the logs to the chip mill as part of their waste. This material is split and the mud dropped onto the ground before the wood is sent to the chipper. The outsides of the logs are washed with a high-pressure water spray to remove additional dirt before they get to the chippers. Coastal NSW is usually very dry, so they do not have as much trouble with mud and dirt as do mills in Tasmania or Victoria.

Japan does not require any sort of phytosanitary certificates for its imported woodchips. Indonesia did have phytosanitary forms, and the AQIS people fill these out for the mill.

The mill is currently processing both old and young logs. If they were going to use more thinnings, they would probably buy new machinery. The mechanical splitter can make the logs less than 1 m in diameter, which is the size needed for the chipper. The chips go through a screening device. The material that is too large is burned. The undersized material is sold for landfill cover. About 1.0% to 1.7% of the material is undersized and about 3% oversized. It is important to use species of similar hardness and density for the formation of uniform pulp. The chips are sampled for mud and decay before they are loaded onto the ship. Usually only very minor amounts (<0.1%) are detected.

Currently the mill has only one big chip pile. In the future, they are planning on maintaining separate piles of pine chips, high-quality *Eucalyptus* chips, and low-quality *Eucalyptus* chips. Chips rotate through the stack in about 4 to 5 weeks. They are dropped into a hopper and loaded onto a belt that takes them to the ship. When we examined the belt, it was covered with small larvae, referred to as “chip bugs.” These had been previously identified by AQIS as *Tribolium castaneum*, *Carpophilus* sp., *Oryzaephilus surinamensis*, and *Aridius* sp. Insects were also flying around in this area.

The ships are loaded at the rate of 1,000 tonnes per hour. Ship capacity is up to 50,000 tonnes of chips. This is the largest port of this type in southern Australia. There are only about eight ports similar to this in all of Australia. Sydney has a smaller facility, as does Melbourne, and there are several smaller ones in Queensland. The port handles about 750,000 tonnes of woodchips per year and could easily do twice that amount. The military is going to be putting in a large dock in the same harbor, and the chip mill will be able to use this for much of the year, so they are looking to expand their operation.

We examined the logs in the yard in detail. A few logs had brown rot in the center, including extensive amounts of mycelium, probably of *Laetiporus portentosis*. We also observed some white pocket rot. The thinning operations bring in younger trees that are usually better quality. The younger material crushes and splits very often and is not suitable for sawing. In some of the logs with mudgut, we saw fresh foraging galleries in the butt of the log with workers and soldiers of *Coptotermes* in them. Michael Haverty and Jack Simpson discussed the possibility of a pathologist and entomologist going to Japan to sample holds of arriving ships to determine what is likely to survive transport. The Japanese do not seem to be worried about importing any pests with the chips.

The port does not currently export any eucalypt logs except very small numbers of exotic woods for specialty purposes, such as crafts. They do ship some pine logs.

After visiting the mill, we stayed overnight in Cooma.

September 18 Cooma to Tumut to Canberra

We drove from Cooma towards Tumut on the Snowy Mountain Highway. We passed through the Kosciuszko National Park in which all non-native species have been removed. Not much fuel reduction management is being done in any of the National Parks. As we drove through the Snowy Mountains, we saw phasmid defoliation of *E. delegatensis* (alpine ash) and *E. pauciflora* (snow gum), which is not a commercial species. Acacia rust, caused by *Uromycladium*, was also present in the plants along the highway. There were also large plantings of *Pinus radiata* along the ridges of the mountains. They were showing evidence of *Dothiostroma septosporum* colonization, but there were obvious variations in resistance. The pines are very sensitive to microclimate variations. In many cases, one observes *Dothiostroma* in the valleys, but not along the ridgetops. Many U.S. diseases and insects of radiata pine are now present in Australia, including *Ips grandicollis*, *Ceratocystis,* and *Ophiostoma* stain. Additional insects and diseases of pines could be imported easily if Australia continues to import whole logs (with bark) from Canada and the United States.

As we drove into Tumut along Rt. 18, we saw many types of mistletoe in old, large *Eucalyptus* in pastures along the road. Mistletoe-infested trees are common in the Tumut Valley as a result of the protracted decline of the trees after drought. These paddock trees are under considerable stress and are at the end of their lifespan. The trees were primarily *E. largiflorens* (black box).

In Tumut, we visited the SFNSW office and then went to the mill operated by Weyerhauser Australia Pty. Ltd., where we were hosted by Peter Stiles. This mill produces sawtimber exclusively from *Pinus radiata*. All logs are initially scanned, debarked, and sorted into bins by size. When enough logs are in a certain bin, they are moved to the sawmill for a sawing run. The logs are generally in the logyard for only 3 to 5 days before processing, but they can sit in the bush for 2 to 3 weeks (less time in the summer) before being brought to the mill. Ideally, they would like the logs to sit in the bush for less than a week because of the rapid development of bluestain. The logs that we saw were very clean, with little insect damage, decay, or bluestain. The debarking operation was 90% to 95% efficient, which is not an issue for lumber production. This could cause problems if raw logs were imported to the United States because even small amounts of bark can harbor the three types of bark beetles found in Australia, *Ips grandicollis*, *Hylastes ater* (Paykull), and *Hylurgus ligniperda* (Fabricius). The latter two species are from Europe; *H. ligniperda* has recently been introduced to New York State in the United States.

Once enough logs of a particular length and diameter are accumulated, they are sawn to fill a specific order. Sawing and sorting are largely automated. Stress grading is done automatically by the computer. The rough boards are then kiln-dried overnight at 140°C with temperature and humidity regulated by computer. Railroad ties ("sleepers") are dried for 48 h. The target moisture content for all material is 12%. The mill has 11 kilns. Logs are quite variable in their moisture content, especially in the winter, and comprise a mixture of young and old material. Therefore, computer regulation is necessary to achieve uniform drying. Some of the sawn timber is treated with CCA and dried in a separate kiln. They can treat up to 600 m^3 (21,189 ft^3) of wood with CCA per day.

After kiln-drying, the boards are finished in the planing mill where they are sorted, graded, and wrapped for shipment. The amount of wood converted to lumber is about 40% of the original 400,000 m^3 (14.1×10^6 ft^3) of logs per year. Often the centers of the logs cannot be cut into timber because of the high percentage of juvenile wood, which would cause extensive warping and cracking. Approximately 40% of the material is recovered on-site and burned for energy. Off-cuts are either chipped or the fiber is sent to a new composite board factory. All the lumber is sold for domestic construction.

We then met Duncan Watt, Planning Forester with SFNSW, and traveled to pine plantations near Tumut. The primary planted species is *Pinus radiata*. The Tumut Region contains 84,000 hectares (207,569 acres) of radiata pine on state lands and 24,000 hectares (59,305 acres) on private lands. This is half the total population of radiata pine of NSW. Currently there are no root rot or heart rot fungi of *P. radiata* in Australia. It would be very detrimental if fungi such as *Phellinus pini* or *Veluticeps* spp. were to be introduced. In the plantation we saw test plantings of 5 to 10 different pine species, including *P. lambertiana* (sugar pine), *P. ponderosa* (ponderosa pine), and *P. jeffreyi* (Jeffrey pine). At 1,000 m (3,000 ft) elevation, radiata pine suffers a large amount of snow damage and is not the ideal species for planting in this area. The test plots were set out to determine if other alternatives would be better, but the market demand is for radiata pine. Mills no longer favor *P. ponderosa* because it takes too long to dry.

In the plantation, the stands were being thinned and the logs usually sit out in the log decks for 1 to 7 days. It is best to get them out of the forest quickly because of bluestain fungi. There are rarely any internal defects in these logs, although needles are damaged by Dothistroma blight. The most important species of bluestain fungus is *Sphaeropsis sapinea*, but introduced species of *Ceratocystis* and *Ophiostoma* are also common. Blue stain in the wood decreases the quality of the logs for chips since more processing is required to brighten the fiber. In this area, *Hylastes ater* bark beetles were swarming all over the logs that had just been cut. These beetles can carry ophiostomoid fungi. Another problem beetle is *Hylurgus ligniperda*.

During the thinning process, the branches, needles, and flared butt ends of the trees are left in the forest until replanting. This helps with erosion control. At planting, the slash is piled and burned.

At a second stop, the forest was primarily composed of *Pinus contorta* (lodgepole pine) and a species of *Picea*. Many of these trees had died from drought and herbicide damage. They had tried other species in this area, including the 5-needle pines, *P. monticola* (western white pine), *P. lambertiana* (sugar pine), and *P. strobus* (eastern white pine), but changing to these species will probably not work because of market demand for extensive quantities of a single species (that is, *P. radiata*). The 70-year-old sugar pines were immense. New sugar pine cannot grow to this size in the United States because of *Cronartium ribicola*. Unfortunately, *Ribes* is imported into Australia as an ornamental, so the introduction of *C. ribicola* is a good possibility.

In ponderosa pine, we saw tip and shoot blight caused by *Sphaeropsis*. *Sphaeropsis* is also found on radiata pine and is very common in drought-stressed and hail-stressed trees. Root infections can also occur when trees are under drought stress. Secondary fungi then move in, including *Phomopsis*. Crown damage can also occur in the crown due to cold damage. We saw many trees with extensive dieback in the crown but were not able to determine the cause. The lower branches appeared not to be so affected. It seemed more extensive than one would associate with Dothiostroma needlecast or the Monterey pine aphid, *Essigella californica*.

We then visited a clearcut of radiata pine. The slash was left in the field and is later windrowed and burned. The area is then replanted in the following year. These trees are thinned when they are 12 years old. At this time, they are the proper size for the chipper. Only one thinning is made. Again, there was much discoloration in the crowns of the trees. Some of the trees were 32 to 33 years old and were quite large. The logs in the stack were very clean with no indications of insects or disease. The bark is kept on the logs in the bush and removed at the mill.

We returned to Canberra in the evening.

September 19 Canberra to Grafton

In the morning we traveled to Hume, ACT, on the outskirts of Canberra and visited Integrated Forest Products. We were hosted by Paul Job, the Sawmill Production Manager. This plant is currently processing both *Pinus radiata* for the domestic structural timber market and *Pinus ponderosa*, some of which it exports as kiln-dried lumber to the United States. The two species are kept separate throughout the production line. All logs are from the Canberra region.

Bob McGovern, the Log Yard Manager, showed us around the mill. They were currently debarking ponderosa pine. Blue stain will develop in ponderosa pine if it is kept too long before kiln drying. In the summer, the pine logs need to be processed within 2 weeks, but they can go as long as 5 weeks in the winter. No decay or borers were observed in the log yard; the trees appeared very healthy. There is a termite problem in Australia with structural lumber made from radiata pine, but not in trees on the stump. The radiata pine logs are dried at 140°C (284°F), but the ponderosa pine must be dried at a lower temperature [100°C (212°F)] to prevent internal checking and collapse of board.

The trees arrive from the state government department and are evaluated for diameter and width. They are scanned with a computer and also measured by hand. Samples are taken by government inspectors on Tuesdays and Thursdays as spot-checks to make sure that volume calculations are accurate. They usually sample three to five loads. Some logs are rejected by the mill. The size limit for this mill is 580 mm (22.8 in.) diameter—those that are larger are rejected and taken away to another mill for cutting. Large logs will destroy the saw. Logs are sold by weight, so it is important to return the logs as soon as possible so they do not lose too much weight from drying. They are resold by the state to a different company that will turn them into railroad sleepers. Logs will also be rejected if they have defects or if they are too short. The rejected logs are stockpiled for 2 weeks and then collected by the state supplier and sent for chips or to other yards that can handle bigger material. Some logs need trimming if branches are left on. The waste and undersized material is chipped and sold to a pulp mill. A new plant will be opening soon that will be closer.

The logs are debarked and sorted into different bins by size. Sometimes the base of the log will flare out. These will be sawn off by the machine and then sent back through the debarking process. The debarking machine can handle 130 logs per hour. The bark is carried by a conveyer belt underneath the log carriage and dumped onto a waste pile. This is sold to nurseries for mulching material. Undersized material is sold to a neighboring pallet manufacturer.

Once the logs are debarked, they are kept off the ground and are stacked until enough accumulate of a certain size to be sawn. Ponderosa pine logs are kept separate from radiata pine logs. The logs in the saw yard should be turned over every 2 weeks to reduce the development of blue stain. Some logs may be kept as long as 3 months while waiting for the right number of other logs of the same dimension for sawing. During this time, the wood will darken and a little blue stain will start coming onto the surface of the log. There were very few obvious insect problems on the logs. Debarking technology is not 100% efficient, with some bark remaining around the branch stubs and irregularities in the bole.

The mill is currently running two shifts that operate the dry kilns and three shifts for the planer. *Pinus radiata* is dried at 140°C (284°F) with a 12-h drop. *Pinus ponderosa* needs 33 h at 100°C (212°F). In older kilns, this would have taken 65 h. *Pinus ponderosa* is especially subject to splitting, so water is added back to prevent overly rapid drying. After kiln drying, the wood is run through a planer. Scraps of wood that would normally be discarded are fingerjointed together to make a salable product.

We then flew from Canberra to Grafton, where we met Rob Heathcote, Business Development Manager for the State Forests of New South Wales, Hardwood Plantations Division. He took us to J. Notaras and Sons Pty. Ltd., where we were hosted by Spiro Notaras, one of the two brothers who own the mill. This hardwood mill uses a variety of different *Eucalyptus* species to produce beautiful hardwood flooring. Three grades of flooring are produced and sold in long boards: “pioneer grade” sells for about $1,000 AU per cubic meter, “standard grade” sells for $2,000 AU per cubic meter, and “select grade” sells for $2,600 SU per cubic meter. Recently they have been selling more pioneer grade material domestically, although the Japanese purchase more select grade. Smaller boards are sold for parquet work. The mill is only running at about 40% of capacity due to a depressed market. In the past year, they suffered damage from a fire and two floods. In the past, the mill produced lumber for framing material, but now all framing is done with pine. The mill switched to flooring, a value-added material, in order to continue operation.

Logs are obtained from selectively logged stands so a variety of different grades of logs are used. Some of the trees are quite large and are 60 to 70 years old. The mill pays the government a stumpage value based on volume, as well as an extraction fee. Many different species are used including *E. grandis* (rose gum), *C. maculata* (spotted gum), *E. crebra* (iron bark), *E. delegatensis* (alpine ash), *E. regnans* (mountain ash), *E. sieberi* (silvertop ash), *E. pilularis* (blackbutt), *E. andrewsii* (New England blackbutt), *E. bosistoana* (grey coast box), *E. fastigata* (brown barrel), *E. saligna* (Sydney blue gum), *E. propinqua* (grey gum), *E. cypellocarpa* (mountain grey gum), *E. viminalis* (manna gum), *E. dalrympleana* (mountain gum), *E. nitens* (shining gum), *E. paniculata* (grey ironbark), *E. sideroxylon* (red ironbark), *E. resinifera* (red mahogany), *E. acmenioides* (white mahogany), *E. obliqua* (messmate), *E. laevopinea* (silvertop stringybark), *E. eugenioides* (white stringybark), *E. muellerana* (yellow stringybark), *E. microcorys* (tallowwood), and *Syncarpia glomulifera* (turpentine).

The log yard is usually totally filled, but the market has been bad for the past year so they maintain a decreasing inventory of logs. In January, sales were down by one quarter and another 40% in February and March. Gradually it has been getting better, but the mill owners do not want to invest in many new logs. There was a huge inventory of sawn, stickered lumber waiting to be kiln-dried and milled. A large portion of the log is lost during sawing and processing. Only about 40% of the log is sawn into rough timber, and another 18% to 20% of the weight is lost by drying. The center of the log cannot be sawn, often because of termite damage or decay, but it tends to split and check too much anyway and must be discarded. Defects in the logs from wounds, decay, and branch stubs will also increase the amount of loss. They feel that it is best to saw the logs as soon as possible. If they wait too long, the surface becomes checked, decreasing the grade of the material and allowing more moisture to be lost during drying. Some species are more prone to defects than others. *Eucalyptus grandis*, for example, has no internal defects from termites. Over 30,000 ha (74,132 acres) of *E. grandis* has been planted along the coast, but it is subject to frost damage.

The wood waste is burned to heat the dry kilns, but the burner is old and will probably have to be replaced, especially if the number of kilns is increased. A U.S. company is putting in a power plant in the area, and the mill will probably sell its waste to them in the future.

Certain species of *Eucalyptus* need to be pressure treated. *Eucalyptus saligna* (Sydney blue gum) is susceptible to borers, so the sapwood needs to be treated. *Lyctus* beetle or other powderpost borers can also be a problem, so sapwood is treated with borax. The mill used CCA (chromated copper arsenate) in the past, but waste disposal problems caused them to switch to borax. The wood is treated to several different hazard ratings: “5” for wood in contact with water, “4” for fenceposts, and “3” for exterior wood. Green lumber for international export is pressure treated. Pressure treating takes about 2 h.

The wood is dried outside for 2 to 3 months and is then kiln-dried. It is initially dried at 42°C (107.6°F) and 85% humidity (steam) for pre-drying. This takes about 4 weeks and gets the moisture content down to 20%. The wood is then placed in the kiln and dried for about 1.5 weeks at 65°C to 70°C (149°F to 158°F) to moisture content of 9% in a process that is controlled by computer. The wood moisture content usually drops about 1.5% per day in the kiln. After kiln drying, the wood is re-steamed to take the moisture content back to 10.5% to 11%. The lumber is then shrink-wrapped so that it stays dry. Normal production requires seven kiln loads of lumber per week. Wood that is air-dried in the yard for 3 months usually has a moisture content of 14% to 15%. It needs to be in the kiln for only 3 to 5 days.

The wood is then finished in the planer mill and cut into flooring boards. Smaller pieces are made into parquet material. Costs are saved by selling every scrap of wood that has no defects. Mr. Notaras personally goes through the discard bins every day to make sure that they are not throwing away anything that can be sold. The final product was very attractive and is used for high-value floors, primarily in Australia and Japan. We were shown pictures of their floors in gymnasiums, retail stores, marinas, boardwalks, train stations, and hot springs.

We stayed overnight in Grafton.

September 20 Grafton, New South Wales

In the morning we toured eucalypt plantations in the Grafton area. On the way, we observed spotted gum, *Corymbia maculata*, in native forests. This species prefers dry, infertile sites where many of the seedlings are suppressed but then released after thinning. It is tolerant of fire, as are most eucalypt species. *Eucalyptus delegatensis* is not tolerant of fire. It grows on wet sites. After a fire, it regenerates as an even-aged stand because all the previous trees die. We also passed through some forests dominated by blackbutt, *E. pilularis*. Some of these trees were severely infested with mistletoe, probably indicating poor health of the trees.

Fire scars in all eucalypts are a major infection court for decay, especially associated with old coppice growth. There is also a high incidence of decay associated with pruning wounds and cerambycid injuries. White rots are often associated with beetle damage. This may actually help in the beetle life cycle. The wood is usually quite hard when the beetles initially infest it, but the development of decay fungi softens the wood by the time of emergence. Decay can develop in very young trees that have been wounded or have beetle damage.

Phellinus noxious is found in native forests but has not been seen in plantations in New South Wales. Three-year-old material has been seen with *Phellinus*, *Fistulina spiculifera*, *Hymenochaete*, and other corticoid fungi, including *Phlebia* and *Phanerochaete* spp. *Phellinus* is not as common as in the United States, but both *Phellinus* and *Ganoderma* can form long-lived chlamydospores that can remain viable for long periods of time.

Rob Heathcote was very interested in finding markets for the wood of camphor laurel, *Cinnamomum camphora*. This is an invasive species that they would like to find a market for in the United States. The wood is quite beautiful. It is currently used for specialty products, such as cutting boards and essential oil bottles. The tree is commonly found in wetter areas. Usually there is a single parent tree that seeds prolifically, so after 30 years the entire area is infested. The seeds are dispersed by birds, so the trees are frequently found along fenceposts.

In *Eucalyptus* plantations, trees are debarked and chipped in the field. They are kept clean and not dragged along the ground. We observed 7-year-old thinnings of *E. grandis*. The trees are not intensively managed and are not pruned. Some of the material was left on the ground because the load was not large enough to fill a truck. This was an experimental stand that was planted at different spacings and received different thinning treatments. The plots were 30 by 30 m (98.4 by 98.4 ft), and the least dense planting was 250 stems per hectare (about 100 stems per acre). The stand had been thinned 6 weeks before. This is the type of plantation that is being set up for pulpwood. We were surprised to see terrestrial leeches all over the forest floor. In *E. grandis*, an undescribed species of *Hymenochaete* has been associated with a heartrot in cut trees with branch wounds, cerambycid injuries, and *Xyleborus* galleries. A lot of slash was left on the ground. This will usually decay within 2 years, but it is more resistant to decay than pine slash.

In 3-year-old *E. grandis* plantings, we saw cockatoo damage in which the entire trunk of the tree had almost been severed. The cockatoos were looking for beetle larvae. We also saw spurs develop at the base of trees. This occurs when the tree is initially blown over and it cracks. The tree stays alive and the portion of the stem receives nourishment from the rest of the tree, so it appears to be a spur (when actually it is just part of the initially broken stem). Sometimes these spurs become infected with *Botryosphaeria*. This can also happen with broken branches in the crown.

Much of the plantation land is actually old dairy land that was put back into trees when England stopped importing much of its dairy products from Australia. This happened with the formation of the Economic Union of Europe—England now gets its dairy products from Europe. The government offers economic incentives to put in eucalypt plantations. The government leases the land; the owner retains ownership of the land, but the trees can be owned by NSW or shared in a joint venture. In the northern area of NSW, they have put in 50,000 hectares (123,553 acres) of *Eucalyptus* and want another 50,000 hectares (123,553 acres). Half of this will go for chips for exports, because the people who live here do not want to put in pulp mills. The rest will go for sawlogs. The plantation program is primarily focused on sawlog production because demand for chips is vulnerable to the economics of Japan.

Since the market from Japan has dropped substantially, a large portion of debris was left on the next plantation that was observed. Large boles were simply abandoned in the field. This was a plantation of *E. pilularis* and *E. saligna* (black butt and Sydney blue gum) that was a little over 20 years old. These plants can grow over 2 m (6.6 ft) per year on a good site and were much healthier than the natural forests of Eden. The trees are debarked at the stump. The trunks appeared to have little decay or other problems. In the area, we did observe a psyllid on *E. saligna* that was causing a lot of leaf desiccation and death.

On the way back, we saw the “Vincent Tree,” a specimen tree of *Eucalyptus saligna* that was 65.5 m (215 ft) tall and 7 m (23 ft) wide in 1964. A decay fungus was fruiting out of one side at the base.

In the evening, we flew to Brisbane, Queensland.

September 21

We visited the Queensland Forestry Research Institute (QFRI) in Indooroopilly, Queensland, a suburb of Brisbane. We met with Drs. Judy King, Senior Entomologist, Forest Protection Program, and Ross Wylie, Program Leader and Forest Entomologist, Forest Protection Program. The QFRI is a state government organization that is partly supported by external funding. They are a commercial institute and are externally funded by industry. They just received a major contract to bait large portions of Queensland for fire ants. The Institute employs about 130 people, half of whom are scientists and the rest are research support. They are housed in two locations. The majority of scientists are split between Brisbane and Gympie, about 180 km (111.8 miles) north of Brisbane. Another 10 scientists are 2.5 h away in Atherton, northern Queensland. The northern facility is concerned with more tropical problems.

The Institute has six primary programs: Genetic Resources, Sustainability, Silviculture, Timber Protection, Forest Protection, and Wood Products. Forest Protection has four entomologists, three pathologists, and two in forest health surveillance. Their main work is in forestry, and they provide technical advice and research on native pines (that is, *Araucaria* spp.), cypress, and the hardwoods of Queensland. They have a web page with information about diseases and insects at http://www.dpi.qld.gov.au/forestry/.

They told us that there was very little radiata pine in Queensland but there were more tropical conifers, such as hoop pine, *Araucaria cunninghamii*. There is some radiata pine on the southern border with New South Wales. Pines are being used for chips, but *Eucalyptus* are not. This is a political decision because the public does not want to turn native trees into wood chips. In recent years, the housing market in Queensland has been quite bad. Several sawmills have closed down for weeks at a time because of the low demand for lumber.

In Queensland, there is an agreement between the Greens (that is, environmentalist groups) and the timber industry to phase out harvesting of native trees in favor of plantation trees over the next 20 years. They are working together to form a hardwood plantation industry. The Institute is doing research on how to establish a hardwood industry within the next 20 years. They have a good list of pests for these species.

Considerable effort has been put into quarantine policymaking in Queensland. The Institute has offshore projects with nine different countries in Asia and the Pacific Islands. They also do forest surveillance in these countries so they know what diseases and insects are present because they are concerned with pests on species of *Eucalyptus* and *Acacia* from neighboring countries. This input is provided to AQIS and AFFA. They also identify pests on timber and trees for AQIS interceptions, as well as on native and plantation trees. Emergency response teams have been put in place for dealing with emerging pests as part of an incursion management plan.

We then met with Bruce Brown, who is a pathologist and coauthor of *Diseases and pathogens of eucalypts*. He is retired but comes out for specific projects with the Institute. We were joined by Geoff Pegg, another forest pathologist. We discussed various diseases that could possibly be associated with logs of eucalypts and pines. They stated that not much was known about canker fungi in Queensland, nor in the rest of Australia. Blackbutt (*E. pilularis*) has a problem with *Botryodiplodia* (*Lasiodiplodia*). There is also a bacterial wilt of eucalypts caused by *Ralstonia solanacearum*, which is a problem in Brazil and China and is also found on the wet soils of northern Queensland. The bacterium generally does not get into the stem and is usually restricted to the root system. However, oozing from cross sections of stems of affected 13-month-old *E. pellita* in north Queensland has been observed. The bacterial wilt generally seems to affect trees less than 2 years of age in Queensland; whether the bacterium continues to be present after this is not known. They did mention that a lot of work was being done on canker fungi in Tasmania eucalypts but that little pathology in general was being done on the native forests of Queensland.

We asked about heartrots and decay fungi. In plantations, the trees are still too young to be showing a lot of decay. The oldest plantations are 30 to 35 years old. They more frequently show insect damage than heartrot. The plantations are not pruned. If they were, the decay fungi would probably get in through the pruning wounds. In the rainforest, they have seen problems with *Phellinus noxius* in hoop pine production and in the understory eucalypts. This is a rather insidious fungus and seems to spread like *P. weirii* (in large infection pockets).

In eucalypt plantations, they have had a problem with Ramularia shoot blight (caused by *Quambalaria pitereka*), which attacks the young, growing shoot. This affects spotted gums in the genus *Corymbia*. The attack is restricted to the growing shoots, however, and the fungus is not systemic. It would not be a quarantine issue.

Another problem associated with leaves is various species (seven in Queensland) of *Mycosphaerella*. *Cylindrocladium quinqueseptatum* can be a problem of *E. pellita* in northern Queensland. This is a tropical species of *Eucalyptus*.

Armillaria has been isolated in Queensland. It is usually residual from older stands and occurs in Brisbane on older trees. It has been shown to remain viable on older trees for decades and was found on the grounds of the old Parliament House in Brisbane that was cleared of trees in the 1850s. There are often cases of it surviving in stumps in the United States. It is not a major problem in Queensland.

Rigidiporus vinctus has been identified from hoop pine. It was associated with occasional trees in the 1970s but did not spread from the originally infected tree. Recent research has shown that there is now 100% infection of stumps in an area. They do not know whether this is going to be a problem in the plantations. It might be dispersed by spores but might also be spread by root-to-root contact.

We then went to the AQIS Queensland Office at the Port of Brisbane and met with Bill Crowe, Senior Quarantine Entomologist. He told us that all timber that is imported to Queensland is already debarked and is fumigated with methyl bromide upon arrival. Unfortunately, the methyl bromide does not penetrate deeply into the wood. They have had some interceptions from packing material and dunnage, including *Monochamus alternatus*, a wood-boring beetle.

Once a beetle is detected in one container, all the other containers from that source are tracked down and checked. Pheromone traps are placed in the port area to monitor, and any dead trees in the area are felled and checked. They have isolated two species of the *Bursaphelenchus* nematode, but neither of these has been *B. xylophilus*, the pinewood nematode. They have had no interceptions of Asian longhorn beetle in Brisbane, although there were one or two interceptions in Sydney. They do get large quantities of beetle larvae that are very difficult to identify.

Large-sized bamboo imports are not common, but insects have been found in bamboo tree stakes. It is difficult to fumigate material such as this because it is wrapped up in bales and shrink-wrapped.

A separate branch of AQIS deals with ballast water. A lot of marine organisms are showing up. Nothing has been introduced into the waters of Brisbane, but they have found mussels outside the port of Eden and southeastern Asian species of mussels in Cairns.

They have a problem with timber that has an impervious surface, such as when materials have been shellacked. Fumigants cannot penetrate such surfaces. This occurs with furniture from Indonesia and Malaysia, including bamboo furniture. Dunnage and furniture are their two most important problems. Sports equipment from India and period furniture and reproductions from Europe are also items of concern.

Some commodities have specific insect problems. They have intercepted *Incisitermes minor* in yachts. *Cryptotermes brevis* has become established in two cities but is being controlled by fumigation at government expense.

AQIS will inspect shipments that are being exported and provide a phytosanitary certificate based on the requirements of the importing country. Certain countries require this, but others do not. AQIS would be the certifier if APHIS imposes restrictions on importing woody materials to the United States.

Methyl bromide fumigation of timber is usually done on the dock in tents and in other permanent chambers. The rate is dependent on the infestation of the material.

They have intercepted cerambycid beetles from Douglas-fir (*Pseudotsuga menziesii*) and other conifer species from the western United States and Canada. Currently they do not know the species of the beetles, because they are in the larval stage. They have sent samples to entomologists in Canada to identify them, but this is very difficult. They have a problem getting identifications done because there just are not many taxonomists (either of insects or pathogens) in Australia. They are trying to form a network of taxonomists, even including ones from overseas. No one wants to pay for taxonomic work, and very few taxonomists are being trained. The key is to build taxonomic identification into funded projects. We discussed the use of cameras and computers that are being used to send images from ports in the United States to taxonomic experts. This works well if identification can be made on gross features but does not work so well for fine details.

Another problem that AQIS has is that the ships are often filled with contaminants of other materials—such as grain, soil, and leaves. Currently they are doing external inspections of 100% of all container shipments coming into Australia. They turned up all sorts of insects once they started doing this. Internal inspections are done based on origin of shipment. During an internal inspection, a portion of the shipment is sampled and inspected. This is routinely done in areas that have the African snail, although it depends what the material is and what it is packaged in. External checks often reveal different types of snails, snakes, and toads inside the containers. Quarantine efforts have been enhanced because of foot and mouth disease. They recently have increased their staff, especially for the inspection of mail in Sydney.

We received a tour of the AQIS facilities. They have separate areas for inspection of food, wood, baskets, plants, and other products. Fumigation is done either on the wharf, in mobile tents, or in permanent chambers. There is also another fumigation facility in Brisbane that has big fumigation tents. All roses and cut flowers are devitalized by dipping them in Roundup® after they are fumigated with methyl bromide. The methyl bromide is not recaptured—it disperses rapidly in the air. Combinations of methyl bromide with other fumigants, such as carbon dioxide, are not acceptable.

We then toured a chip mill at the Port of Brisbane called Queensland Commodity Exports. Our host was Andrew Dawson. They are currently chipping *Pinus elliottii* (slash pine). This company is a partnership of three Asian companies, and they are contracted to sell their chips to Japan. In the future, they are planning on changing to eucalypt chips with the aim of getting 400,000 tonnes/year from plantations. They are not planning on shipping any to the United States because they are basically a Japanese-owned company.

Currently, the company receives chips as either mill residue (40%) or as whole trees that are chipped on-site (60%). In the past, they did the debarking and chipping in the field, but volumes were too low. Trucks with mill residue are turned up on end for discharge of chips. A truck can contain 25 tonnes of chips, and it takes 16 min to unload a single truck. The chipper is designed for small-diameter material and can handle over 1,000 tonnes per day. The logs are kept in the yard for only one day. They are debarked, and the bark is sold for landscape material. Sawdust is sold for animal bedding. After debarking, the boles are chipped. The chips pass by a magnet to remove any metallic objects. They are then passed through a sizing screen, and anything oversize is sent back to the chipper. Small material and sawdust are collected, and properly sized chips are carried by conveyer belt out to the chip pile. The screener can handle 200 tonnes of chips per hour. The chip pile holds 45,000 to 50,000 tonnes of chips. The ships hold 36,000 to 40,000 tonnes and takes 50 h to load. This is done by pushing the chips into a collection hole by the chip pile. They are then carried up through a series of conveyors to the ship. Before loading, they are automatically sampled and the amount of bark, decay, size of the chip, and fiber analysis (percentage moisture) determined. This is important to determine the value of the chips loaded onto the ship because they are bought based on weight.

The logs that we observed did not show signs of much insect or disease damage. There were a few old *Ips grandicollis* galleries (native to the United States and imported to Australia). Some of the chips had some blue stain, which can develop in just a few days. Temperatures within the chip pile are quite hot and cause a steaming effect, according to the mill operators. They have not had any problems with combustion. The chips are usually exported within 3 months after chipping. Recently they have stayed on the chip pile for about 6 months due to lack of demand for the material in Japan as a result of their downward economic turn. If they are kept too long, the chips oxidize and turn dark. This is bad because more bleaching chemicals are needed to brighten up the pulp. The chips lose moisture in the pile—usually from about 50% moisture to 45% moisture. One problem with losing excess moisture is that the chips are lighter and the ship does not ride as deep in the ocean as it should.

There were no reports of the chip insects as we observed in the mill in Eden.

There are no log exports from the port of Brisbane. They are trying to increase the export of hoop pine. Very few logs are imported through this port—just some specialty logs from New Guinea. No North American logs arrive in Brisbane. Actually very little timber moves through this port. Some chipboard is exported, but that is about it.

September 24

In the morning we met Bruce Brown and Judy King who took us to Grant Timbers in Woodford, Queensland. On the way to the mill, Bruce told us about his database on microorganisms of *Eucalyptus*. It currently has 20,000 records, and he printed out copies and gave them to us. We discussed several of these pathogens in more detail. *Armillaria pallidula* was originally collected by Brown. It was associated with losses in a *Eucalyptus* plantation over several years and fruited in May for several years in a row. It has not been collected since. Although *Armillaria* can be a problem in certain local situations, it is not in general a major problem in Queensland. *Armillaria* is moderately significant in fruit orchards and ornamental plantings in the granite belt area of southeast Queensland.

We then discussed hoop pine, which grows only in areas that used to be rainforest, probably because it needs exposure to mycorrhizal fungi for growth. It was originally thought that it would grow only in areas that already had hoop pine, but it will actually grow in any rainforest soil. In the nursery, it has to be raised under shade cloth; nursery plants have had problems with *Rhizoctonia* (including the perfect stage). Hoop pine also has problems with *Phellinus noxius* that arises from stumps of original plantings. *Phellinus* moves from tree to tree, probably by spores, but also from root contact. The fungus will grow 1 to 2 m (3.3 to 6.6 ft) up the base of the tree as an external mycelial sheath. When the plantation is thinned, they get more *Phellinus*, since fruiting bodies develop on cut stumps and release many spores into the air. The other major problem in hoop pine has been the white rot fungus *Rigidoporus vinctus* [*Junghuhnia vincta* (Berkeley) Hood & M. Dick]. This usually develops in the early years of the second rotation. Some plantations have shown stump contamination of 100%. This will be studied in more detail in the future to determine the relationship of stump colonization to the spread of infection. *Rigidoporus* seems to have a narrower host range than *Phellinus*. *Phellinus noxius* is also found on species of *Pinus*. They are trying to develop a biological control but have not been successful.

We also discussed *Phytophthora cinnamomi*, which has caused outbreaks of disease in the rainforest, usually in very wet soils. At McKay, Queensland, the pathogen was found along ridge tops instead of in valleys, where it is usually located. It was associated with patches of dead trees and had spread out with time. The ridge tops have a shallow soil on top of a wet, clay soil that holds a lot of water. It is also thought that feral pigs help spread the pathogen by disturbing the soil. It was first reported in the 1950s and was probably spread by logging equipment. By the 1970s, it had expanded exponentially, but activity is now reduced. The soil dried up considerably during the 1980s, and the pathogen never did spread down the slopes.

We arrived at the Grant Timber sawmill in Woodford and met Shane Grant, the Managing Director. This is a hardwood mill that uses several different species that they cut from a natural forest in the area. The species include brush box (*Lophostemom conferta*), turpentine (*Syncarpia glomulifera*), and the eucalypts blackbutt (*E. pilularis*), rose gum (*E. grandis*), and tallowwood (*E. microcorys*). They have a website at http://www.granttimbers.com.au where the different hardwood species are discussed.

We walked through the log yard and observed many logs with mud gut and live *Coptotermes* (termites) within the logs. On one log of *E. pilularis*, the termites had made tubes on the outside of the cut face. The termites were still active in the tubes. We also saw very large holes from the giant wood moth (*Endoxyla cinereus*) on *E. grandis* and longicorn beetle holes. The giant wood moths take about two years to mature, and the larvae form large holes as they move around in the tree. There did not seem to be much decay in most of the trees, although one log showed fungal mycelia in cracks in the center of the log. The logs had been in the log yard for a couple of months. Shane Grant observed that termites prefer pine to hardwoods and will often destroy the pine portions of a structure while leaving the hardwood material alone.

We then observed the sawmill operation. The saw consisted of a pair of blades, which allows them to saw *Eucalyptus* and other hardwoods without developing extensive warping after the cut (which happens when a single saw blade is used). The cuts are perfectly straight. They have cut posts of turpentine wood and sold them as 4 by 4 veranda piles without further processing.

The wood is kiln-dried at 60°C for 7 days; each kiln holds 40 m^3 (1,413 ft^3) of wood at a time. Humidity is monitored so that all the wood in a kiln load is at a fairly constant moisture percentage to get more uniform drying. The wood is held at 45°C until it reaches constant humidity. The moisture content of the wood is monitored more closely than in the past. All the wood is air dried to 20% moisture before kiln drying, and they do not allow more than 5% difference of moisture content between packs to go into the same kiln (so really have moisture contents of 18% to 22%). Target moisture content is 9%, although it will equilibrate to a slightly higher moisture content due to local climate after kiln drying.

Grant Timbers belongs to TRADAC, the Timber Research and Design Council. This group works with selected sawmills and helps them by researching protocols to achieve certain moisture standards. They work with researchers to develop these protocols. The Council monitors moisture and does spot checks, thereby certifying that the wood reaches certain standards. Because of this, they get special quality assurance labels that are beneficial for marketing and allow them to charge a higher price for their product. The moisture content as the material leaves the gate is checked using computers and hand meters and certified. The drying regimes recommended by the Council are dependent on the local climate. Initially, the local climate was monitored so that it could be taken into consideration for drying regimes.

They try to keep in stock 1,200 m^3 (43,378 ft^3) of cut timber that is air drying in preparation for kiln drying. After kiln drying, the wood goes to the finishing mill to form the finished material—often high-value flooring. The finished material is shrink wrapped after stacking it into different sized packs. When installing flooring inside office buildings, it is often convenient for the workers to use smaller packs that are easily carried on elevators and down hallways.

We then went to the Weyerhaeuser Australia Pty Ltd. Mill in Caboolture, Queensland. On the way, Bruce told us how a large area was burned in the mid-1980s. The wood was salvaged, but because of the massive quantities it was stored under sprinklers to prevent infestation by borers. The trees were mostly *Pinus elliottii*, *Pinus caribaea*, and some other species of pine. After about 15 months under wetting, severe decay by *Rigidoporus lineatus* destroyed much of the wood. It is thought that the basidiomycete started to grow after bacteria had destroyed the pit membranes, allowing the decay fungus easy access. Literature reports had suggested that *R. lineatus* can grow under conditions of limited oxygen.

At Weyerhaeuser, we met Craig Morris, Resources Manager. Weyerhaeuser acquired the mill in 2000; it was formerly an Australian-owned company. The mill produces approximately 350,000 m^3 (12.4×10^6 ft^3) of wood per year. They also have an export chip business at the Port of Brisbane, which we visited on Sept. 21, that handles 250,000 m^3 (8.8×10^6 ft^3) of wood chips per year. The chips are produced both from pulp logs and as by-products of this mill (and others).

The trees are obtained from private forests that the mill has contracts with. They own the trees but not the land, and the resource is becoming limiting. Initially they had access to 20,000 ha (49,421 acres) of trees, but this has dropped to 3,000 to 4,000 ha (7,413 to 9,843 acres). The land is essentially being cleared for real estate due to the high value of shorefront property. The trees are almost entirely *Pinus elliottii*, but they are slowly changing to *P. carribaea* and clonal hybrids of *P. elliottii* and *P. caribaea*, which are propagated from cuttings rather than being grown from seed. Product is structural timber for the domestic market. They have been hit hard by the downward turn in housing and have reduced production to one shift instead of the normal two shifts. They do not plan on shipping raw logs to the United States because it would not be economically feasible. The offcuts are burned as fuel for the boilers that heat the dry kilns. The wood is dried at 116°C for 8 hours, although the wood inside does not reach that temperature. The current requirement to kill *Sirex*, for example, is a core temperature of 65°C for 2 hours. The mill wants the dry kiln hot enough to “plasticize” the wood in order to set it straight without warp. The target moisture content is 8% to 12%, and it later equilibrates to 13%. The wood is kiln-dried immediately without sitting around for air-drying in order to have uniform moisture content within the kiln charge.

We walked through the log yard, which holds enough logs for about a week’s worth of sawing. The logs are debarked in the yard and might sit for a while before sawing. The log supply is difficult to maintain in this region because much of the bush is very wet during certain times of the year and it is difficult to transport logs. Blue stain can develop within a week and is often associated with wounds in the bark caused by mechanical harvesting. Logs are transported from as far away as 200 km (125 miles). Transport of logs is a major expense. In the log yard, the trees appeared very clean and were nearly free of insects and pathogens. Some logs did have extensive blue stain. Bruce explained later that the normal blue stain fungus was *Sphaeropsis sapinea*, but species of *Ceratocystis* started to show up once *Ips grandicollis* was introduced from the United States. *Ips* is currently restricted to southeastern Queensland. This blue stain is probably *Sphaeropsis* because there was no sign of beetle activity. Needles and branches arrive on the cut logs, but these are removed during the debarking process.

We then followed the process of cutting the debarked logs into boards, which was done with multiple bandsaws. The boards were sorted and stacked into piles with stickers in between levels for kiln drying. They have four kilns available for drying, along with some older ones that are used for reconditioning.

After kiln-drying, the boards are planed with a high-speed, 30-weight "molder." They are currently sorted, graded, and stacked by hand. The mill will be installing a new machine to do this and make the process more automated. Everything is tracked by computer, and the final packs are labeled and barcoded.

We then visited a pine plantation in Beerburrum/Beerwah with Denis Maloney who is with the Department of Public Industry (DPI) Forestry group. The DPI is a self-sustaining organization. The money obtained by selling the trees pays for expenses, land acquisition, and plantation expansion; a payment is also made to the government. The plantation is currently planting *P. elliottii* X *P. caribaea* hybrid cuttings. The pine is cut and processed in the field, leaving the slash behind. The material being harvested during our visit was 36-year-old *Pinus elliottii*. Only the new plantations are hybrids.

After the trees are harvested, as much litter is left in the field as possible. It is generally chopped up, and many of the old stumps are pushed up. In wet, low sites, windrows are built up and new trees are planted at 5-m (16.4-ft) by 2.4-m (7.9-ft) intervals. One thinning is done at about 17 years, and the entire rotation is harvested at 20 years. The goal is about 450 stems/hectare (1 hectare is 2.47 acres, or about 182 stems/acre) for the final cut. These trees are selected for wood properties and fast growth. They are sacrificing a little size by harvesting before 30 years, but it is thought to be worth it in productivity. Different levels of cultivation are done depending on the wetness of the site. In very wet areas, continuous mounding is done, with water between the rows. Better-drained sites have strip cultivation where the trees are planted behind a skidder at 5-m intervals. Before planting, the sites are cleaned up with Roundup®. The seedlings are containerized and can be planted all year, with the heaviest planting occurring from December to August during the summer rains. After planting, monoammonium phosphate is applied as a fertilizer. Weed growth is prevented by a top spray of simazine that prevents weed seeds from sprouting, and then the area is treated again with Roundup® in late spring. The weeds that do grow are kept in check with contract mowing. In the past, the trees were pruned, but this may be discontinued because the trees grow so quickly that it is hard to keep the core trunk to 15 cm (5.9 in.). In the past, the trees were pruned at age 4 to 5 years to a height of about 5 m (16.4 ft). At age 5, the first prescribed burn is done. The trees are about 10 m (32.8 ft) high at this time. The canopy closes within 6 to 7 years.

Ips is known to attack stressed trees, including those affected by fire damage and mechanical wounds. After a major fire, *Ips* can get into trees within 6 weeks. After *Ips*, the *Xyleborus* pinhole borer invades when the trees are very sick or dying. These trees were free of disease. No evidence of *Dothiostroma* was seen, although it could develop when they have a protracted winter that is cold and wet. *Sphaeropsis* does not seem to be a major concern. As a shoot blight, it is usually associated only with stressed trees. *Pinus carribaea* does seem to be susceptible to *Sirex*, but that has not yet been introduced to Queensland. *Pinus elliottii* is resistant to *Sirex*, and the *P. elliottii* X *P. caribaea* hybrids are just being tested. *Phytophthora* has been found on isolated spots and in nurseries where it stays active for many years. A government plan will shortly be released that deals with managing for *Phytophthora*. This may change some forestry practices. It is a national plan under endangered species legislation and has been about 5 years in the making. It is not known what the effect will be on Queensland forestry.

September 25

We returned to the Queensland Forestry Research Institute and discussed giant wood moths with Ross Wylie, Judy Cook, and Simon Lawson, Hardwoods Forest Entomologist. The larvae of the moths feed on tree roots for the first year. They then move up the trunk and bore a hole into the bole. They become very large and create large tunnels within the wood as they feed. Cockatoos feed on them and will practically destroy the tree to get them out. Some species of *Eucalyptus* are more prone to moth damage than others; smooth-barked trees are most often at risk. *Eucalyptus grandis* (rose gum) and *E. tereticornis* are probably the most susceptible. Susceptibility begins in *E. grandis* when it is about 18 months old, or as soon as the trees reach a diameter of 6 to 7 cm (2.4 to 2.8 in.).

We traveled north of Brisbane to Pomona and Cooroy with Simon Lawson, Ross Wylie, and Bruce Brown. During the trip, we discussed hoop pine, *Araucaria cunninghamii*. There are about 40,000 hectares in Queensland, about 30,000 hectares (74,132 acres) in the south and 10,000 hectares (24,711 acres) in the north. It is primarily a rainforest species and can be grown only in certain areas, perhaps due to important mycorrhizal associations. It is used for high-quality furniture, feature paneling, rulers, and flooring. The current rotation is 50 years, but they are trying to drop it to 30 to 40 years. Some is still growing after 70 years.

In Queensland, there is still some harvesting of thinnings from native forests, but in very low volume. All cutting in the rainforest is prohibited.

We visited some eucalypt plantations in Pomona. The species was *E. cloeziana* (Gympie messmate). The area had been harvested of *E. grandis* in 1996, and the *E. cloeziana* trees were planted in March 1997. They are currently being tested for nitrogen and phosphorous fertilization regimes, but it is a good site so the addition of fertilizer does not influence growth very much. The trees were quite large for 4.5 years old. They are resistant to most insects and too young for disease. Researchers are working to decrease the rotation and are doing genetic improvement with *E. cloeziana* and *Corymbia maculata* (spotted gum), the two main plantation species of southeastern Queensland. The current stocking rate is 1,200 stems per hectare (about 490 stems/acre). The trees are pruned, and the effect of pruning on wound formation and fungal infection is being studied. If pruning proves to be detrimental, this practice will likely be discontinued. The trees are usually thinned to 600 stems per hectare (about 240 stems/acre) after 3 years, and to 300 stems per hectare (about 120 stems/acre) at 10 years.

A group of smaller trees was also examined. These were 2.5 years old and were being defoliated by the eucalypt leaf beetle. Initially these beetles defoliate the upper crown. The adult beetles eat the older leaves; a second infestation will result in total defoliation. The trees usually recover after one season. There was also some *Mycosphaerella* leaf disease. The trees were not well flushed due to lack of moisture.

We also saw lerp psyllids on the leaves of these younger trees. Some of these insects produce a toxin that results in a necrosis, although we did not observe it with this species. There was a lot of honeydew and sooty molds.

There was an older planting of *E. grandis* in the area. Some of these trees had cerambycid damage that resulted in cankering, probably due to the entrance of decay and canker fungi. This stand also had significant lerp psyllid damage.

We next examined a 50-year-old plantation of very tall *E. cloeziana* and *E. grandis* that had not been extensively managed. There were large termite mounds here. This is the stand in which the entomologists first noticed the giant wood moths in 20-m- (65.6-ft-) high poles. We observed a gum moth, which mimicked a eucalypt leaf. These are solitary insects and are not a major pest. We did see some feeding damage on an adjacent leaf.

As we returned to Brisbane, we saw a few trees with mistletoe along the highway. The infestation was not as severe as in the Tumut Valley.

September 26

The team returned to Canberra.

Victoria, Western Australia: September 16–25, 2001

September 16

The WIPRAMET sub-team of Dr. Harold Burdsall, Jane Levy, and Dr. Andris Eglitis flew from Canberra to Melbourne.

September 17

The sub-team was met at the hotel by Mr. Simon Murphy of the State Department of Natural Resources and Environment. Mr. Murphy is head of the Forest Science Center and manages the Research and Development Group at the Heidelberg facility of the Department. Mr. Murphy led our tour through forested lands northeast of Melbourne, including the areas of Toolangi and Narbethong. Along the way, we had an opportunity to learn more about the ecology and management of eucalypt forests from Mr. Murphy.

One of the primary eucalypt species in this region is the mountain ash, *Eucalyptus regnans*. As a component of the wet sclerophyll forests, this species exhibits poor fire tolerance and does not resprout following fires. However, the fires serve to prepare the seedbed for natural regeneration. In the absence of fire, *E. regnans* requires gaps in order to regenerate. Commonly, the understory includes two species of wattles [*Acacia dealbata* (silver wattle) and *A. melanoxylon* (blackwood)], both of which fix nitrogen but also compete with mountain ash for moisture and nutrients. The mountain ash forests range in elevation from 250 m (820 ft) to 1,000 m (3,281 ft). At the lower elevations there is some mixing with forests of messmate stringybark (*E. obliqua*) and manna gum (*E. viminalis*) that range from sea level to 500 m (1,640 ft) in elevation. At the higher elevations, mountain ash mixes with alpine ash (*E. delegatensis*) and snow gum (*E. pauciflora*) in forests that extend to tree line [1,300 m (4,265 ft)]. Where mountain ash forests grade into gullies, the vegetation takes on a “rainforest” appearance and an important tree component that appears is myrtle beech, *Nothofagus cunninghamii*. An interesting wildlife connection has been found for the mountain ash forests. The Leadbetter’s possum, previously thought to be extinct, has been found to inhabit these forests in Victoria. The possum utilizes old snags left behind after wildfires and requires a disturbance regime that provides hollow snags for nesting and regrowth for food. The mountain ash attains an extremely large size [over 2 m (6.6 ft) in diameter and 80 m (262 ft) in height] and lives to be 400 years old. We learned that fire-killed mountain ash checks readily in the sapwood and is not particularly good for sawmills. Two major fires have occurred in these forests near Melbourne since 1939, and extensive salvage harvesting was done in both cases.

Along the road, we saw another important species of *Eucalyptus* (*E. camaldulensis*, river red gum). This species grows in areas that experience periodic flooding. The flooding is essential only for regeneration of the species; once river red gum is established, it does not require a flood for 50 years. We learned that some of the problems with pests (for example, *Uraba lugens*, the gum leaf skeletonizer) and with regeneration stem from the fact that natural flooding patterns have been altered by irrigation needs in the area. We were told that river red gum tolerates competition well and produces a durable wood that is used for railroad ties and fenceposts.

We traveled to Kingslake West where we met Dr. Ian Smith, forest pathologist and organizer of our trip in Victoria, and Mr. Nick Collett, entomologist. Both work for the State Department of Natural Resources and Environment in Heidelberg, Victoria. They were accompanied by Paul Barber, a graduate student in forest pathology at Latrobe University. We drove to a plantation of 3-year-old *Eucalyptus globulus* that has been established as a progeny trial to examine the performance of 44 families of seed sources. The trial was set up through a partnership involving a number of collaborators including the State, the Cooperative Research Centre, and the Centre for Forest Tree Technology. The area receives 1,100 mm (43 in.) of annual rainfall and is surrounded by native forest, which provides an ideal opportunity to test the effects of leaf pathogens on the different provenances of blue gum. Paul Barber explained how the test site is being used to evaluate three species of *Mycosphaerella* (including *M. cryptica*, *M. nubilosa*, and another species). Mr. Barber has found considerable differences in resistance to the leaf disease within the families of *E. globulus* planted at the site. Part of this difference relates to the rate and timing of the production of juvenile foliage. For example, *M. nubilosa* is particularly damaging on juvenile foliage, and those families with less juvenile foliage experience fewer problems from this pathogen. We learned that a moist site such as this is very conducive to the development of leaf pathogens but that there have also been some problems with *Mycosphaerella* on drier sites as well. In general, however, as you move away from the coastal influence there are fewer problems with the foliar pathogen. (On this site, we also found some evidence of defoliation by the autumn gum moth, *Mnesampela private.*)

In the same area, we saw plantations of *Pinus radiata* and inquired about its uses and the associated pest problems. Monterey pine has been planted extensively in the area, the primary use being for sawlogs that yield structural grade framing lumber, studs, and trusses that are easier to use than eucalypts. In the past, native forests were cleared to make room for plantations of *P. radiata*. The recently introduced aphid (*Essigella californica*) is now very widespread in the country, occurs in the Kingslake area, and produces some defoliation. Host trees are most susceptible 15 years of age onwards; younger trees are generally not defoliated. Damage appears to be confined to the old needles and is greatest in the top half of the tree. There also appears to be a connection with nutrient levels: aphid damage increased with increased soil nitrogen. We inquired about bark beetles and learned that *Ips grandicollis* has been in the Mt. Gambier area since 1983 and produces four generations per year there. Apparently, the beetle confines its attacks to slash and does not usually infest living trees. Two other exotic species of bark beetles, *Hylurgus ligniperda* and *Hylastes ater*, breed in old slash and sometimes feed on seedlings but are not considered more than a local nuisance in Victoria. Nick Collett pointed out that as long as the timing of slash creation is managed, then these beetles do not present a problem.

En route to our next stop, we discussed some pest–eucalypt associations with our hosts. We learned that wood borers are not likely to cause problems in eucalypt plantations because rotations are generally 10 to 15 years, and wood borers are not usually found in trees less than 15 years old. Lyctid powderpost beetles have been found in the sapwood of mountain ash residues. These insects are probably found in all States except New South Wales and Tasmania and are also associated with wood in use. Other insects of significance with mountain ash include the lerp psyllids (*Cardiaspina* spp.), the walkingstick (*Didymuria violescens*), and cossid wood moths in sawn timber. Mountain ash forests are too cold for *Phytophthora* fungi.

We briefly visited a landing where native trees had been harvested. Typically, harvesting is not done in the winter (although it was this year); trees are stockpiled through the summer until May, and then moved in the winter. Stockpiling is generally such that butt logs with decay are separated from sawlogs at the landing. These harvest and transport activities are based on having the appropriate road conditions.

Along the road, we stopped at a nature trail that passed through a cool rainforest with a mixture of species including mountain ash (*E. regnans*), blackwood (*Acacia melanoxylon*), silver wattle (*A. dealbata*), sassafras (*Athosperma* sp.), tree ferns (*Dixonia* sp.), and myrtle beech (*Nothofagus cunninghamii*). The acacias are fairly short-lived in these stands, dying out after about 80 years. Dr. Ian Smith pointed out that some of the myrtle beeches in these types of stands were dying out due to the Chalara wilt disease that is vectored by the platypodid ambrosia beetle *Platypus subgranosus*. The ambrosia beetles infest the dying trees and in the process produce copious amounts of frass that contains the wilt fungus. This fungus-laden frass is ejected from the bole, is carried by the wind, and enters other beech trees through wounds, where infection by the transmitted fungus weakens them to the point where they are infested by the ambrosia beetle to continue the cycle. The fungus causing the wilt disease also spreads by root contact and is a key disturbance agent for creating gaps in these mixed stands.

Next, the team traveled to Marysville to visit plantations of *Pinus radiata* that are currently managed by Hancock Victorian Plantations Pty Ltd. The plantations were first established in 1938 by the State government and until recently were managed by the Department of Natural Resources and Environment. Many of the plantations have been corporatized into private holdings, such as Hancock. In some cases, the trees are owned by the private company while the state retains ownership of the land but leases it to the company. After the trees are harvested, the land will revert to the State. The Hancock holdings in the Marysville area total 6,000 hectares (14,826 acres), of which 4,000 hectares (9,884 acres) are planted in *Pinus radiata*. The trees on these lands are either very old or very young. Many of the older stands were not thinned because of prevailing market conditions at the time. Given the fact that thinning had not occurred on time, we inquired if *Sirex noctilio* had been a problem in these plantations. We learned that this insect was a big problem in Victoria in the 1960s and in the Mt. Gambier area in the 1980s, when more than one million trees were killed. Currently, a trap tree program, originally developed by Fred Neumann, is being conducted in cooperation with the Forest Science Centre. The trapping calls for the weakening of trees by injecting them with banvel herbicide and cutting them after the flight period of the wood wasp. In the Marysville plantations, some aphid damage has occurred from *Essigella californica*, and in some cases, a phosphorus deficiency has aggravated this damage. The older trees were currently being harvested with a 4-day rotation between felling and transporting of the logs. Tree felling is done with a harvester–forwarder with a chainsaw blade. The trees are partially debarked on site, with further debarking done at the port. Slash is removed fairly promptly after harvest. Typically, harvesting operations can be carried out all year round, using ground-based equipment. The second rotation is beginning on leased lands, with hand planting between May and August [1,100 stems per hectare (445 stems per acre)] followed by an herbicide treatment 6 weeks later. A 30-year rotation is normal for softwood sawlog production. Hancock's holdings total 150,000 hectares (370,657 acres) of plantations, which includes eucalypts (*E. globulus* and *E. nitens* for fiber production) as well as Monterey pine.

Other pest problems that were discussed in connection with *P. radiata* included the nematode that has been found in the Melbourne area. At the same time, they intercepted a longhorn borer, *Arhopalus* sp., a beetle that infests dead and dying trees. Dothistroma needle disease was prevalent in Victoria in the 1970s and 1980s. Resistant cuttings are being used in anticipation of an increased *Dothistroma* problem in the next rotation.

The team traveled to the Acheron Valley to observe a harvesting operation in a forest of native mountain ash. The mountain ash forests are highly productive, capable of yielding 900 to 1,000 m^3 of wood per hectare (roughly 131,000 to 145,000 board feet per acre). This stand had regenerated in 1938 from a very large wildfire, and trees were already over a meter in diameter and quite tall. The harvesting was being done with a machine with a fixed cutting head capable of directional felling. We observed that the bark easily slips off during the harvesting operation and the logs are completely debarked as they are piled in the landing. During the summer months, the inner bark of mountain ash adheres to the bole and debarking is not as easy. (We learned that this is the same situation for most species of *Eucalyptus.*) We were told that they occasionally find termites and decay in the butt logs during harvesting. These decayed ends are cut off and are placed in a separate pile from the sawlogs. We saw some wavy patterns on the inner bark, the signature of a sapwood feeding insect, possibly the scribblygum moth, *Ogmograptis scribula*. We inquired about the cossid wood moths and were told that they are not common in mountain ash but are more likely to be associated with species such as silvertop ash (*E. sieberi*) and eucalypts growing on drier sites in the Gippsland area. These insects tend to have a narrow host range, and some occur with longhorn borers.

At the end of the day, we visited another rainforest gallery with a mixture of myrtle beech and mountain ash. There was evidence of Chalara wilt in the myrtle beech (*Nothofagus cunninghamii*), a wilt disease that is spread by root contact and by the ambrosia beetle *Platypus subgranosus*.

September 18

The Team traveled to Geelong to the port facility at Corio Bay. The port has traditionally been used for trade in wool and wheat and now handles wood chips as well. We were met at the port facility by Steve Roffey, Resources Manager for Midway Proprietary, Ltd. His company ships *Pinus radiata* logs through the port to Korea, Japan, and India. The company was formed in 1980 by sawmillers from Victoria who contracted with the Japanese firm Mitsui to provide chips for export. Midway Pty Ltd sent its first shipment of hardwood chips to a Japanese paper company in 1986. In 1991, the company obtained residual roundwood, supplied by a network of sawmills, and in 1995 diversified into pine plantations. Now Midway owns 10,000 hectares (24,100 acres) of *Pinus radiata* plantations. In a joint venture they also established plantations of *Eucalyptus globulus* [currently 3,500 hectares (8,649 acres) and eventually 8,000 hectares (19,768 acres)] for export chips. Some plantation lands are owned by Midway, and other lands are leased. All the holdings are within 150 km (90 miles) of Geelong. Eucalypts are currently being planted where Monterey pine is harvested. The cost of reestablishing a plantation is $1,700 per hectare ($688 per acre), with an eventual yield of 800 tonnes of product per hectare. *Pinus radiata* is grown on a 30-year rotation for saw logs, and *Eucalyptus globulus* is grown on a 12-year rotation for pulp logs. The current harvest rate for *P. radiata* is 170,000 m^3 (6×10^6 ft^3) per year; 22% for domestic use, 24% for export sawlogs, and 54% for export pulpwood. Annual export volumes have steadily increased from 1985, to 700 metric tonnes in 2000. Midway Pty Ltd exports only chips, and other companies ship their logs to Japan. The softwoods are transported from the woods with bark on, and the bark is removed at the port with a chain flail. Less than 0.75% of the chips contain bark, and the bark constitutes 0.4 to 0.5% of the chip weight. Eucalypts are not debarked at the port; the bark generally comes off easily during harvest (except for 2 months in the summer). We were told that there is very little bark that goes into *Eucalyptus* chips, even less than for softwood chips. Chips are made from solid wood only; if decay is found, the log is still processed but the contractor is notified of noncompliance.

Steve Roffey inquired about current regulations for treatment of wood, and Jane Levy explained the procedure that is being employed in Chile for *P. radiata* chips. The chips are sprayed with chlorpyriphos and a fungicide as they are being loaded onto the ship. *Eucalyptus* logs could be brought in only if they are treated with a heavy dose of methyl bromide, so that is not currently being done. We inquired about the turnover rate of chip piles and logs handled by Midway. It is possible to stockpile two shiploads of hardwood chips, and at most, a load of chips would be 3 months old by the time it is loaded. As such, there may be considerable heat generated in the piles. Log stock also normally has a 3-month turnaround. Some departures will occur from that timeframe, given that the harvesting period is only from October to May such that some hardwood material may be held for 9 months to provide an even flow. Softwoods are most typically on a 6-week turnaround cycle in order to minimize bluestain.

We inspected a pile of hardwood thinning residue and found some evidence of kino and wood borer galleries in the small logs. The kino is a bright red chemical deposit in the annual rings that results from insect infestations, fire, and mechanical stresses caused by bending and twisting of the trunk.

The team also visited another facility in the port that deals in logs of *Pinus radiata*. Mr. Ian Sedger from Softwood Plantation Exporters (SPE) discussed the company's operations and pointed out that they ship 1.3 million metric tonnes of logs per year from the Port of Geelong. They have a 4-week turnaround of their *P. radiata* stock that is shipped to India and Korea, primarily for core veneer. They also ship logs for other companies, including some from New Zealand. Additional species exported by SPE include *Pinus ponderosa*, *P. pinaster*, *P. elliottii*, and *Pseudotsuga menziesii.* We inspected some of the pine logs at the site and found evidence of bark beetle galleries and late-instar larvae that appeared to be *Ips grandicollis*. Ian Sedger said that he had also seen associated wood borers in the forest. Ian Smith pointed out that the wood borer *Arhopalus* has also been seen in association with *P. radiata*. When markets are down, the logs are sometimes kept on site for 4 to 5 months so that they will dry out and will be easier to sell at a lighter weight.

Steve Roffey took the team to a plantation of *Eucalyptus globulus* that is owned and managed by Midway Pty Ltd in a location not far from the port of Geelong. The plantation is a joint venture with the Japanese company Nippon Paper. The plantation was established in July 1996 at 1,000 trees per hectare (400 trees per acre). Although annual rainfall in this area is only 650 mm (26 in.), the growth is expected to be 20 m^3/hectare (258 ft^3/acre) per year. Typically, the foliage is analyzed in the second year of growth to determine if fertilization is necessary. At the present time the volume was 43 m^3/hectare (554 ft^3/acre) at age 5 years. This growth had been attained despite a drought (precipitation 15% below the normal level). In spite of the drought, we did not observe any evidence of longhorn borers and were told that they are usually not present in plantations younger than 10 to 12 years of age. (These trees will likely be harvested before that time.) We inquired about other potential pests and were told that the plantation is monitored for autumn gum moth, *Mnesampela privata*, which attacks juvenile foliage. We saw evidence of the blister sawfly, *Phylacteophaga froggattii*, on the foliage and were told that the 4- to 5-year age class may also be infested by the *Perga* sawflies. Pathogens, including the foliar fungi, had not been identified as a problem here.

September 19

The team met with personnel from the Institute for Horticultural Development. The Institute is part of Agriculture Victoria, which is a division of the State Department of Agriculture, Energy and Minerals. The Institute is located in Knoxfield, Victoria, and provides diagnostic services to various individuals and agencies including AQIS. The Institute maintains a collection of insect and disease specimens that include organisms associated with agriculture and forestry in addition to horticulture. We met Mr. Gordon Berg, Manager of Crop Health Services, James Cunnington, pathologist, Dr. Mali Malipatil, Senior Systematic Entomologist for Crop Health Services and Paul Barber, pathologist from Latrobe University. We discussed our lists of "Pests of Concern" with these specialists from the Institute and University and were shown some of the Institute's insect and fungal specimen collections.

Later in the day, we toured the Dandenong Ranges and North Park near Melbourne and examined some trees infected by Armillaria root disease (almost certainly caused by *A. luteobubalina*). It was interesting to note the behavior of *Armillaria* in this setting. The fungus was producing decay in the sapwood of live trees, extending as wedges tapering from the base of the tree to a point several feet above the ground on these old-growth trees.

September 20

The team traveled from Melbourne to Perth, Western Australia. We were met at the airport by Dr. Richard Robinson, pathologist (our host for the Western Australia portion of the site visit), and Dr. Janet Farr, entomologist. Richard and Janet both work for the Science and Information Division in the Department of Conservation and Land Management (CALM) for the state of Western Australia.

September 21

In the morning, the team went to the offices of CALM in Perth and met with several people from the Forest Products Commission. Commission members present at the meeting were Terry Jones, Manager of Industry Development, Trevor Butcher, and Dr. Graeme Siemon, Timber Scientist. CALM members in attendance included Mike Stukely and Colin Crane. Also present at the meeting were Dr. Elaine Davison, mycologist, Curtin University of Technology, Mike Grimm, quarantine entomologist for AQIS, Brea Read, Forest Industries Federation of WA, Dr. Giles Hardy, pathologist, Murdoch University, and Andrew Loch, entomologist with CSIRO, located in the CALM Research Centre in Manjimup. We learned that the Forest Products Commission was originally a part of CALM but was recently split off into its own Department to manage the commercial side of the forest resource. The Commission has a Research Centre with 11 scientists that evaluate wood properties and how industry utilizes the resource.

Terry Jones gave a presentation on the status of the wood products industry for Western Australia. He discussed a forest management plan that was drawn up in 1994 to determine the harvest levels in native forests of jarrah (*Eucalyptus marginata*), karri (*E. diversicolor*), and marri (*Corymbia calophylla*). According to this plan, the harvest rates for jarrah were to be 490,000 m^3 (208×10^6 board feet) per year and 220,000 m^3 (93.3×10^6 board feet) per year for karri. High-quality sawlogs would be produced, and a value-added requirement called for kiln-drying of 50% of the sawn output. There was also a market for green structural material (mine timbers) derived from karri and exported to Europe. Residues of karri would be chipped and exported. Marri was to be used primarily for export chips and for production of shakes. This forest management plan was to be in effect for 10 years. However, last year (2000) there was a change in State government and the 1994 plan was put aside, requiring instead that the harvest in native old growth forests be reduced by 99%. Now, only 1% of the native old growth forest is available for harvest with an allowable harvest of 140,000 m^3 (59.4×10^6 board feet) per year of jarrah and 40,000 m^3 (17×10^6 board feet) per year of karri. With the change in government, 37 new parks were established, which further reduced the amount of native regrowth forest available for commercial harvest. All the jarrah harvest except thinning residues will be processed as completely as possible locally to obtain the value-added advantage when sold. Karri harvest will also have value-added activities with kiln drying done to provide local jobs. The situation with treatment of marri is less certain, but it will probably still be harvested for the chip market. Although marri has been viewed in the past as a wood unsuited for furniture due to an abundance of kino that it produces in response to physical stresses, fire damage and insect attacks, some people are discovering how to market this feature and the use of marri in furniture is increasing.

In 1999 to 2000, there were 397,000 m^3 (168×10^6 board feet) of timber produced [221,000 m^3 (94×10^6 board feet) hardwood and 176,000 m^3 (74×10^6 board feet) softwood] in Western Australia. There will probably be a cap of 400,000 m^3 (169×10^6 board feet) of softwood for a mill in the southern part of the state, although structural softwoods are gradually replacing structural hardwoods. Most of the softwood resource is *Pinus radiata*, with some *P. pinaster* and *P. maritima*. Besides structural lumber, some other uses for softwoods include medium density fiberboard [150,000 m^3 (63.6×10^6 board feet) per year], particleboard [150,000 m^3 (63.6×10^6 board feet) per year], and pallets. Although softwoods have been replacing hardwoods for structural wood, there is a concern that *P. radiata* will not be replanted when it is harvested. There is a tendency to replant *P. radiata* sites with faster-growing, shorter-rotation hardwoods (*E. globulus*) for pulp production. Terry Jones felt that planting incentives might be needed to avoid a shortfall of sawlog resource in the future. In some low-rainfall sites that do not lend themselves to competitive pulpwood production, there is an effort being made to grow eucalypt sawlogs on a 25- to 30-year rotation. There may also be a veneer plant set up in the northern portion of the state to deal with the dry site *P. pinaster* resource. The state also plans to import sawn lumber from New Zealand and Douglas-fir from California. Some softwood is now being shipped to India in spite of the low supply.

Brea Reed from FIFWA (Forestry Industry Federation of Western Australia), a promotional group for forest industry, spoke to us about some of the current uncertainties facing the logging industry. She felt that there could be significant business buyouts and that as many as 1,000 industry people (plus 1,500 associated people) could lose jobs. The future of the industry may depend on a greater level of value-adding than has been done in the past. A program of retraining would be needed as well, to train people from saw-milling to making furniture, for example. Brea spoke of an increasing market in Chicago for “casual furniture.” Three companies are working in this arena making both casual and indoor furniture from jarrah (*Eucalyptus marginata*). (In the past, jarrah was primarily used for production of railroad ties, with considerably less value added).

Mike Grimm, entomologist from AQIS, spoke to us on some aspects of insects associated with wood imports. He stated that with local production being down and with increasing imports into Australia, there is an influx of wood that is susceptible to powderpost beetles. Some of this imported wood is being infested by *Lyctus brunneus* and by the native auger beetle (Bostrichidae). Mike pointed out that the states develop their own rules if a pest becomes established in a given state. He cited the example of the aphid *Essigella californica* that now occurs in Victoria, Tasmania, and Western Australia, and these states are treated as “islands” with regard to this insect. Mike Grimm also made an interesting observation about *Eucalyptus globulus* in Western Australia. He pointed out that the species does not shut down the stomata during dry conditions and large patches of trees die during extremely hot periods.

The team discussed the list of "Insects of Concern" with the entomologists present at the meeting. Dr. Janet Farr has studied the gum leaf skeletonizer moth *Uraba lugens* in Western Australia and provided local information on the biology of this important defoliator based on her work. In the eastern states, *U. lugens* pupates in the litter, whereas in Western Australia it prefers to pupate on the bark of the host. When feeding on river red gum (*E. camaldulensis*) in the eastern states, the insect primarily defoliates the lower canopy, but in Western Australia this feeding preference is more vague as feeding occurs higher into its host trees. Janet felt that the behavior on jarrah is different from the behavior on river red gum further east. Although *U. lugens* has been found on *E. globulus* in Western Australia, it does not do very well on this host, and its pupation site is unknown. Insect survival seems to be highly variable, depending on the host; *E. camaldulensis* and *E. moorei* are favored hosts where survival is high and *E. marginata* and *Corymbia calophylla* are intermediate hosts.

The wood moths of the genus *Endoxyla* (=*Xyleutes* spp.) are not common in Western Australia. They are normally pests of trees larger than plantation size. Dr. Farr pointed out that the termite *Coptotermes acinaciformis* occurs in Western Australia, as does *Bifiditermes* sp., which is associated only with dead wood. A fairly common wood-infesting beetle present in Western Australia is the lymexilid *Atractocerus* spp. At one time these beetles were considered a problem, causing sapwood degrade, but now there has been acceptance and their galleries are considered part of the "natural" grain of the tree.

The cosmopolitan powderpost beetle *Lyctus brunneus* has been found in chips of *Eucalyptus*. Dr. Farr recounted that when she first arrived in Western Australia, she received a call from Bunnings, a local company that was concerned about a shipment of chips to Japan that contained these insects. However, Dr. Siemon (Forest Products Commission, 2002, personal communication) points out that the Japanese have never complained about receiving chips infested with lyctids, despite many years of trade with Australia. There are four other species of lyctid powderpost beetles in Australia besides *L. brunneus*. One species that does not occur in Australia, *L. sinensis*, is of concern here as a quarantine pest.

Andrew Loch, who is studying the insects associated with *E. globulus* plantations, stated that the weevil, *Gonipterus* sp., is a major pest in southwestern Western Australia.

The auger beetles (Bostrichidae) infest live fruit trees and some eucalypts and related species as well [e.g., bottlebrush (*Callistemon* sp.) and *Melaleuca* sp.].

An important wood borer in Western Australia is the bullseye borer *Phoracantha acanthocera*. Dr. Farr has studied the association of this insect with a brown decay that occurs on karri (*E. diversicolor*). The presence of the wood borer and the decay are often related. Larval galleries are normally 2 m (6.6 ft) long, although Dr. Farr has found one that was 7 m (23 ft) in length. The bullseye borer has a greater tendency to infest stressed tress, although it attacks healthy trees as well. Marginal sites for karri generally have greater levels of infestation. The wood borer is often abundant in karri regrowth (sometimes with incipient decay). Some work by Dr. Farr suggests that it will be a serious problem in older regrowth trees as well. Historically, the wood borer was not considered a problem in older milled trees, but there could be many reasons for this, including an abundance of clean older trees such that affected trees were left. A helpful diagnostic clue for finding the bullseye borer is the presence of "kino" bleeding as a result of vents created by the larvae. Mechanical damage and fire scars are not reliable clues to infestation.

Later in the day, the team traveled with Richard Robinson and Janet Farr to the port city of Bunbury, about 150 km (90 miles) south of Perth. Along the route, we saw significant branch dieback in two species of eucalypts, *E. rudis* (flooded gum) and particularly *E. gomphocephala* (tuart). The level of dieback in tuart was particularly impressive, and we learned that the immediate apparent cause is mainly a cerambycid (*Phoracantha impavida*) that girdles branches, causing severe crown decline. There are two main hypotheses to explain the dieback: a change in ground water table levels and declining annual rainfall or a reduction in the application of fire following European settlement that favors peppermint (*Agonis* sp.) over tuart. We examined some of these trees and found extensive kino being produced from wounds by the bullseye borer *Phoracantha acanthocera*. We also saw another adult wood borer (probably *Coptocercus* sp.) on the bole of one of the debilitated tuart trees.

September 22

We visited the Port of Bunbury and toured a chipping facility operated by WA Plantation Resources. The General Manager of Woodchip Operations, Mr. Ian Telfer, showed us the facility, owned by Marabini, a Japanese trading company that is a major exporter of chips. This port has been exporting chips of marri (*Corymbia calophylla*) and karri (*E. diversicolor*) since 1976. All the chips sent from here are destined to the Japanese paper market. Prior to 1994, the source of chips was forest residues; since then the company has been processing chips from plantation hardwoods, primarily *Eucalyptus globulus*. Last year, 300,000 tonnes of *E. globulus* chips were produced and shipped; in 2001, the total will be 450,000 tonnes. Eventually, the volume will increase to 1.1 million tonnes of chips, reflecting the growth of plantations in the area. WA Plantation Resources currently manages plantations on 34,000 hectares (84,000 acres) and is harvesting around 500,000 tonnes per year from those lands through contract operators. At present, all chipping is carried out at Manjimup, but another chip mill is planned for the community of Donneybrook, 40 km (25 miles) southeast of Bunbury, and should be operational in 2003. Another mill is near completion in Albany, and Albany-based operations will export chips through the Port of Albany. Eventually, the combined chip exports of all these companies will be around 4 million tonnes per year. There is significant involvement from the government, through the Forest Products Commission.

Products arrive at this port in Bunbury by rail and by truck and are stockpiled for loading. There are 24 to 26 vessels loaded here per year. There have traditionally been four products produced at this port: (1) *E. globulus*, (2) a marri/karri mix, (3) pine, and (4) karri thinnings. There will be three products in the future as the supply of marri/karri declines due to reduced harvest in the native forest. There are fewer contaminants in *E. globulus* than in chips from the native woods, but the fibers are denser in the older trees. Chips from *E. globulus* are whiter and are easier to process. The port has an automated sampling system that extracts a sample of chips during the loading process. A sample is collected for every 100 tonnes loaded, and a report is generated every 1,000 tonnes. The bags of samples are sent to Japan. Otherwise, no inspection is done, and a phytosanitary certificate is not needed for the loaded ship. We were told that the stockpile sometimes balls up with mold, but the company has not heard any complaints about this from Japan. There is considerable variation, but generally chips of *E. globulus* are stored less than 6 months; the chips contain a large amount of sapwood, and when dry, the fibers start to break down. Pine is chipped on site (at the port), and the annual production for pine is 70,000 tonnes per year. Each ship holds about 35,000 to 40,000 tonnes and can be loaded at the rate of 900 to 1,000 tonnes per hour.

September 23

The team drove from Bunbury to Manjimup.

September 24

The team met with personnel from WA Plantation Resources in Manjimup and learned about the plantation resource and associated harvest operations in the area. We met with Richard Breidahl, General Manager of Plantation Operations, Tim Mitchell and Steve Wood from the Plantations Branch of the Forest Products Commission, and Alan Seymour, Branch Manager for Southern Forests from the Forest Products Commission. Also present at the meeting were Chris Shedley, who conducts research on site productivity, and Andrew Loch, entomologist from CSIRO. WA Plantation Resources is a subsidiary of Marabini in Japan and has over 30,000 hectares (74,000 acres) of plantations in the area between Bunbury and the port of Albany. They export 500,000 tonnes of blue gum (*Eucalyptus globulus*) chips and 300,000 tonnes of marri/karri (*Corymbia calophylla/E. diversicolor*) chips per year. All the exports for the company are in the form of chips. Mr. Breidahl pointed out that the first plantations of blue gum (*E. globulus*) were established by the company in 1988 and the first exports (30,000 tonnes) were in 1994. We also learned that the total volume of chip exports, between WA Plantation Resources and the other company near Albany (Integrated Tree Cropping), is expected to be 2 million tonnes by 2006. Some questions were asked regarding the requirements for importing chips into the United States and Jane Levy replied that APHIS currently requires fumigation with a heavy dose of methyl bromide, something that is currently difficult logistically.

Alan Seymour, who oversees the jarrah (*E. marginata*) and karri (*E. diversicolor*) sawlog operations in the southern part of the state, told us that the annual production figures for those two species are 100,000 m^3 (3.5 $\times 10^6$ ft^3) and 140,000 m^3 (4.9 $\times 10^6$ ft^3), respectively. He believes that there is a great potential for utilizing karri regrowth and that it is an "unallocated resource" at this time. WA Plantation Resources carries out forest health surveys, organized by Chris Shedley. Some of the specific forest insect surveys have involved Dr. Rob Floyd from CSIRO and have led to the work that Andrew Loch is currently doing on cataloging the insects associated with *E. globulus* plantations. They hope to fund a similar position for pathology but have been unable to do so thus far.

Following the information meeting, the group traveled to the field in Yornup to observe a harvesting operation in a plantation of *E. globulus*. The harvest activity was being carried out on a 9-year-old plantation using a mechanized harvester with a debarking head. Logs are debarked as they pass through the head that has a computerized sensor to cut them to a specified length. Debarking is fairly complete by this process, and usually less than 2% of the bark remains attached. The equipment is capable of harvesting 200 tonnes per day and can handle trees up to 1 m (3.3 ft) in diameter. Since payment for wood is made on the basis of weight, logs are moved from the woods on the same day they are harvested. Another motive for prompt transport of the wood is that chip quality deteriorates as logs age and dry out. Eventually, chipping may be done in the forest, but little of that is done right now. Other management details that are being worked out with plantations such as these include the possibility of pre-commercial thinning treatments at 2 or 3 years of age, followed by harvest at age 11 years. At this time, the management treatments vary by site and by owner.

We traveled to Britsand Loop (southwest of Manjimup) to observe a harvesting operation in a native forest of karri (*E. diversicolor*). We learned that clear-cutting is the best regeneration method for karri. Ideally, the species is grown on a rotation age of 100 years, with two thinning entries, the first being done at 30 years of age. Sites are replanted with 2,200 seedlings per hectare (800 per acre) to have a fully stocked stand at age one of 1,666 plants per hectare (600 per acre). A market needs to be found for the thinning residues because there are 30,000 hectares (74,132 acres) of karri available for management outside of reserve areas. According to Alan Seymour, there are 100,000 tonnes of wood residue produced annually from karri thinnings. Thinning residues could be utilized for chips, sawlogs, and power poles.

We inquired about the pest problems associated with karri forests and were told that *Phoracantha*, particularly *P. acanthocera* (bullseye borer), is the main problem. Armillaria root disease is another problem, primarily in regrowth. Richard Robinson pointed out that the intensity of thinning operations is tied to the degree of *Armillaria* present in the stand. Although it does not affect karri, another important pathogen in associated species is *Phytophthora cinnamomi*. Jarrah (*E. marginata*) is particularly susceptible to *P. cinnamomi*. Surveys are conducted for the disease. We were shown a map from some of the managed stands that where the Phytophthora root disease pockets were delineated. Another organism of interest, primarily in terms of wood quality, is the wood-boring lymexilid, *Atractocerus* spp. Some of the key hosts in these southern forests are western Australia blackbutt (*Eucalyptus patens*), jarrah (*E. marginata*), and particularly karri (*E. diversicolor*).

Andrew Loch pointed out that recently established plantations of *E. globulus* have had problems with spring beetles (Scarabaeidae). In particular, some blue gum plantations were sprayed numerous times last year to control defoliation by *Liparetrus jenkensi.*

Once we returned from the field to Manjimup, we briefly met with Mr. Mark Bending a contractor involved in some of the harvest operations in blue gum pulp plantations. He pointed out that the harvester we saw earlier in the day may not be the most efficient equipment to use in that setting and that in the future, they may go to whole-tree logging instead. He said that trees are hard to debark from March through May. In addition, in consideration of dry conditions, they may plant in less droughty sites in the future.

The team returned to the CALM offices for a closeout session with personnel from WA Plantation Resources and CALM specialists on what we had seen during the day. We also had an opportunity to examine insect specimens collected by Andrew Loch from *E. globulus* plantations. Dr. Janet Farr provided the names of scientists she had worked with in Japan at the Forest Products Research Institute who have developed a pheromone for *Monochamus* spp. wood borers.

Later in the day, we visited a naturally regenerated karri forest in the Diamond area near Manjimup. The stand was 115 years old and had developed in a converted wheat field. Codominant trees in this single-story stand were well over 1 m (3.3 ft) in diameter and over 40 m (131 ft) tall. Brush and vines occupied the understory. This stand was a strong testimonial to the potential for growing karri on good sites in even-aged stands. In the adjoining natural forest we saw a mixture of species including very large karri [>2 m (>6.6 ft) in diameter], marri (*Corymbia calophylla*), and jarrah on slightly drier sites. Some Armillaria root disease was evident on some of the large karri trees and was producing sections of decay in the outer sapwood.

September 25

The team visited the Diamond Wood Chip Mill and was met by Philip Durell, Production Manager for the facility. Mr. Durell explained that the mill occupies a site of 14 hectares (34.6 acres) and is owned by WA Plantation Resources. Upon arrival, logs are either chipped immediately or stored for a while. The site has storage capability of 500,000 tonnes of wood. Although there is considerable seasonal variation, there is typically a stockpile of 200,000 tonnes (half a day's production), and some logs may sit in storage for as long as 6 months. Logs that arrive are placed on a quartz sand bed to minimize soil contamination. The mill was built in 1975 and typically produces 650,000 tonnes of chips per year. Chip products include a marri/karri mix (60%/40% by volume) and *E. globulus* chips. The Diamond mill has been processing karri regrowth and plantation blue gum since 1994. The mill easily produces 1,000 tonnes per day and could produce 1 million tonnes of chips per year. The proportion of native and plantation hardwood supply is shifting fairly dramatically away from the native forest. This year, native forest production will be 400,000 tonnes; next year it is expected to be 280,000 tonnes. We inquired as to phytosanitary condition of the material coming into the millyard. Mr. Durell pointed out that native logs come in with bark attached and may sometimes have mycelia present; not so with plantation blue gum that tend to be cleaner. Butt logs are separated out from other logs to minimize the amount of decayed wood that is chipped. At the site, we observed some galleries of cossid wood moths in native karri and also found an adult *Phoracantha* beetle, probably *P. semipunctata* (Dr. Farr), walking toward a pile of freshly peeled *E. globulus* logs. There is a very high awareness of contaminants (charcoal, plastic, metal) at the mill and careful screening is done to minimize these.

In the afternoon, the tour of Western Australia concluded, and the team traveled from Manjimup to Perth.

September 26

The sub-team returned to Canberra.

Tasmania, South Australia: September 16–25, 2001

The Tasmania/South Australia sub-team included Dr. Dennis Haugen, USDA Forest Service entomologist, Drs. Gregg DeNitto and John Kliejunas, USDA Forest Service plant pathologists, and Dr. Ed Podleckis, APHIS plant pathologist.

September 16

We departed Canberra early in the morning for the flight to Hobart, Tasmania. We were met in Hobart by Tim Wardlaw, forest pathologist, Forestry Tasmania. Tim and Dr. Humphrey Elliott, Chief of Forest Research and Development, Forestry Tasmania, took us on a tour up Mt. Wellington overlooking Hobart. Travel up this 1,270-m (4,167-ft) mountain provided a view of various native ecosystems from lower wet sclerophyll forests to subalpine forests of snow gum (*Eucalyptus pauciflora*). We were also afforded a fine view of Hobart and the surrounding waterways. The view from the top, however, was shortened by the arrival of a snow squall accompanied by winds over 60 kph (37 mph). Rather than risk becoming snowbound, we struggled against the wind back to the vehicles and descended back to Hobart. Tim then took us to the Royal Tasmanian Botanical Gardens in Hobart to view the extensive plantings of native and exotic vegetation. We spent the night in Hobart.

September 17

The morning was spent at the headquarters office of Forestry Tasmania, where we received an overview of Forestry Tasmania and forest industry operations. In addition to Tim and Humphrey, we were greeted by Dr. David de Little, entomologist with Gunns Ltd. Tasmania has a temperate maritime climate. No place on the island is more than 115 km (72 miles) from the water. The main ports are Hobart, Davonport, Burnie, Bell Bay, and Triabunna. The latter three are the ports from which wood chips are exported. The main timber resource in Tasmania is the wet sclerophyll eucalyptus forest. The principal species include *Eucalyptus regnans*, *E. delegatensis*, and *E. obliqua.* In addition to native forests, the plantation resource is becoming a more important component. Plantation species include *E. nitens* and *E. globulus*. The species selected for planting depends on elevation and site characteristics.

Forestry Tasmania is now a government–business enterprise that oversees about 1.5 million hectares (3.7 million acres) of multiple use state forestlands and 178,000 hectares (439,848 acres) of forest reserves. Approximately 830,000 hectares (2.1 million acres) are available for wood production. The remainder is under some reserve designation (World Heritage, National Park, and other), about 40% of the total. Currently, there are about 72,000 hectares (178,000 acres) of state forests in plantation, with 50,000 hectares (123,553 acres) of softwoods (mainly *Pinus radiata*) and 22,000 hectares (54,363 acres) of hardwoods. Hardwoods are by far the type of plantation being established. Softwood plantations are still being established but at a much lower rate than eucalypt plantations. About 6,000 hectares (14,826 acres) of plantations are being established each year, mainly through the conversion of native forests and pasture land. Forestry is the second largest employer in Tasmania after mining.

Forestry Tasmania has a number of joint venture agreements, including one with GMO Renewable Resources, Inc., for the softwood plantation resource. GMO Renewable Resources owns the timber resource, which is managed by Rayonier. They receive services for fire protection, forest health, and research from Forestry Tasmania. This agreement does not extend to the hardwood resource.

Forestry Tasmania has a Regional Forest Agreement with the federal government for the management of forestlands in the state. This agreement provides a long-term strategic plan for 20 years. It assures that the resources are conserved with the long-term production of wood supplies being quantified. The agreement identifies the annual allocation of wood from state land to forest industries.

The state has a Forest Practices Code that is applicable to private and government land. It requires that a Forest Practices Plan be prepared for all forestry operations. A Plan is prepared for each coupe [harvest unit averaging 50 hectares (124 acres) in native forests and 50 to 60 hectares (124 to 148 acres) in plantations] that is proposed for harvest. The Plan provides specific management information, such as what will be removed, how it will be removed, limitations due to special issues (rare flora and fauna, archaeology, geomorphology, and landscape), and regeneration efforts. Officers of the Forest Practices Board, an independent government agency, approve plans if all the proposed activities are appropriate. Inspectors with the Board can visit a site at any time and stop operations if violations are occurring. They have the authority to issue warrants that can lead to fines and imprisonment.

As stated above, Forestry Tasmania manages both natural forests and plantations. The main hardwood plantation species are *E. globulus* (85%) and *E. nitens* (15%). Forestry Tasmania has begun managing its hardwood plantations for the production of high-quality saw logs. They manage on a 20-year rotation. Pruning of the lower 2.8 m (9.2 ft) is done at about age 3. Only those plantations in good condition and growing at appropriate rates are pruned. About 300 trees/hectare are pruned as future crop trees. Trees selected for pruning are based on growth and quality rather than spacing. At age 8 to 10 years, plantations are thinned of non-pruned individuals. These trees are sold as pulp logs and for poles. Chips are currently exported primarily to Japan but also to Indonesia, Korea, and Taiwan. Plantations of *P. radiata* are managed for saw log production with an average rotation age of 25 years. Some new *P. radiata* plantations are being planted by Forestry Tasmania but at a low rate. Natural forests that are managed are primarily younger forests that regenerated following stand-replacing fires. Logs harvested through commercial thinning from these coupes are classified as regrowth and are considered of higher quality for pulpwood than those from old-growth forests. Native forests are managed on an 80- to 100-year rotation, which can be reduced to 55 years with thinning. When the drier, more open forests are regenerated as natural forests, advanced regeneration is often retained during logging. Clearfalling is still the primary means of harvesting wet eucalypt forests, although research is being conducted on alternatives to clearfalling in wet forests. Seed for regeneration are collected from local trees to maintain local genetic characteristics. Seed of species are pooled to mimic preharvest species composition and proportions.

Approximately 40% of the state of Tasmania is in reserve status, mainly in the west. About 17% of State Forest is managed by Forestry Tasmania, and contains both production forests and protection forests (forests where logging is excluded, such as wildlife habitat strips and riparian strips). Private forested land comprises 39%. Half the wood harvested in Tasmania comes from private forestlands, which contain 1,031,000 hectares (2.5 million acres). At maximum development, it is estimated that only 5% of the State Forest land in Tasmania will be in plantation.

John Kliejunas presented information to the group on the purpose of our visit and the procedure we use for pest risk assessments. He explained the past risk assessments that have been completed, with emphasis on the recent one on *Eucalyptus* from South America, and how the information in that assessment could be useful to the Australians. John identified the scope of the present assessment, which includes plantation *Eucalyptus* (*E. regnans* and *E. globulus*) and certain native forest eucalypt species.

David de Little presented information on the forest resources and operations of Gunns Ltd., the largest private forest landowner in Tasmania. They are the largest hardwood sawmiller and producer of decorative wood veneer in Australia. The veneer logs are harvested from natural forests and are processed at mills in Boyer and Somerset. They are also the largest exporter of wood chips in Australia. Gunns owns 175,000 hectares (432,434 acres) of freehold land. Most is in the northwest part of the state, but holdings are found scattered throughout. They have 65,000 hectares (160,618 acres) in plantation, with 60,000 hectares (148,263 acres) of *E. nitens* and 5,000 hectares (12,355 acres) of *P. radiata*. Gunns is planting about 6,000 hectares (14,826 acres) per year solely of *Eucalyptus*. They produce about 13 million *Eucalyptus* seedlings per year at their nursery in Burnie. Most are planted on their lands, but they do sell to other private forest landowners. They also have a research section, which is involved in *Eucalyptus* genetics research and breeding, forest health surveillance and management, and fiber technology. Gunns has five export chip mills: one at Triabunna, two at Long Reach, one at Hampshire, and one at Bell Bay. These mills produce more than 4.5 million tonnes per year of *Eucalyptus* chips from both plantations and natural forests. The foreign markets for these mills include Japan, China, Korea, Indonesia, and Taiwan. They have expansion capacity planned of 2.5 million tonnes of plantation chips by 2008, a 50% increase over current production.

The Forest Research Centre of Gunns Ltd. focuses on forest health surveillance, forest pest management, and *Eucalyptus* breeding. They do all of their breeding for *E. nitens* and are involved with a cooperative for *E. globulus*. Gunns is self-sufficient for seed production from their seed orchards. Although they make observations for a number of pests, only a few are controlled. Management of vertebrate pests (e.g., wallabies, possums, and pademelons) is achieved by using sodium fluoracetate (compound 1080). Autumn gum moth, *Mnesampela privata*, is one of the major insect pests. It and other defoliators are controlled with aerial application of chemical insecticides (pyrethroids). Mycosphaerella leaf disease, caused by *Mycosphaerella* spp., is the principal disease, but no management strategy is currently in place. Kirramyces leaf spot, caused by *Phaeophleospora* (*Kirramyces*) *eucalypti*, is another pathogen of concern on *E. nitens*, as is *Armillaria* spp. The forest health surveillance teams are vigilant for exotic incursions. An active monitoring program for gypsy moth, both European and Asian strains, is underway.

Tim Wardlaw presented information on work he has done on the occurrence of stem decays in 20- to 40-year-old regrowth of native forests. The main species he examined through stem dissection included *E. regnans*, *E. delegatensis*, and *E. obliqua.* A high proportion (about 90%) of the stems had some level of decay. *Eucalyptus obliqua* had the highest proportion with severe stem decay. In all species, the decay appeared to be entering the stem mainly in association with branches. About 55% of the aboveground decay was branch related. It is unknown whether the decay fungi attack branches or enter the stem after the branch is shed. When compared with studies of conifers in the northern hemisphere, decay incidence and severity in this study was about mid-range. About 93% of the decay columns originated from aboveground sources. Belowground butt rots accounted for 7% of the decay. A species of *Armillaria* was the principal species coming up through the butt. Species identification has not been confirmed, but it is suspected to be *A. novazealandii*. Isolations were made from decay columns, but species have not yet been determined. Members of the Hymenochaetaceae appear to be common. *Aleurodiscus* sp. and *Dichostereum* sp. are frequently observed fruiting on branches. *Phellinus wahlbergii* is a common butt rot fungus in mature forests, spreading from below ground root contact. *Griphola* spp. is also common in older forests. Genera and species vary with age of the tree. In general, white rots affect young forests, while older forests support brown rots. Efforts are now in place in production forests to reduce stem damage during thinning to less than 5%.

Only limited studies of decay have been done in plantation forests. There is concern about an increased incidence of decay associated with pruning for production of high-quality saw logs. In limited surveys on moister sites [above about 1,100 mm (43.3 in.) annual rainfall], a high incidence of decay was associated with pruned branches, and the larger the branch diameter, the higher the incidence. This work was done on older trees of marginal quality. It is hoped that the incidence of decay will drop with current management of pruning higher quality trees at age 3 years with one lift.

Dr. Jane Elek, entomologist with Forestry Tasmania, next discussed the monitoring program for leaf beetles (Chrysomelidae) in eucalypt plantations. A formal system of monitoring for these insects has been developed to determine the need for control. Susceptible plantations are visited every 2 to 4 weeks during the spring and early summer to monitor for beetle eggs and larvae. A survey protocol is established, the results of which are examined with an economic model to determine if threshold levels are exceeded. Variables in the model include site characteristics, plantation age, rate of tree growth, beetle population, and predator populations. In general, leaf beetle populations fluctuate on a regional basis. Adults are highly mobile. If control is needed, the current practice is to aerially spray plantations with a pyrethroid insecticide (Dominex®). Because these insecticides affect a wide number of non-target insects, including natural enemies, alternative materials are being examined, and hopefully they will become registered for use.

We heard a presentation by Dick Bashford, entomologist with Forestry Tasmania, on common wood borers of eucalypts. Only a few species of longhorned beetles (Ceramybicidae) attack healthy, living eucalypts. When they are present, they are usually associated with some stress factor, primarily drought. When trees are downed, longhorned beetles usually arrive within 30 days to infest the trees. Proper hygiene is the most effective means of reducing the incidence of wood borers. This includes debarking logs and moving them from the forests to the mills as quickly as possible. When logs are left in the forest, in addition to longhorned beetle attacks, termites may colonize decayed areas. Wood moths (Cossidae) are another group of wood borers of uncertain economic impact. Though they would not survive long in debarked logs because of drying of the wood, they are capable of boring up to 20 cm (7.9 in.) and providing infection courts for secondary pests. *Eucalyptus delegatensis* seems to be more susceptible to wood borers. Dry forests have high levels of termites nesting in trees. They are occasionally seen, but are rare, in *E. nitens* plantations. The common dry forest termite genus is *Porotermes*, which is common in logs. There are no native bark beetles (Scolytidae) on *Eucalyptus* (a few species of exotic bark beetles have been introduced to Australia and attack non-native tree species); however, ambrosia beetles (Platypodidae) are common in *Eucalyptus*.

David de Little discussed a complex of insects that preferentially occupy chip piles. These include members of the Staphylinidae, Nitidulidae, and Lathridiidae. Insects in this complex are primarily fungus feeders, but they do lay eggs on the chips. To date, they have not resulted in problems for ports in Japan and are remarkably similar to the complex of insects recently described on softwood chips in British Columbia by David Evans.

Tim Wardlaw next presented information on cankers and other diseases in Tasmania. In general, the incidence of deep cankers, those penetrating the cambium, is low. He indicated that he rarely sees *Cryphonectria eucalypti* associated with stem cankers on plantation grown *E. nitens*. Canker incidence was associated with bark roughness, with 97% of rough-barked trees developing cankers and only 11% of smooth-barked trees with cankers. The rough-barked trait associated with increased canker risk is associated with southern New South Wales provenances. Victorian provenances of *E. nitens*, which dominate the deployment in plantations, are much less likely to develop the rough bark. Dr. Yuan Q. Xing and Dr. Caroline Mohammed, University of Tasmania, have examined *Eucalyptus* forests across Tasmania and have reported on fungi recovered from damaged stems and branches. Thirteen of 29 fungal species had not been previously described in Australia. Three species frequently encountered were *Cryphonectria eucalypti*, *Cytospora eucalypticola*, and *Valsa* sp. Few of these fungi have undergone pathogenicity testing. Two pathogens that are recovered from cankers are species of *Phoma* and *Phomopsis*.

Three species of *Phytophthora* may cause problems in native Tasmanian forests. *Phytophthora cinnamomi* is widespread in areas below 600 m (1,969 ft) elevation. The pathogen is not usually observed, or if present, causes minimal damage, under the denser vegetative cover of wet sclerophyll forests and rainforests. *Eucalyptus globulus* is immune to *P. cinnamomi*, and *E. nitens* is susceptible. Analysis of *P. cinnamomi* in Tasmania has found little genetic diversity. Both the A1 and A2 mating types of *P. cinnamomi* are present in Tasmania, but the A1 type is much more common. *Phytophthora citricola* and *P. cactorum* are observed in limited amounts in *Eucalyptus* seedlings. Another root and root collar disease that has caused scattered deaths of *E. nitens* is associated with *Cryptosporiopsis* sp. A specific pathogen has not been identified. This disease is known only from three locations. It infects roots and progresses to the root collar causing girdling of affected trees.

The team, accompanied by David, Humphrey, and Karl P. Wotherspoon, a Forest Health Officer with Forestry Tasmania, then traveled south to an *E. globulus* plantation near the town of Geeveston. The town is the administrative base for Tasmania's most southern timber industry.

Karl explained the forest health surveillance effort that is used in plantations. The surveillance program has three main components. The first is an aerial survey, to identify larger areas of damage or damage that is of broad scale. The second is a follow-up roadside review of areas identified during the aerial survey to determine causal agents involved and extent of damage. The third is an intensive ground survey of plantations. The general purpose of this phase is to provide the local District resource managers with information on insects and diseases and on silvicultural characteristics of the plantation. Surveillance is followed by the reporting process, which provides reports that include performance assessment, diagnosis of any pests or diseases, and recommendations on appropriate silvicultural management. Forestry Tasmania plantations receive annual health surveys, and detailed ground surveys are done in 1- to 2-year-old plantations as well. In addition to any insects or diseases, plantations are examined for weeds, animal damage, stocking levels, tree size and growth rate, and suitability for pruning.

We looked at a 2-year-old plantation of *E. globulus* managed by Forestry Tasmania, and trees were up to 4 m (13.1 ft) tall. Normally, plantation establishment involves windrowing and the application of fertilizer and herbicide to the row. Seedlings are planted by hand with 3 m (9.8 ft) between rows and 2.5 m (8.2 ft) within rows [about 1,100 trees/hectare (445 trees/acre)]. Planting occurs during the winter, except at higher elevations where snow limits planting to the spring. At age 3 years, the final crop trees are pruned to 2.8 m (9.2 ft). A thinning of the non-pruned trees for pulpwood occurs between ages 8 and 11. Final harvest for sawlogs occurs around age 20. We spent the evening in nearby Port Huon.

September 18

On September 18, we met with Dave Robson, Sales and Operations Forester for Forestry Tasmania. The team traveled with Dave and Tim to a native forest harvesting site managed by Forest Tasmania. They were harvesting *E. obliqua*, *E. delegatensis*, and *E. regnans* from the wet sclerophyll forest on a 70- to 80-year rotation. Dave explained the 3-year plan for the area that identifies the coupes ready for harvest. It is a strategic plan from which Forest Practices Plans for each coupe are written. The logs from this coupe are for saw logs, with the retention of advance reproduction on the site. Some brown rot decay and termite damage were seen in the bottom logs. No damaging agents were observed higher in the logs. Standard practice is to debark logs at the landing and redistribute the bark on the site and along the snig tracks (skid trails).

We traveled to a 15,900-hectare (39,290-acre) LTER (long term ecological) site at Warra, about 60 km (37 miles) southwest of Hobart. The Warra site, which is a sister site to other LTER sites around the world, was established in 1995 with two objectives: to foster long-term (5 or more years) ecological research monitoring and to facilitate the development and demonstration of sustainable forest practices. The site is managed by a policy committee, which includes representatives from Forestry Tasmania, the University of Tasmania, and other agencies. The most common forest type at Warra is wet *E. obliqua* forest, the most widespread forest community in Tasmania. Dick Bashford, Forestry Tasmania, presented some background information on LTER and described a long-term monitoring of log decay and invertebrate biodiversity study in which he is involved. The log decay study includes monitoring paired sets of small (regrowth) and large (old growth) *E. obliqua* for invertebrates. Insects are sampled nondestructively by covering 3-m (9.8-ft) sections of log in netting. Emerging adults are caught in pit fall traps at ground level and in bottles at the apex of the top of the enclosure. A new section is enclosed at 6-month intervals. The study will provide information on comparative decay rates and resulting invertebrate biodiversity on different size logs.

In the afternoon, we returned to Hobart and visited with Dr. Caroline Mohammed, Forest Pathologist, and some of her students at the University of Tasmania. Dr. Mohammed has a joint appointment with the university and with CSIRO. We discussed a decay study with Dr. Karen Barry, a post-doctoral employee. Karen is examining the host response of *E. nitens* to decay fungi that enter via pruning wounds. She is specifically looking at decay incidence at various pruning heights. The identification of fungi involved is underway. This is a similar study to the one in older plantation trees reported by Tim Wardlaw. Dr. Mohammed reported that canker fungi are not significant in plantations. Isolates of a fungus from Tasmania previously thought to be *Endothia gyrosa* were examined by South African researchers and identified as the new species *Cryphonectria eucalypti*. Marie Yee, a Ph.D. student, and Dr. Zi Qing Yuan presented their work on beetles and decay in downed logs that is being done as part of the Warra LTER study.

We traveled with Dave de Little and Tim Wardlaw (they accompanied us on the rest of the trip in Tasmania) to the port town of Triabunna and the Gunns Ltd. Chip Mill. We met with Craig Bailey, Mill Manager, and Brett Cusick. This mill produces chips only from native forests. Logs are debarked in the bush before being shipped to the mill. Some non-*Eucalyptus* logs, such as sassafras (*Atherosperma moschatum*), silver wattle (*Acacia dealbata*), and myrtle (*Nothofagus cunninghamii*), become part of the chip mix at a very low percentage in low-yield chips. When high-yield chips are produced, only *Eucalyptus* are included in the mix. Approximately 800,000 tonnes of chips are produced and shipped from the port of Triabunna each year. The only current buyer of chips from the mill is Nippon Japan. When logs are received, they are segregated by quality in the log yard. All logs are washed to remove soil prior to entering the chipper. A small proportion of chips, 60 to 80 tonnes per year, come from local sawmills and are mixed with the rest of the chips. As chips are produced, samples are taken automatically (every 100 tonnes) to determine chip quality. In addition, chips are sampled every 100 tonnes when being loaded onto ships. The turnaround from log arrival at the mill yard to loading onto ships is highly variable from hours to up to 3 months. Logs we observed were typical of those from native forests with decay and termite damage being present, but in a low proportion. We spent the night 8 km (5 miles) south in the coastal town of Orford.

September 19

On the morning of September 19, our group visited a harvest site in dry, east coast sclerophyll forest. We were met by Tony O'Malley, Gunns Ltd. Forester. The land is government owned and managed by Forestry Tasmania. The primary species being removed included *E. obliqua*, *E. globulus*, and *E. amygdalina*. The typical harvest on this type of unit yields 100 tonnes/hectare (40.5 tonnes/acre) of saw logs, compared with 400 to 500 tonnes/hectare (162 to 202 tonnes/acre) in wet sclerophyll. An uneven-age management system is employed to obtain the benefit of retaining advanced growth. Regeneration is a mix of seed tree retention and regrowth retention; the best-formed trees are retained as seed trees, and clumps of undersized acceptable regrowth are left undisturbed. Sawyers select the leave trees on the site. Some low-intensity spot fires are used for the reduction of fine fuels. The bark removed from logs is returned to the forest by skidders. We saw some logs with brown rot decay and evidence of termite damage. These logs are segregated and sent to mills for the production of lower quality chips. Tony discussed Forest Practices Plans, referred to as FPPs. The FPP contains details of the method and prescriptions for operation according to the Forest Practices Code. The Code provides a set of standards to protect environmental values during operations. Values include soils, site productivity, landscape, geomorphology, water quality and flow, flora, fauna, genetic resources, and archaeology.

We arrived in Launceston at noon and toured a Gunns sawmill. The sawmill produces flooring, paneling, mouldings, and laminated beams from Tasmanian hardwoods (*E. delegatensis*, *E. regnans*, and *E. obliqua*).

In the afternoon we visited two Gunns chip mills near Launceston. These are the Long Reach mills. We were accompanied by Alistair McKendrick, Gunns Ltd., Kevin Jordan, AQIS Quarantine Officer, and Sharon Harrot, AQIS Shipping Officer. We were told that no special endorsements are required on phytosanitary certificates for log and chip exports. AQIS does a visual inspection of chips prior to shipment. They principally look for living insects. They have more concern with the potential entry of any exotic organism from the ships and the loading of chips into ships' holds that previously carried other materials, such as grain. The first mill produces about 900,000 tonnes per year, almost all of which is exported. This mill produces only one chip quality, E50, which can be produced from most *Eucalyptus* logs. The logs were a variety of sizes and had visible termite damage and decay in the lower portion. We observed brown rot with mycelial felts in a number of the logs.

At the adjacent Gunns chip mill, we were escorted by Peter Hilliard of Gunns Ltd. This mill produces E48 and E50 chips. These chips can come from natural forests, including regrowth, and plantation logs. We observed a small amount of non-*Eucalyptus* species in log decks of both mills. This included silver wattle, myrtle, and sassafras. There was a significant amount of white rot in larger logs. Because logs with brown rot have a very low yield, they are usually left in the field. The maximum storage time of logs and chips prior to shipment is about 3 months. These mills average two ships per month, but this is variable, depending on the market. All the Gunns chip mills follow the same chip sampling protocol for quality determination. Logs are branded by certified classifiers in the field for species, volume, and defects that determines the segregation into one of the three quality classes. These brands can be tracked from the mill back to the individual coupe and the classifier. We spent the evening in Launceston, in a former boarding house started by the great great great grandfather of our host, David de Little.

September 20

We traveled to the Gunns Ltd. and Cooperative Research Centre for Sustainable Production Forestry offices in Ridgely. We received a tour of the chip quality-testing laboratory where all the chips collected from the five Gunns mills are tested. We went south of Ridgely to the Gunns Surrey Hills Tree Farm. This is a large contiguous land holding of Gunns that contains about 50,000 hectares (123,553 acres) of plantations, 15,000 hectares (37,066 acres) of native forest, and 40,000 hectares (98,842 acres) of forest reserves. Marcel Griffiths, Operations Forester, escorted us. This holding has lands from low elevations near sea level to 800 m (2,625 ft). Cold tolerance is an issue in this area, so Gunns concentrates on managing *E. nitens*, which has been selected for cold hardiness. *Eucalyptus nitens* is not native to Tasmania but is native to high-elevation forests in Victoria and New South Wales. *Eucalyptus globulus* is more susceptible to cold and can suffer shoot dieback and invasion by opportunistic fungi. Marcel took us to a harvesting operation in a 14-year-old plantation. Typical harvesting age in this holding varies from 11 to 20 years, which is determined by pulp yield that is influenced by elevation. Harvesting was being done by a Timbco feller buncher (a cut to length processor) and a forwarder. Debarked logs may stay decked in the field up to 8 weeks to allow drying to the proper moisture content. Logs in the field are permitted a 2% bark tolerance, but normally a lower percentage is achieved. We observed two types of leaf beetles (Chrysomelidae), *Chrysophtharta bimaculata* and *Paropsis* spp. The decay fungus, *Aleurodiscus mirabilis*, was found fruiting commonly on dead branches.

From the harvest site, we traveled to the Gunns Hampshire chip mill in the Surreys Hills Estate. This is the newest Gunns chip mill, commissioned in 1995. We were met and escorted by Chris Davey, Mill Manager. This mill produces 1.2 million tonnes per year of chips. They produce four chip products: mixed hardwood, E50 from native forest, E54 from plantation and high-quality regrowth (*E. obliqua* and *E. delegatensis*), and toll chips for a local mill. The production rate is 4,000 to 5,000 tonnes per day, which is hauled by truck to the Burnie port. About 60% of the logs come from Gunns freehold lands, 20% to 30% from government lands, and 10% from other private lands. Logs are stockpiled in different areas based on their quality classification. Average storage time of logs at the mill prior to chipping is 30 days, but it is highly variable.

We traveled to the port of Burnie from the Hampshire mill. John Barber, Gunns Ltd., met us. Most (95%) of the chips at this port come from the Hampshire mill. The remaining chips come from local sawmills. They are tested for quality and added to the appropriate mix. The port site can store 80,000 tonnes of mixed forest chips, 80,000 tonnes of E50, and 60,000 tonnes of E54. Each ship holds 40,000 to 45,000 tonnes. The port loads on average 28 vessels each year. They previously exported pine chips but have not for the past 3 years. They have also exported some eucalypt logs from this port, but not regularly. *Pinus radiata* logs are exported from the port to Korea and Japan. These are debarked at the destination port. We spent the evening at Boat Harbour.

September 21

We traveled to Wiltshire and viewed a Forestry Tasmania merchandising yard trial with Mike Farrow. The purpose of the yard is to receive, sort, and prepare logs for their maximum value. Only logs that can be sawn or made into veneer are processed. Expert sawyers examine each log to determine the best utilization. They saw logs into the appropriate lengths and remove defective portions. Segments that are defective or too short are sold as firewood. Defective logs are sent to a chip mill. The main product desired is export-quality veneer logs. The aim is to recover veneer (rotary peeled) logs from logs that would traditionally be graded as pulpwood. About one-third of the logs they receive are veneer quality. The other two-thirds are split equally between sawlogs and pulp logs. This trial was started in April 2000 and will close at the end of 2001. This pilot yard processes about 2,000 tonnes per week from State Forest lands. The principal species received is *E. obliqua* coming from coupes up to 40 km (25 miles) away. Different methods of bar coding and labeling are also being tested. Forestry Tasmania is proposing to establish merchandising yards in three areas in the state, near Geeveston, Bell Bay, and Smithton. These are the main areas of plantation development. When an operational yard is established, they want to achieve 200,000 tonnes per year.

In the afternoon, we returned to the Burnie port and met with Jeff Angel of Forestry Tasmania to view export logs, both eucalypt and *P. radiata* logs. Gunns and Rayonier have a joint agreement to ship *P. radiata* logs. The eucalypt logs are exported by Forestry Tasmania. Logs are individually identified with bar codes that contain information on species and volume. Logs are shipped in holds, not in containers. Korea is the main destination for the *P. radiata* logs. There is no debarking requirement by Korea. Logs are fumigated upon arrival in Korea. The primary quarantine issue we observed was that the logs sat directly on the soil. Bottom logs with soil are washed prior to loading. Efforts are being made by Forestry Tasmania to get the Port of Burnie to hard surface the yard.

We toured the Gunns Somerset nursery near Burnie, where 13 million *Eucalyptus* seedlings are produced each year. Most of these are planted on Gunns lands, and the excess seedlings are sold. The nursery is new and has numerous state-of-the-art features for a container nursery. Forestry Tasmania has its own container nursery that also produces 13 million seedlings yearly.

Our last stop of the day was to visit Andy Warner, Private Forests Tasmania (PFT). Andy provides governmental assistance to smaller landowners similar to the U.S. Cooperative Extension Service. About 80% of the private forestlands are in small ownership. The primary role of Private Forests Tasmania, a Tasmanian government authority established under the Private Forests Act in 1994, is to promote sustainable native forest management and encourage the expansion of plantations on private land. PFT encourages landowners to grow high-value products on their small areas to obtain acceptable economic returns and provides planning and policy advice. Andy sees increasing opportunities for farmers to enter the export log market. Because of the small volumes private owners have available, a tree growing cooperative, Farmwood, has been formed that combines timber from various owners for sale. Our last evening in Tasmania was spent in Burnie.

September 22

We flew via Melbourne to Adelaide and spent the night.

September 23

The next day we drove approximately 500 km (311 miles) southeast to Mt. Gambier in the lower southeast of South Australia, adjacent to the state of Victoria. We spent the night in Mt. Gambier.

September 24

We met with Dr. Charlma Phillips, Forest Health Scientist with ForestrySA. ForestrySA (formerly the Woods & Forests Department) has been privatized, and much of their work is done under contract for industry. They also manage smaller areas for private owners. There is no harvesting of native forests in South Australia. The primary focus of plantation species remains *P. radiata*, and there is no conversion to *Eucalyptus*. The vast majority of government land is to stay in *P. radiata*, although there are experimental plots of *Eucalyptus*. Plantation *Eucalyptus* is a result of the conversion of pastureland and has increased in about the past 5 years. A major user of *Eucalyptus* chips is Kimberly Clark, which has a pulp mill near Millicent. This mill uses both softwood and hardwood chips for pulp production. Kimberly Clark does not own a *Eucalyptus* resource but buys timber from ForestrySA and private owners. A rotation of 10 to 13 years is expected, depending on soil. A geographic area in southeast South Australia and western Victoria, known as the Green Triangle, is receiving attention for the growing of *Eucalyptus globulus* because of the region's good soils, high rainfall, and mild winters. Investment companies are buying or leasing lands in this area for the production of *Eucalyptus* plantations. ForestrySA and joint venturers (Mitsui Plantation Development Pty Ltd, Nippon Paper Treefarm Australia Pty Ltd, and MCA Afforestation Pty Ltd) are managing a Green Triangle Tree Farm program for production of plantation *E. globulus* chips for export through the Port of Portland. The *E. globulus* plantations will be within a 150 km (93 mile) radius of the port.

We went to a 9-year-old *Eucalyptus* plantation just inside the border of Victoria with Charlma and Peter Lock, Kimberly Clark forester. Kimberly Clark deals mainly with pulp logs to feed their mill. They need 25,000 tonnes/year of *Eucalyptus* chips for the mill. They keep their *Eucalyptus* and *P. radiata* chips separate because of different pulping requirements. Peter expects the pulp mill capacity to be exceeded within several years as the recently planted *Eucalyptus* comes of age. The current exports are all *P. radiata.* About 1 million tonnes are exported annually. Chips go to Japan, and roundwood pulp and sawlogs are shipped to Korea. Three companies are in line to export *Eucalyptus* chips to Japan when they become available.

A mechanized harvesting operation was underway in the plantation. A Timbco processor cut, debarked and delimbed, and cut the trees to length. A forwarder then picked up the bundles and moved them to the chipper. A chipper processed the logs and blew them into vans for hauling to the mill. This equipment will be changing soon as a smaller feller buncher is used with a skidder, and a flail debarker/delimber at the chip machine will be added. Much of the bark was removed from the logs, but strips sometimes remained attached. When the forwarder picked up the bundles, limbs were incorporated. We saw many logs with a thin layer of soil on them. All of this contamination went into the chipper at the landing. There are four workers per shift on the site plus the truck driver. Working two shifts per day they harvest an estimated 300 tonnes per day. This plantation will be regenerated through coppicing. When shoots are about 3 to 4 m (9.8 to 13.1 ft) tall, they will be thinned to two shoots per stump. Since additional sprouts will come up, this thinning is repeated in 1 to 2 years. Plantation trees are not pruned, because chips are the product. Even when sawlogs might be the objective, pruning is not done because of decay entry. They estimate that there are three rotations of eucalypts for every one rotation of pine. Even so, pine plantations are not, for the most part, being planted to eucalypts. New eucalypts are being planted on converted pasture, but with the expansion of the wine grape industry, land is at a premium. Kimberly Clark is harvesting about 500 hectares (1,236 acres) per year and 300 tonnes per day to feed their mill. To meet this demand, some 30-year-old *E. regnans* plantations in Victoria are being harvested and chips hauled 600 km (373 miles).

Lock and Phillips were split on their opinions as to whether eucalypt acreage would exceed that of pines, with Lock believing it would and Phillips disagreeing. Interestingly, all of Victoria's state-owned plantations have been sold to a subsidiary of the John Hancock Insurance Company. The native forests in the area are described in the rest of Australia as "scrub" forest. They are composed of primarily *E. obliqua* and *E. ovata*. There are also *E. camaldulensis* growing in the paddocks. These native trees are highly protected and, except for rare occasions, cannot be harvested. According to Phillips, the most common diseases found in these plantations include the leaf pathogens in the genera *Mycosphaerella* (especially *M. cryptica*) and *Aulographina.* Because the plantations in the area are still young, decays are relatively uncommon. Phillips believes the low disease incidence is probably also due in part to the low humidity.

We returned to the office and discussed the forest health situation with Charlma. ForestrySA does aerial detection over the *P. radiata* plantations, mainly looking for patches of mortality. These are examined by ground crews to determine if sirex woodwasp (*Sirex noctilio*) is present. Other surveys are not routinely performed. ForestrySA provides forest health services on the lands they manage and to larger owners under contract. This includes assessment of insects and pathogens that are observed or submitted for analysis. The focus in *Eucalyptus* is on younger trees up to 3 years old when growth impacts are most probable. The primary focus is on agents damaging foliage, especially defoliators. All the insect pests are native to Australia. The major problem in *E. globulus* plantations is autumn gum moth, *Mnesampela privata*. The caterpillar skeletonizes leaves in its early instars and consumes entire leaves later. When damaging levels are detected, an aerial spray program with synthetic pyrethroids is considered. Other insects that are present, but usually not damaging, include scales, leaf beetles (*Chrysophtharta bimaculata* and *Paropsis* spp.), and the bulls-eye borer (*Phoracantha acanthocera*). The bulls-eye borer is sometimes found in young trees but normally only one to two insects per tree. Other borers are found in higher numbers in older native trees but not in plantations. Blue gum psyllids (*Ctenarytaina eucalypti*) are very common on young trees but are not considered to have any effect. Outbreaks of the gum-tree scale, *Eriococcus coriaceus*, on plantation-grown

E. nitens in South Australia is a major reason *E. globulus* is the preferred species for planting. Charlma pointed out the lack of research on most of the native insect pests of eucalypts in Australia. Research is usually only done when the insect becomes a pest elsewhere. Mycosphaerella leaf disease, caused by *Mycosphaerella cryptica* and *M. nubilosa*, is the only disease of any significance, but no control is used. She stated that, although insects and diseases are currently not a problem of plantation grown eucalypts in South Australia, some species might develop into pests over time, as eucalypt plantations are new to this area. Charlma provided input on the tables of Pests of Concern with corrections and confirmations for South Australia.

In the afternoon, we visited with Mick Underdown, ForestrySA. Mick is in charge of the private forestry program at Forestry South Australia. We traveled to a 12-year old *E. globulus* plantation in an area known as the Heath near the town of Tarpeena. It has not been harvested but is being retained as a seed orchard. Part of the plantation had been thinned to evaluate growth response. Across the road was a 1-year-old coppice stand of *E. globulus*. We looked for possible pests in this plantation. Charlma and Mick found several insect pests on the stems and foliage, including spitfires (*Perga* spp.), autumn gum moth, lerp psyllids, leaf beetles, and psyllids. They did not consider these insects to be of any consequence in this plantation. We also noted some unidentified fungal leaf spots and decays.

We stopped at a road maintenance station near Penola to observe Mundulla Yellows in a mature *E. globulus.* This disease was first noticed on *E. camaldulensis* near the town of Mundulla, South Australia. The disease now occurs in other states as well, and on a wide range of eucalypt species and other native flora. The cause has not been determined, but a distinct RNA pattern has been identified as consistently associated with symptomatic trees. We looked at a tree that had been screened and found to have this marker. Symptoms include a slow crown decline, with yellowing and mortality of individual branches. This disease has not been observed in forested conditions but usually in association with roads and paddocks, and the Australians believe that this is related to the stress placed on trees in these disturbed sites.

Our final stop of the day was at a CSIRO screening trial of eucalypts at the Plantation Forest Research Centre outside of Mt. Gambier. This trial was planted in 1979 and 1982. Species of *Eucalyptus* (including *E. globulus*, *E. nitens*, *E. obliqua*, *E. regnans*, *E. sieberi*, and *E. viminalis*) from across Australia were planted to evaluate growth form and rate for potential planting in South Australia. From this trial, *E. globulus* was selected as the best species for plantation production in southeastern South Australia.

September 25

We drove back to Adelaide (with a stop in Kingston to view the giant lobster) and visited the Waite Campus, University of Adelaide. We met with Dr. Gary Taylor, entomologist and taxonomist of psyllids. Gary provided references on his research on psyllids. Gary also has an interest in the mistletoes of Australia. All the mistletoes are endemic to Australia and are distributed mainly by the mistletoe bird that consumes the berries. Birds are the only means of seed dispersal. The mistletoe bird has developed a process of defecation that increases the likelihood of seed placement on branches. Mistletoes here are in the family Loranthaceae and include the genus *Amyema*, of which there are two species in the Adelaide area and eight species in South Australia. Many of the mistletoes are generalists, attacking *Acacia*, *Casuarina*, and *Citrus*, among others. The seeds require live tissue to germinate. So while the seeds could adhere to imported logs, Taylor feels the possibility of establishment is remote. Gary discussed a project funded by USDA examining potential biological control agents of *Melaleuca* for use by the United States. They are looking at gallflies, a group of Diptera in the family Fergusoninidae, on *Melaleuca* and *Eucalyptus*. Twenty species of these flies are reported in the literature on *Eucalyptus*. Each fly species has a specific nematode species (*Fergusonia* spp., Sphaerulariidae) as an obligate associate. His team has identified at least an additional 50 species of these flies on *Eucalyptus*, although they have not been classified and named. Several of these species are on *E. obliqua* but none on *E. regnans*, *E. globulus*, or *E. nitens.* One species has been identified on *E. viminalis*. These flies produce small galls on leaf tissue and require living tissue for oviposition (Fig. 8).

Dennis and Gary continued the entomological discussions of psyllids, while John and Ed examined the various eucalypts in the Waite arboretum and Gregg visited the university library. We spent the night in Adelaide.

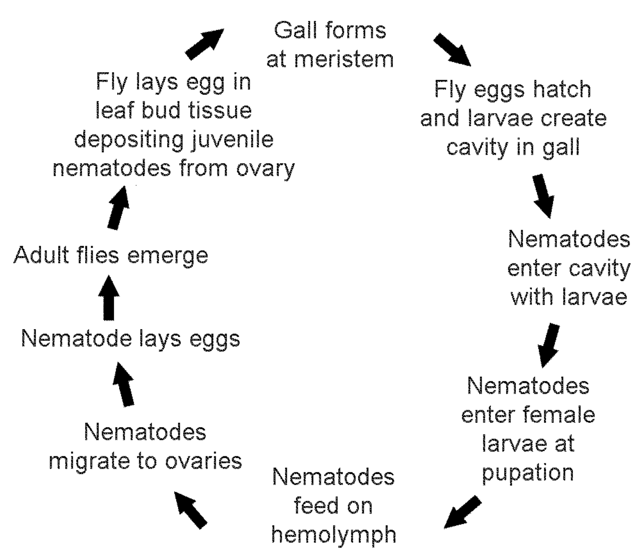

Figure 8—Gall fly lifecycle.

September 26

We flew back to Canberra and rejoined the WIPRAMET group.

Canberra: September 27–28, 2001

The three WIPRAMET sub-teams reassembled in Canberra at the offices of Plant Biosecurity for a closeout session. Each group discussed some of the highlights of things they learned during their State visits. The sub-team that traveled to Queensland and New South Wales (Mike Haverty, Borys Tkacz, Jessie Micales) made the following observations: *Eucalyptus sieberi* was an additional eucalypt species that was being chipped. Termites were swarming in some areas, and logs with termites were seen in some log decks. The team learned that the termite *Coptotermes acinaciformis* was introduced from Australia into New Zealand in logs. Adults of *Hylurgus ligniperda* were seen swarming at a log deck with various species of pines. Some clonal hybrids of pine (*Pinus caribaea* and *P. elliottii*) are being managed intensively for sawlogs, using herbicides and fertilizers. The wood borer *Phoracantha mastersi* was seen on blackbutt, *Eucalyptus pilularis*. The newly introduced wood borer *Arhopalus* sp. was also seen on pines. The team learned that the eucalypt species most susceptible to the wood moth *Endoxyla cinereus* are *E. grandis*, *E. tereticornis*, and *E. camaldulensis*. Another eucalypt species, *Eucalyptus cloeziana* (Gympie messmate) is infested by *Endoxyla cinereus* as a fairly small tree, 6 to 7 cm (2.4 to 2.8 in.) in diameter and 18 months old. There were a number of suggested additions to our table on "Insects of Concern," including the following: the leaf beetle *Chrysophtharta cloelia* on *Eucalyptus dunnii*, *E. globules*, and *E. grandis*; *Pergagrapta polita* on *E. tereticornis*; addition of several hosts for *Phoracantha solida*; the walking stick *Ctenomorphodes tessulatus* on *E. grandis* and *E. syncarpia*; *Creiis* sp., a lerp psyllid, on *E. dunnii*; and three other species of scarabs including *Automolus* spp., *Liparetrus* spp., and *Epholcis bilobiceps*.

The sub-team that traveled to Tasmania and South Australia (Dennis Haugen, Gregg DeNitto, John Kliejunas, and Ed Podleckis) also offered some highlights of their State trip. They met with Tim Wardlaw who studies decays in regrowth of eucalypts in Tasmania and learned that a high proportion of stem decay was associated with branches. In discussions with Dick Bashford, the team was told that there are few cerambycids associated with eucalypts in Tasmania. Insects attracted to chip piles in South Australia include the Lathridiidae, known as "minute brown scavenger beetles." These insects are not considered forest pests but rather are attracted to moldy material and debris and are sometimes found on flowers. In South Australia, the team found termites in log decks of regrowth and learned about the bullseye borer (*Phoracantha acanthocera*) from entomologist Charlma Phillips.

The sub-team that traveled to Victoria and Western Australia (Hal Burdsall, Jane Levy, and Andris Eglitis) reported on some observations of organisms in the field, including Armillaria root disease producing advanced decay in live trees in both states, a number of sightings of wood borer damage (primarily *P. acanthocera*), leaf diseases, sawflies, and leaf beetles. The team was also able to gather an extensive amount of literature from Australian specialists on pests related to eucalypts.

Based on information gathered during the State visits, the decision was made to increase the scope of this assessment. Originally, the eucalypt species thought to be the primary commercial species were plantation-grown Tasmanian blue gum (*Eucalyptus globulus*) and shining gum (*E. nitens*) from the entire country and native species from Tasmania, including mountain ash (*E. regnans*), alpine ash (*E. delegatensis*), black peppermint (*E. amygdalina*), messmate stringybark (*E. obliqua*), and manna gum (*E. viminalis*). We learned that there are a number of other species being harvested in significant amounts that could also form the basis of an export resource. As such, we added the following species to be assessed, and considered all these species in all the states where they occur: marri (*Corymbia calophylla*), spotted gum (*C. maculata*), Gympie messmate (*Eucalyptus cloeziana*), karri (*E. diversicolor*), Dunn's white gum (*E. dunnii*), flooded gum (*E. grandis*), swamp gum (*E. ovata*), blackbutt (*E. pilularis*), Sydney blue gum (*E. saligna*), silvertop ash (*E. sieberi*), and lemon-scented gum (*Corymbia citriodora*).

The entire WIPRAMET team met briefly with Dr. Mike Cole and Dr. Bill Roberts, Chief Plant Protection Officer (AFFA), to revisit the topic of cooperative strategies for Incursion Management that Mike Cole had discussed with us in the opening session. Even though incursions into Australia have not increased in the past 25 years, public concern has increased and AFFA feels a strong need to respond to those concerns. Some of the important priorities that were identified by Dr. Roberts and Dr. Cole included developing a target list for exotic species along with the appropriate diagnostic capabilities for them, the need for a strategy for response to Asian gypsy moth, and a surveillance strategy (recognizing that formalized surveys rarely pick up incursions). They pointed out that data sheets should be done to a common standard so that they can be shared internationally. They also felt that a digitized system for identification of quarantine pests would be useful. The team agreed with the importance of collaborative strategies, and Borys pointed out that the collaboration needs to involve our National office in Washington, D.C.

September 28

The team departed Canberra and returned to the U.S.

Appendix B—Scientific Authorities for Species of *Eucalyptus, Corymbia*, and *Angophora*

Eucalyptus

E. accedens W. Fitzg.
E. acmenioides Schauer
E. agglomerata Maiden
E. aggregata Deane & Maiden
E. alba Reinw. ex Blume
E. albens Benth.
E. amplifolia Naudin
E. amygdalina Labill.
E. andreana Naudin
E. andrewsii Maiden
E. angulosa Schauer
E. approximans Maiden
E. aspera F. Muell.
E. astringens (Maiden) Maiden
E. bancroftii (Maiden) Maiden
E. baueriana Schauer
E. baxteri (Benth.) J.M. Black
E. behriana F. Muell.
E. beyeri R. Baker
E. bicostata Maiden, Blakely & Simmonds
E. bigalerita F. Muell.
E. blakelyi Maiden
E. blaxlandii Maiden & Cambage
E. bleeseri Blakely [*Corymbia bleeseri* (Blakely) K.D. Hill & L.A.S. Johnson]
E. bosistoana F. Muell.
E. botryoides Smith
E. brachycalyx Blakely
E. bridgesiana R.T. Baker
E. brookerana A.M Gray
E. caesia Benth.
E. caleyi *Maiden*
E. calophylla R. Br. ex Lindl. [*Corymbia calophylla* (Lindl.) K.D. Hill & L.A.S. Johnson]
E. camaldulensis Dehnh.
E. cambageana Maiden
E. camphora R.T. Baker
E. capitellata Smith
E. cephalocarpa Blakely
E. cinerea F. Muell. ex Benth.
E. citriodora Hook. [*Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson]
E. cladocalyx F. Muell.
E. clavigera A. Cunn. ex Schauer
E. cloeziana F. Muell.
E. coccifera Hook.
E. concinna Maiden & Blakely
E. confluens W. Fitzg. ex Maiden
E. conica Deane & Maiden
E. consideniana Maiden
E. coolabah Blakely & Jacobs
E. cordata Labill.
E. coriacea A. Cunn. ex Walp.
E. corymbosa Smith
E. cosmophylla F. Muell.
E. creba F. Muell.
E. crenulata Blakely & Beuzev.
E. cypellocarpa L.A.S. Johnson
E. dalrympleana Maiden
E. dealbata Cunn. ex Schauer
E. deanei Maiden
E. deglupta Blume
E. delegatensis R.T. Baker
E. dendromorpha (Blakely) L.A.S. Johnson & Blaxell
E. dichromophloia F. Muell.
E. diversicolor F. Muell.
E. diversifolia Bonpl.
E. dives Schauer
E. drepanophylla F. Muell. ex Benth.
E. drummondii Benth.
E. dumosa Cunn. ex Schauer
E. dunnii Maiden
E. dwyeri Maiden & Blakely
E. elata Dehnh.
E. eremicola C.D. Boomsma
E. erythrocorys F. Muell.
E. eugenioides Sieber ex Sprengel
E. ewartiana Maiden
E. eximia Schauer [*Corymbia eximia* (Schauer) K.D. Hill & L.A.S. Johnson]
E. exserta F. Muell.
E. fasciculosa F. Muell.
E. fastigata H. Deane & Maiden
E. ferruginea Schauer
E. fibrosa F. Muell.
E. ficifolia F. Muell. [*Corymbia ficifolia* (F. Muell.) K.D. Hill & L.A.S. Johnson]
E. flocktoniae (Maiden) Maiden
E. foecunda Schauer
E. forrestiana Diels
E. fraxinoides H. Deane & Maiden
E. gamophylla F. Muell.

E. gardneri Maiden
E. gillenii Ewart & L. Kerr
E. gillii Maiden
E. glaucescens Maiden & Blakely
E. globoidea Blakely
E. globulus Labill.
E. globulus Labill. subsp. *bicostata* (Maiden, Blakely & Simmonds) J.B. Kirkp.
E. globulus Labill. subsp. *globulus*
E. globulus Labill. subsp. *maidenii* (F. Muell.) J.B. Kirkp.
E. globulus Labill. subsp. *pseudoglobulus* (Naudin ex Maiden) J.B. Kirkp.
E. gomphocephala DC.
E. gongylocarpa Blakely
E. goniantha Turez.
E. goniocalyx F. Muell. ex Miq.
E. gracilis F. Muell.
E. grandis W. Hill ex Maiden
E. grandis W. Hill ex Maiden X *camaldulensis* Dehnh.
E. grandis W. Hill ex Maiden X *urophylla* S.T. Blake
E. gregsoniana L. Johnson & Blaxell
E. guilfoylei Maiden
E. gummifera (Sol. ex Gaertner) Hochr. [*Corymbia gummifera* (Gaertn.) K.D. Hill & L.A.S. Johnson]
E. gunnii Hook.
E. haemastoma Smith
E. hemiphloia F. Muell.
E. huberiana Naudin
E. incrassata Labill.
E. intermedia R.T. Baker [*Corymbia intermedia* (R.T. Baker) K.D. Hill & L.A.S. Johnson]
E. intertexta R.T. Baker
E. jacksonii Maiden
E. jensenii Maiden
E. johnstonii Maiden
E. kingsmillii (Maiden) Maiden & Blakely
E. kondininensis Maiden & Blakely
E. laeliae Podger & Chippend.
E. laevopinea R.T. Baker
E. largiflorens F. Muell.
E. lehmannii (Schauer) Benth.
E. leptophylla F. Muell. ex Miq.
E. leucophloia Brooker
E. leucoxylon F. Muell.
E. lirata W. Fitzg. ex Maiden
E. longifolia Link
E. loxophleba Benth.
E. macarthurii H. Deane & Maiden
E. macrandra F. Muell. ex Benth.
E. macrorhyncha F. Muell. ex Benth.
E. maculata Hook. [*Corymbia maculata* (Hook.) K.D. Hill & L.A.S. Johnson]
E. maculosa R. Baker
E. maidenii F. Muell.
E. major (Maiden) Blakely
E. mannifera Mudie
E. marginata Donn ex Smith
E. megacarpa F. Muell.
E. melanophloia F. Muell.
E. melliodora Cunn. ex Schauer
E. micrantha DC.
E. micranthera F. Muell. ex Benth.
E. microcarpa (Maiden) Maiden
E. microcorys F. Muell.
E. microtheca F. Muell.
E. miniata Cunn. ex. Schauer
E. moluccana Roxb.
E. moorei Maiden & Cambage
E. morrisii R.T. Baker
E. muelleriana A.W. Howitt
E. nicholii Maiden & Blakely
E. nigra R.T. Baker
E. niphophila (Maiden & Blakely) L.Johnson & D. Blaxell
E. nitens (H. Deane & Maiden) Maiden
E. nitida Hook.
E. nortonii (Blakely) L.A.S. Johnson
E. notabilis Maiden
E. nova-anglica H. Deane & Maiden
E. nutans F. Muell.
E. obliqua L'Her.
E. oblonga DC.
E. occidentalis Endl.
E. odontocarpa F. Muell.
E. odorata Behr & Schlecht.
E. oldfieldii F. Muell.
E. oleosa F. Muell. ex Miq.
E. oligantha Schauer
E. oreades R.T. Baker
E. ovata Labill.
E. oxymitra Blakely
E. pachyphylla F. Muell.
E. paniculata Smith
E. papuana F. Muell. [*Corymbia papuana* (F. Muell.) K.D. Hill & L.A.S. Johnson]
E. parramattensis E.C. Hall
E. parvifolia Cambage
E. parvula L.A.S. Johnson & Blaxell
E. patellaris F. Muell.
E. patens Benth.
E. pauciflora Sieber ex Sprengel
E. pauciflora Sieber ex Sprengel subsp. *niphophila* (Maiden & Blakely) L.A.S. Johnson & Blaxell
E. pellita F. Muell.
E. perriniana F. Muell. ex Rodway
E. phaeotricha Blakely & McKie
E. phoenicea F. Muell.
E. pileata Blakely
E. pilularis Smith
E. pimpiniana Maiden
E. piperita Smith
E. platyphylla F. Muell.

E. platypus Hook.
E. polyanthemos Schauer
E. populnea F. Muell.
E. porosa F. Muell. ex Miq.
E. prava L. Johnson & K. Hill
E. preissiana Schauer
E. propinqua H. Deane & Maiden
E. pruinosa Schauer
E. pulchella Desf.
E. pulverulenta Sims
E. punctata DC.
E. pyriformis Turcz.
E. pyrocarpa L.A.S. Johson & Blaxell
E. quadrangulata H. Deane & Maiden
E. racemosa Cav.
E. radiata Sieber ex DC.
E. radiata Sieber ex DC. subsp. *robertsonii* (Blakely) L.A.S. Johnson & Blaxell
E. redunca Schauer var. *elata* Benth.
E. regnans F. Muell.
E. resinifera Smith
E. risdonii Hook.f.
E. robertsonii Blakely
E. robusta Smith
E. rossii R.T. Baker & H.G. Smith
E. rostrata Schltdl.
E. rubida H. Deane & Maiden
E. rudis Endl.
E. redunca Schauer var. *elata* Benth.
E. saligna Smith
E. salmonophloia F. Muell.
E. salubris F. Muell.
E. scabra Dum.-Cours
E. scoparia Maiden
E. seeana Maiden
E. sessilis (Maiden) Blakely
E. siderophloia Benth.
E. sideroxylon Cunn. ex Woolls
E. sieberi L.A.S. Johnson
E. signata F. Muell.
E. smithii R.T. Baker
E. socialis F. Muell. ex Miq.
E. sparsifolia Blakely
E. spathulata Hook.
E. sphaerocarpa L.A.S. Johnson & Blaxell
E. squamosa Deane & Maiden
E. staigeriana F.Muell. ex Bailey
E. stellulata Sieber ex DC.
E. stenostoma L. Johnson & Blaxell
E. tectifica F. Muell.
E. tenuiramis Miq.
E. tereticornis Smith
E. tessellaris F. Muell. [*Corymbia tessellaris* (F. Muell.) K.D. Hill & L.A.S. Johnson]
E. tetragona (R. Br.) F. Muell.
E. tetrodonta F. Muell.
E. todtiana F. Muell.
E. torelliana F. Muell. [*Corymbia torelliana* (F. Muell.) K.D. Hill & L.A.S. Johnson]
E. trachyphloia F. Muell.
E. transcontinentalis Maiden
E. triantha Link
E. umbra R. Baker
E. umbrawarrensis Maiden
E. urophylla S.T. Blake
E. viminalis Labill.
E. viridis R. Baker
E. wandoo Blakely
E. wardii Blakely
E. willisii Humphries, Ladiges & Brooker
E. woodwardii Maiden
E. youngiana F. Muell.
E. yumbarrana Boomsma

Corymbia

C. bleeseri (Blakely) K.D. Hill & L.A.S. Johnson (*Eucalyptus bleeseri* Blakely)
C. calophylla (Lindl.) K.D. Hill & L.A.S. Johnson (*Eucalyptus calophylla* Lindl.)
C. citriodora (Hook.) K.D. Hill & L.A.S. Johnson (*Eucalyptus citriodora* Hook.)
C. citriodora Hook.) subsp. *variegata*
C. eximia (Schauer) K.D. Hill & L.A.S. Johnson [*Eucalyptus eximia* Schauer]
C. ficifolia (F. Muell.) K.D. Hill & L.A.S. Johnson (*Eucalyptus ficifolia* F. Muell.)
C. gummifera (Gaertn.) K.D. Hill & L.A.S. Johnson [*Eucalyptus gummifera* (Gaertn.) Hochr.]
C. intermedia (R.T. Baker) K.D. Hill & L.A.S. Johnson (*Eucalyptus intermedia* R.T. Baker)
C. maculata (Hook.) K.D. Hill & L.A.S. Johnson (*Eucalyptus maculata* Hook.)
C. papuana (F. Muell.) K.D. Hill & L.A.S. Johnson (*Eucalyptus papuana* F. Muell.)
C. ptychorpa (F. Muell.) K.D. Hill & L.A.S. Johnson (*Eucalyptus ptychorpa* F. Muell.)
C. tessellaris (F. Muell.) K.D. Hill & L.A.S. Johnson (*Eucalyptus tessellaris* F. Muell.)
C. torelliana (F. Muell.) K.D. Hill & L.A.S. Johnson (*Eucalyptus torelliana* F. Muell.)
C. variegata (F. Muell.) K.D. Hill & L.A.S. Johnson (*Eucalyptus variegata* F. Muell.)

Angophora

A. costata (Gaertn.) Britten
A. floribunda (Sm.) Sweet
A. intermedia DC.
A. lanceolata Cav.
A. subvelutina F. Muell.

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

Introduction

A draft of the Australian eucalypt pest risk assessment was provided to 80 reviewers in various countries, including Australia, Canada, New Zealand, the Union of South Africa, and the United States. Individual reviewers were selected on the basis of their interest and participation in previous pest risk assessments for imported logs, their expertise in specific taxonomic groups of pest organisms, or their knowledge of pests of eucalypts.

Responses were received from 29 reviewers or organizations (see Acknowledgments for their names and addresses): 10 from Australia, 2 from New Zealand, and 17 from the United States.

The pest risk assessment team read all reviewer responses and, as a group, discussed the comments or concerns of each reviewer. Where deemed appropriate, the team made changes to the document using information derived from the reviewers' comments as well as additional information the team members had developed after distribution of the draft. Comments from reviewers that pertain to specific pests are included at the end of individual pest risk assessments, followed by a brief response from the assessment team. Numerous spelling, grammar, and other "style" errors pointed out by reviewers, and specific reviewer comments on pest distribution and host range in Tables 7 and 8, were noted and changed in the final.

General Comments From Reviewers

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

"Thank you for the opportunity to comment on the document. I have been involved in a few of these PRAs and have no major concerns with the methodology employed or the conclusions reached." (Bain)

"The team has compiled, condensed, and presented a broad array of information concerning insects and microorganisms associated with eucalypts in Australia and estimated their potential risk to the forest resources in the U.S. in a concise and readable fashion. The lists of potential pests are larger than those in some of the previous pest risk assessments, likely due to the fact that this assessment dealt with many tree species within their native distributions where they co-evolved with their respective guilds of associates. The selection of representative insects and pathogens in similar habitats seems to be a reasonable compromise approach for evaluating potential risk of introducing invasive species into the U.S." (Cameron)

"I believe that this assessment is a great improvement when compared to those of the past. In other words, I think that the team has done a very good job with the constraints and lack of knowledge with which you have had to deal. I applaud the adjustments that have been made and the expanded considerations, too. I have a few concerns that I have listed below. However, in the final analysis, I support all of the team's conclusions with MODERATE certainty." (Cobb)

"I have briefly reviewed the report and am, generally, very happy with its contents and impressed by the layout and thoroughness of the technical information contained, which is a credit to its compilers." (Collett)

"I have read the report and it is very comprehensive." (Davison)

"I focused on the section on pathogens and felt that the authors had produced a good analysis. There is much speculation and extrapolation required in this work and I had no reservations with the conclusions reached." (Margaret Dick)

"In general, I was impressed with the thoroughness of the analysis, and the clarity of the presentation. There is much useful information here." (Hansen)

"I am impressed with the extent and depth of this analysis. I congratulate the team on all the hard work that it must have taken to produce this assessment." (Jacobi)

"In summary, this is a clear, well organized treatment of the serious problems involved in the importation of eucalypt raw logs and chips from Australia to North America. As usual, the 'trip ticket' provided a fine overview of the trip and problems occurring in forested areas in Australia." (Lattin)

"Overall, we were impressed with the document. The WIPRAMET team must have put a great deal of effort into summarizing a substantial amount of information on Australian pests of *Eucalyptus* spp. Overall, the PRA was very well written and provided some excellent summary tables for readers (table 7 and 8)." (Osterbauer and Johnson)

"It appears that the Assessment Team has done an excellent job at identifying the potential insect pests and plant pathogens that could be introduced into North America." (Paine)

"I have just finished going through the draft of the "Pest risk assessment of the importation into the United States of unprocessed eucalypt logs and chips from Australia." You have all done a great job putting it together so quickly and so well. I agree with your selection of insect pests and assessment of the risk of them to the United States." (Phillips)

"I believe that the study team has done an excellent job! I agree with their conclusions that 'There are numerous pest organisms found on eucalypts in Australia that have a high probability of being inadvertently introduced into the United States on unprocessed logs or chips'." (David Wood)

Major Issues of Reviewers

Other comments from reviewers not pertaining to specific pests were organized into 10 major issues. The following section identifies these issues, summarizes specific reviewer comments with respect to each issue, and provides a response to each issue from the Wood Import Pest Risk Assessment and Mitigation Evaluation Team.

Issue 1: Inadequacy of the Pest Risk Assessment Process

Reviewers' comments—Certain reviewers believed that the pest risk assessment process used in this document was not adequate to identify all the potential risks associated with the importation of unprocessed logs or chips of the 18 eucalypt species.

"As in previous risk assessments, you have stated, 'this risk assessment is developed without regard to available mitigation measures.' The separation of mitigation measures from the pest risk assessment process is unrealistic and may lead to the exclusion of important information that would assist APHIS in establishing effective regulations. Clearly, many complex interacting factors influence the potential risk of introducing pests associated with importing logs and chips. Some of these, listed somewhat in chronological order, are

1. unmanaged native forest,
2. managed native forest,
3. plantations of native species,
4. plantations of exotic species,
5. poorly managed plantations,
6. well managed plantations,
7. harvesting,
8. debarking,
9. chipping,
10. screening chips,
11. location, method, and time of storage,
12. means of transport, and
13. manufacturing into pulp, raw lumber, kiln dried lumber, treated lumber, and board products.

Any or all of these factors may greatly influence, or mitigate, the potential risk of introduction of pests into the U.S. and should be considered in the individual pest risk assessments." (Cameron)

"I still am critical of Orr's certainty code. Someone should develop a better system, and it should not include anything approaching 100% certainty—not until we have a whale of a lot more knowledge." (Cobb)

"It seems to me that the risks of importing raw logs, and to a lesser extent, wood chips, is too high for the United States. The consequences of actual accidental introductions are clearly documented – we do not need to risk greater hazards." (Lattin)

"Risk assessment process. The risk assessment process is described in Chapter 1 of the draft PRA. We are concerned about the method used to assign the final risk rating for likelihood of introduction. The process allows for the averaging of the risk element ratings for Consequences of Introduction (Table 2). However, for the Likelihood of Introduction, the overall risk rating is based on the lowest rating for the four risk elements. This makes little sense for pests such as the gumleaf skeletonizer moth that has High ratings for three risk elements and a Moderate rating for one risk element. The overall risk rating for Likelihood of Introduction should be treated the same as for Consequences of Introduction." (Osterbauer and Johnson)

"My biggest problem is with the risk assignment. California has accumulated an average of at least one new eucalypt insect each year since 1986. This is a faster introduction rate of specialists on a single plant genus than for any other plant genus of which I am aware. In other words, we are experiencing unprecedented introduction rates through routes that are completely unknown. I do not think anyone could have predicted risk of introduction of more than 2 or 3 of them—and these two or three are the more cosmopolitan of eucalypt insects. Some of the insects we have most feared have not arrived, and some we would not have guessed would have been damaging problems have turned out to be devastating." (Paine)

"The risk assessment is a best guess based on the biology of the organisms. However, given the track record of eucalypt insects over the last 15 years, I expect that unblinking vigilance will be required, despite preconceptions about potential risk." (Paine)

"If chips to be exported are small, this could be done safely if there is a delay for drying them of a few weeks from the time of chipping before they are shipped. Logs, with or without bark, are another matter. It would be foolhardy to export unprocessed logs with or without treatment. Live beetles would reach the USA. The experience of Oregon and Washington in importing unprocessed logs from Siberia and other Asiatic localities, should have taught us a multimillion dollar lesson that should be not repeated on a magnified scale, as proposed. Let the exporter (and/or importer) pay the cost of cleanup in the USA before the first log is shipped. A billion dollar fee should be an equitable down payment for each pest species imported. The balance due when cleanup losses are determined. Prior to 1980 exotic species were imported into the USA at the rate of about one species per decade, from 1980 to 1990 it became about one per year, from 1990 to 1995 it was two or three species per year, 1995 to the present the rate has exceeded that level. In some cases the economic damage and costs have been devastating hand have seriously affected production costs of USA products, such as pecans. These losses should be paid by those who cause the problem, not by the farmers and consumers, as is now the case. The importation of elm logs from Europe has almost eliminated American elms; the importation of Siberian logs, I am told, may totally eradicate a West Coast oak. The list goes on. If we need more chips or logs, then let them be grown and produced here, without the importation of pests and diseases that come through commerce." (Stephen Wood)

Response to comments—The wood import pest risk assessments done by WIPRAMET have traditionally followed the model described in the Generic Risk Assessment Process (Orr and others 1993). The elements evaluated for the Likelihood of Introduction are based on the notion of the "weakest link." If any one of the elements is "Low," then the likelihood of introduction is rated as "Low" despite higher ratings in any of the other elements. For example, if an organism cannot successfully colonize in a new environment, the fact that it has a high likelihood of surviving transit becomes less important. The elements for Consequences of Introduction are not equal and are not averaged to arrive at an overall rating. The highest rating of the first two (economic and environmental damage potential) is the one assigned for Consequences of Introduction, and the third element only comes into play when the first two elements are rated as "Low."

The Generic Risk Assessment Process does not presume that any special mitigation measures will be taken against the commodity. In this manner, risks can be assessed based on the biologies of the organisms under consideration and how they relate to the commodity being assessed. However, all the factors mentioned by the reviewer (Cameron) that constitute the realities of the commodity, its growing conditions, its management, and its associated organisms are considered in the risk assessment process and are important in the risk ratings that are eventually assigned. We acknowledge, for example, that certain organisms are less likely to be associated with a host when that host is vigorously growing in a well-tended plantation. We also factor in such things as the resulting debarking that occurs when trees are harvested during 9 months of the year. Also, the need for logs to be debarked prior to chipping was a factor considered when ratings were developed for the chip commodity. Risk must be demonstrated in order to require regulation, which then includes further mitigation to reduce that risk.

Our risk assessment process considers a broad range of potential pests (both in terms of taxonomic groups and ecological niches), and we anticipate that risk mitigation measures developed for the representative organisms we profile will be effective against similar unknown pests.

The assessors apply the certainty codes to show the level of confidence that they have in the information used to evaluate a risk element. This is intended to be a part of the "transparency" of the risk assessment process, where any reviewer can see and evaluate the same information that was available to the assessor. As Orr and others (1993) point out in the Generic Process, the essence of the ratings is the accompanying narrative, and the assessors' certainty codes are a function of that information that was available to them.

Several reviewers (Paine, Lattin, Wood) made comments about wood importation, its associated pests, and the general increase of pests on eucalypts that we are unable to address in our assessment. We are only evaluating one pathway (eucalypt logs and chips) and are not addressing other commodities that may have figured in some of the recent increases in pests described by Dr. Paine. Whether we should or should not import wood products is also an issue that we cannot address, except to describe the pest risks as they relate to this commodity.

Issue 2: Adequacy of the Pests Considered

Reviewers' comments—Reviewers felt that the insects and pathogens of concern tables (Tables 7 and 8) and the pest categories chosen for detailed individual pest risk assessments were confusing or inadequate.

"It took me quite awhile to figure out how you had organized the analysis—with separate assessments for functional GROUPS of insects and pathogens. Careful description of your process, repeated at key points, would be helpful. Right off, the abstract had me confused. It mentions 'representative insects and pathogens', 'individual pest risk assessments", and lists dozens of specific species and genera. My problem is with the explanation, not the process." (Hansen)

"It would be very useful if these tables (potential insects and pathogens of concern tables) followed the functional groups used in the analysis, and if the pathogens table included taxonomic hierarchy like is done for the insects. There are a lot of strange names here." (Hansen)

"Emphasis on foliar pests. A substantial number of the insect pests examined in the PRA all have a similar habitat (foliage). Bark beetles, well-known disease vectors and pests, are given little to no consideration. We recognize that eucalypts may not be readily colonized by bark beetles because they often shed their bark. However, if information were available, an IPRA on a bark beetle species would be a welcome addition to the PRA." (Osterbauer and Johnson)

"The only missing pests I could think of are the scarab beetles, commonly called Christmas beetles, which are grass grubs as larvae and eucalypt defoliators as adults." (Paine)

"There are a few cases where the text is inconsistent with current conditions. For example, *Trachymela sloanei*, *Glycaspis brimblecombei*, two or three *Aprostocetes* spp., *Nezara viridula*, at least two more psyllids, and probably several other insect species are already present in California, but are not listed in the table as present, or in some cases, even as potential problems. *Trachymela sloanei* is not treated in the text or tables as a potential problem leaf beetle, yet it lays cryptic eggs under loose bark and even if it were not already here, it would be a high risk of entry on unpeeled logs." (Paine)

"It appears that a great deal of material was overlooked in the assessment. From the world catalog of Scolytidae and Platypodidae I photocopied and enclosed pages 1279–1280 that show the host list for *Eucalyptus* species worldwide. The species from Australia were checked by me in ink. From this list you can determine that the number of species from *Eucalyptus* in Australia is far greater than is recognized in your assessment. With intensive collecting, and or review in Australia, this list could be doubled or tripled in its length." (Stephen Wood)

Response to comments—The grouping of organisms for further analysis is intended to make sure that all niches (on the bark, beneath the bark, in the wood) are covered for pathogens and insects. The analysis process is described in detail and is the same as the process used in previous assessments of wood imports, beginning with a listing of the organisms of concern, selecting key species representative of a guild, functional group, or ecological niche, and conducting detailed individual pest risk assessments on those organisms. Additional information on the process was added to Chapter 3 to reduce the confusion.

The insect and pathogen tables include all the organisms that the team could identify on 18 selected species of eucalypts through literature, Australian experts, and other sources. The tables tend to include many organisms in certain niches because those groups are very diverse in Australia (leaf feeding insects being a good example). More than 15 species of Christmas beetles and other scarab beetles (e.g., *Anoplognathus* spp., *Epholcis* sp., *Heteronyx* spp., *Liparetrus* spp.) are listed on our 18 species of eucalypts.

There is no bark beetle IPRA because there are no known bark beetles in Australia associated with the 18 species of eucalypts in our assessment. The leaf beetle group is covered in an IPRA and serves as a surrogate for the Christmas beetle group that occupies a similar niche.

Changes were made in the insect table (Table 7) to show the distribution of the leaf beetle *Trachymela sloanei* and the pentatomid *Nezara viridula* as now including California. Some of the other organisms named by some reviewers as being excluded from the table were not included if they are not known to occur on any of the 18 species of eucalypts within the scope of this assessment.

For the tables of pathogens and insects of concern, the team debated the best way to list organisms, recognizing that there are tradeoffs regardless of the manner that is employed. The team eventually settled on an alphabetic listing given that many users of this document are not specialists and would not readily find the names of certain organisms if they searched through groupings by order and family. Organisms listed in Table 8, potential pathogens of concern, now have an order and family designation listed with them similar to Table 7, potential insects of concern.

Two species of scolytid ambrosia beetles were added to the table of insects of concern, but most of the others identified by Dr. Wood were only on hosts other than our 18 species of eucalypts. However, the IPRA on platypodid ambrosia beetles and pinworms was modified to include four species of scolytid ambrosia beetles, and the IPRA was renamed "Ambrosia Beetles and Pinworms."

Issue 3: Logs or Chips as a Pathway

Reviewers' comments—Some reviewers pointed out that the treatment of chips as a pathway was inadequate or that chips were treated differently among the individual pest risk assessments.

"Wood chips used for making pulp and paper are processed in several ways including debarking, chipping, and screening, each of which reduces the potential for most pest organisms to be associated with this commodity." (Cameron)

"*Eucalyptus* logs are easily debarked immediately after harvest and very difficult to debark after logs have dried out. Bark is a dirty, undesirable waste product, and considered a contaminant among chips used for the production of pulp and paper, and adds to the cost of shipping raw materials. Therefore, *Eucalyptus* logs would very likely be debarked (probably at the harvest site) prior to being chipped and minimal amounts of bark would be included in chip piles, Thus classifications of risk potential based on the assumption that bark is present among chips are probably higher than necessary." (Cameron)

"In several of the pest risk assessments, there are recurring assumptions and uncertainties stated that are not well supported be scientific research. For example, it is assumed that cerambycids and ambrosia beetles will be attracted to volatiles emitted from chips (and thus assumed to be associated with the commodity), and many of the fungi (stain and vascular wilt fungi, Armillaria root rot, and stem and trunk rots) will remain viable and virulent in chips. These assertions may well be true, but they carry important consequences and need to be documented with data collected from the commodity in question. There is a body of information concerning the biological deterioration of pulpwood (logs) and pulp chips during storage, which is not cited in this report. A review of this literature might provide important insight into the persistence and virulence of some of the specific pathogens evaluated in this report." (Cameron)

"This section (Ambrosia beetles and Pinworms IPRA, pest risk potential section) is the first to really consider factors that might affect pest risk potential as they specifically relate to chips. Other IPRAs don't cover this point in as much detail. It would probably be helpful to do so. It would also be helpful for future PRAs to do a literature review on survival of organisms in chips, and if there is not much data available, suggest that research be done. Dave Dwinell did some work on the survival of pinewood nematode in chips, but I am not sure if it was published." (Hodges)

"Chapter 4. As mentioned, I believe a literature review on chip microorganisms and their survival and fruiting should be the subject of a detailed literature review, as well as the subject of some new research. I think you will have to revisit the chip problem on more occasions in the future." (Hodges)

"Adult ambrosia and bark beetles will survive in chips, although the numbers are greatly decreased. Please see our recent paper in Can. Ent. 134: 47-58, where we chipped pine tips infected with pitch canker. There can be many survivors in a mountain of chips where maybe 99% of the beetles died." (David Wood)

Response to comments—Reviewers correctly pointed out that the chipping process would affect the numbers and kinds of insects and pathogens associated with the commodity and that authors of the individual pest risk assessments did not treat this fact uniformly. The discussion on factors influencing risk potential in Chapter 4 was expanded to include more literature review on the effects of chipping. An attempt was made by the team to more fully discuss the differences between logs and chips in the IPRAs.

Issue 4: Determination of Pest Risk Potentials and Use of Pest Risk Criteria

Reviewers' comments—Reviewers pointed out apparent differences in use of the pest risk criteria among authors of the individual pest risk assessments.

"In the consideration of economic impacts, why are shade trees not specifically evaluated? The largest losses due to DED have been to shade trees. Its not a small factor when considering *Eucalyptus*." (Cobb)

"General comment, but triggered by *Cryphonectria eucalypti* canker IPRA, environmental damage potential. The individual authors seem to be using different standards in their PRAs. Here, because eucalypt isn't native, it is stated that there would be minimal environmental damage; ignoring dangers to unrelated plants, and the importance of eucalypts in California ecosystems. Other sections take a very different approach." (Hansen)

"Individual IPRAs. In the foliar diseases and gumleaf skeletonizer moth IPRAs, the assessors provide a third risk rating (assessor's judgment) for the risk elements pest-with-host-at-origin-potential and entry-potential. A criterion should be assigned to a risk element if supported by current data. If there are not data to support the criterion, it should no be assigned. Providing a third risk rating instead only confuses the reader." (Osterbauer and Johnson)

Response to comments—The team made an effort to "equalize" their application of the pest risk criteria as much as possible, considering the wide variety of organisms to which the criteria were applied. However, inconsistencies remain because each of the pests or pest groups is evaluated in isolation from, not with respect to, the other pest organisms. All high ratings are not equally high in terms of risk. The same is true of the moderate and low ratings. However, if the criteria demand a certain rating and if there is no biological justification for changing it (and the fact that it is not as high or as low as some other pest of equal rating is not considered a reason for altering the rating), the rating stands.

The comment addressing a concern regarding the risks to shade and ornamental trees is a valid one. Eucalypts are widely used for these purposes and are a valuable asset to the properties they grace. A number of the IPRAs have been changed to address these concerns, as well as risks to the floral industry that uses eucalypts. In many cases the addition of this resource as one at risk would not have changed the risk rating. The risks are either high or low based on other rather significant considerations.

Comments were received that addressed a concern that additional (authors alternative) ratings were presented in addition to those resulting from the strict application of the formula. In addressing the reviewer comments, the team attempted to come to a standardized method of evaluating the risks. Whenever the risk assigned by the author varies from the strict application of the risk criteria formula, the reason for that and the information that support that decision are provided.

Issue 5: Other Types of Potential Pests

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

"Pest with host-commodity at origin potential. Hitchhikers may be a major concern with shipments of many wood products, as well as other commodities, but do not seem to be treated the same by all authors in this PRA and may be handled otherwise by APHIS." (Cameron)

"The PRA paid particular attention to wood damaging organisms and gave virtually no attention to possible 'hitchhikers', even though there are some special problems in this area. According to my count, Australia now grows 12 species of North American pines and Douglas fir. If I recall, there are other tree species as well (western red cedar, for example). Since a number of non-indigenous insects from other countries are now known to have been introduced into Australia, we must be alert to other pests besides those on eucalypts. For example, a native California aphid is now established there on radiata pine and at least two European bark beetles have become established there, neither of these two is yet known to occur in North America. What we have here is only part of the problem of possible introduction of exotic organisms whose potential for damage to native and introduced trees is quite clear and of great concern." (Lattin)

"Bark beetles, native and introduced, are obvious pests. Australia already has received non-native species, especially related to radiata pines. They cite (trip report) two species of bark beetles present from Europe, neither of which are known from North America. Transshipment of species from one country to another via a third country is a serious problem, demanding close attention." (Lattin)

Response to comments—The issue of hitchhiking organisms on logs, while not a principal component of the pest risk assessment process, was considered by our team. Although it clearly would be impossible for us to address all possible organisms that may be on untreated logs, we did consider this important pathway in our deliberations. The issue of hitchhiking pests on eucalypt logs coming from Australia will be considered by APHIS as part of the overall mitigation requirements.

Issue 6: Crossover of Pests (Alternative Hosts)

Reviewers' comments—One reviewer felt that a better treatment of alternative hosts would improve the usefulness of the risk assessment.

"General comment. It would be useful, I think, to list and discuss Australian fungi that are already present in the U.S. on eucalypts and any that have moved to other hosts. Also non-Australian pathogens (and insects) that have moved onto eucalyptus in the U.S. This would provide valuable perspective to the risk assessment." (Hansen)

Response to comment—An important concern to WIP-RAMET was that of alternative hosts, organisms transported on Australian eucalypts and then settling on other hosts in the United States. During the site visit, the team dedicated a considerable amount of effort to investigating the health of vegetation native to the United States planted in Australia; we found virtually no evidence of Australian organisms adapted to their exotic (our native) plants.

Issue 7: Unknown (Sleeper) Pests

Reviewers' comments—A concern expressed by one reviewer was that organisms that are not recognized as pests in their country of origin may reach pest status when introduced into a new environment.

"We don't know how these insects and diseases are going to behave once they get to the U.S. A case in point is the red gum psyllid, which is killing trees in California right now. It would be unfair to say that these assessments are a waste of time, but what is the response once the organism reaches our shores? How soon will it be detected if at all? I am sure that many of these organisms have already been here and disappeared. Right now I am working on six psyllid species and only two of them are really pests. I would not be able to determine this from a risk assessment. Also, I don't think anyone knows which of the organisms listed will be the next pest in California or the U.S. or if there is some obscure insect or disease that is not listed that will show up and become a pest in a new location." (Dahlsten)

Response to comment—There is a strong sequential filtering or removal of species between the entry phase and the impact phase, so that only a small fraction of species pass from the entry phase to the establishment phase, only a small proportion of those pass on to the spread phase, and a majority of species that become naturalized exert no demonstrable impact in their new range. In spite of this filtering, some organisms that are unknown or of no concern in their country of origin become pests when introduced into new environments. Members of the assessment team, and APHIS, recognize that unknown organisms may pose the greatest risk to our forests. One of the main functions of preparing this risk assessment is to address the issue of uncertainty. If uncertainty did not exist, there would not be a need for a risk assessment. One of the team's responsibilities is to communicate this concern about unknowns to APHIS. From the standpoint of APHIS, a pest risk must be demonstrated in order to regulate a commodity. The reason for this is that a regulation takes away the freedom of an individual or individuals to do something they wish to do. Therefore, APHIS has to show an absolute demonstrable pest risk to meet the legal requirements of placing a regulation into law. It is the responsibility of APHIS to weigh the degree of uncertainty along with the known risks in developing mitigation measures. With this pest risk assessment as a foundation, APHIS determines which specific mitigating procedures are needed to prevent unreasonable risk to the resources of the United States associated with the import of eucalypt logs and chips from Australia.

Issue 8: Risk Associated with Plantation or Natural Forest-Grown Eucalypts

Reviewers' comments—Two reviewers pointed out the lower risk of pests in plantation-grown eucalypts. Other reviewers felt that the risk of pests associated with plantation grown eucalypts was underestimated.

"Commercial eucalypt plantations are relatively free of most damaging organisms since planting stock is selected for pest resistance, they are well managed, and carefully monitored and pests are controlled." (Cameron)

"Lumping *E. globulus* plantation product in with native product is also (as is lumping all the stem and trunk decay organisms together) a false representation of the real situation with *E. globulus*. In western Australia for instance all *E. globulus* plantations are established on open farmland that has been cleared for many years. The summers are long and dry which restricts many foliar pathogens and the rotations are short which restricts the spread of butt and trunk decay organisms. Stem coppicing to produce a second rotation is now rare. Armillaria and stem and trunk rots are virtually nil. This is vastly different than the native forest situation. If *E. globulus* were treated separately, Table 13 would be rated LOW for both Armillaria root rot and stem and trunk rots in both logs and chips." (Robinson)

"The hypothesis that plantations are relatively free of pathogens, especially decay organisms, may be incorrect. Pathogens may not be readily discernable or they may be dormant in the younger trees, but that does not mean that they are not there." (Cobb)

"Chapter 4, Factors Influencing Risk Potential, last paragraph. Elsewhere it is noted that there may be an economic problem from overproduction/overplanting. If true, we may see lower standards of plantation care as prices drop, and more insect/pathogen problems." (Hansen)

"A false sense of security may take place when we compare the pests in plantation grown vs. native forest grown trees. The important point here again is that all the diseases and insects can be found in trees from both sources, although the number may be less in plantation grown trees. Mitigation measures should be the same for both, in my view."
(David Wood)

Response to comments—The scope of the PRA was changed to include a wider range of eucalypt species that are or could be harvested from either natural forests or plantations. The separation of natural forest and plantation-grown species was dropped from consideration with the change of scope. Although differences in incidence of organisms may occur between the two growing situations, this was not considered in the risk ratings because of the variation of growing conditions that may be found between states, owners, and time.

Generally, plantation trees that are intensively managed have a lower incidence of damaging agents than trees in natural forests or in plantations that are not intensively managed. That is an assumption that appears to be true worldwide. This risk assessment did not attempt to quantitatively determine this difference, because the conditions influencing incidence and occurrence vary with place and time. Conditions include site quality, management intensity, weather and climate, tree age, host species, and tree genetics. Economic and supply–demand issues also could influence pest incidence in either plantation or natural forests. Differences in pest occurrence and their levels were noted in IPRAs when such information was available to assessors. This information was normally anecdotal and shared by local Australian personnel. We did not rely significantly on this information to influence risk ratings because of the variability between locations and over time.

Issue 9: Interception Records

Reviewers' comments—Several reviewers commented on the lack of a discussion on previous interceptions of quarantine organisms in the draft risk assessment.

"I suggest that the records from Japan be studied carefully before the final assessment is released. But we must evaluate the accuracy of their inspections." (Cobb)

"I believe that the interception records here in the U.S. are very poor when considering most pathogens and even some wood-inhabiting insects. Unless things have changed, most of our inspectors appear to be poorly trained in spotting pathogens even when they are visible." (Cobb)

"Some very pertinent information (previous interceptions of quarantine organisms) was missing from the PRA. This information could shed new light on the risk elements for the 'Likelihood of Introduction' of some of the pests assessed. Should this occur, we hope the appropriate risk ratings will be changed accordingly." (Osterbauer and Johnson)

Response to comments—Information received from quarantine officials in Japan and from AQIS regarding records of pests intercepted in Japan on eucalypts from Australia was added to Chapter 2. Although some shipments of fresh cut *Eucalyptus* were rejected because of unspecified insects, there have been no interceptions officially reported from dried wood chips.

Issue 10: Insect–Fungal Associations

Reviewers' comments—One reviewer expressed concern that the potential for insects to carry fungal pathogens was not adequately treated.

"As I read through the PRA sections on wood boring beetles and wood staining/wilt fungi, the complex interactions of these organisms needs to be enhanced to better reflect potential threat and the consequences of an introduction. In some cases the lack of available literature on or knowledge about these organisms and their potential for interaction should be a justified reason for concern." (Bergdahl)

"As pointed out in the PRA, wood boring insects tend to have a wide host range that goes well beyond the local hosts and hosts in other parts of the world might even be more preferred. Also, in some cases very little is known about the basic biology/ecology of some of these insects to say nothing about the kinds of exotic or native fungi they might carry once introduced. To emphasize this point, we have been working with the fungi associated with the newly introduced pine shoot beetle (*Tomicus piniperda*). This insect is a known vector of many wood-staining fungi in its native regions and for many of these fungi the taxonomy is still being sorted out. In North America, we now know the pine shoot beetle is carrying a large number of fungi and we are in the process of sorting out those that are native from those believed to be exotic. The point being made here is that the threat posed by the introduction of an exotic insect should not just consider the potential introduction of the insect but must include the risk associated with the exotic and native fungi (or other organisms) it may carry and disseminate irrespective of a true vector relationship. So, in terms of the 'consequences of introduction', these more complex relationships need to be considered, especially relative to 'environmental damage potential'…" (Bergdahl)

Response to comments—We do recognize that the wood boring insects, ambrosia beetles, and bark beetles have a critical association with fungi, in some cases as a symbiotic relationship and in other cases as a vector relationship. These relationships have been documented and considered in previous assessments for bark beetles such as *Hylurgus ligniperda* in Chilean *Pinus radiata* and in this assessment for *Chalara australis*, a pathogen causing a wilt disease inadvertently transmitted by the platypodid ambrosia beetle *Platypus subgranosus*.

Other Reviewer Comments

Reviewers included comments on the draft document and on the risk assessment process in general that provide interesting information but that are outside the scope of this pest risk assessment. Those comments follow.

"It is stated in the Executive Summary and Summary and Conclusions that several forest industries propose to import logs and chips of eucalypts from Australia for processing in various localities in the United States. It seems unlikely that it would be commercially economical to import eucalypt logs or chips in large quantities from Australia into the U.S. due to the distance and freight charges. Yet, a substantial amount of time and money were spent on this pest risk assessment. Perhaps, it would be a better investment in the future to focus more effort on generic issues that apply to wood products from anywhere, such as 1) determining what interceptions and introductions of exotic species other countries have encountered from importation of the commodities in question, and 2) answering some of the uncertainties about the likelihood of association with the wood products under varying management regimes and survival of potential pests from harvest through processing, storage, and transit." (Cameron)

"The Risk Assessment Team (Wood Import Pest Risk Assessment and Mitigation Evaluation Team) should work closely with APHIS to identify important information gaps and work cooperatively with researchers and industry to clarify the effects of each of the factors and processes on specific pest risk." (Cameron)

"International Paper is supportive of an integrated system for preventing the transport, introduction, and successful establishment of exotic pests in the U.S. without placing unreasonable barriers to international trade." (Cameron)

"I think much more effort needs to be expended on determining the route of entry of these organisms in the first place. I have tried to get studies like this funded but to no avail. Until we know more precisely how these insects and diseases are getting here, we will not be able to do too much about them except to keep putting out the fires as they arise. Until we do something about this, a risk assessment will not help too much." (Dahlsten)

"I understand these chips and logs would probably be processed for pulp and would not be used for packing materials. Thus the chances of this material being chipped or used as landscape mulch are low. However, if any of the material is used in landscapes, I must tell you about our research results. Using a native canker causing fungus—*Thyronectria*—on Honey locust we have found that the fungus remains viable in wood chip mulch placed in an irrigated landscape for over 12 months. We are preparing the manuscript on these findings this month and plan to submit the manuscript to the J. Arboriculture." (Jacobi)

"The New South Wales, Queensland trip report discusses pallet manufactures. These pallets are likely areas of concern in shipping a variety of insects and diseases around the world—precisely why the state of Oregon has included pallet businesses in their survey for possible exotic insects in Oregon and part of southwest Washington. These pallets move around a great deal in commerce and thus are potential hazards for unanticipated introductions." (Lattin)

"As with the earlier PRA for Eucalyptus from South America, we were pleased to see some of our more vulnerable ecosystems (e.g. Hawaii) receive attention. We must consider all of the U.S., including our territories, when assessing pest risk." (Osterbauer and Johnson)

"I hope that the mitigation measure recommended by the scientific panel (USDA Forest Service FPM, AB-2S, April 15, 1992) is utilized, i.e., 160^{o}F for 75 min at the center of the log." (David Wood)