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Pest Risk Assessment of the Importation into the United States of Unprocessed *Eucalyptus* Logs and Chips from South America

Abstract

In this report, we assess the unmitigated pest risk potential of importing *Eucalyptus* logs and chips from South America into the United States. To do this, we estimated the likelihood and consequences of introducing representative insects and pathogens of concern. Nineteen individual pest risk assessments were prepared, eleven dealing with insects and eight with pathogens. The selected organisms were representative examples of insects and pathogens found on the foliage, on the bark, in the bark, and in the wood of *Eucalyptus* spp. Among the insects and pathogens assessed, eight were rated a high risk potential: purple moth (*Sarsina violescens*), scolytid bark and ambrosia beetles (*Scolytopsis brasiliensis*, *Xyleborus retusus*, *Xyleborus biconicus*, *Xyleborus* spp.), carpenterworm (*Chilecomadia valdiviana*) on *Eucalyptus nitens*, round-headed wood borers (*Chydarteres striatus*, *Retrachyderes thoracicus*, *Trachyderes* spp., *Steirastoma breve*, *Stenodontes spinibarbis*), eucalyptus longhorned borer (*Phoracantha semipunctata*), Botryosphaeria cankers (*Botryosphaeria dothidea*, *Botryosphaeria obtusa*, *Botryosphaeria ribi*), Ceratocystis canker (*Ceratocystis fimbriata*), and pink disease (*Erythricium salmonicolor*).

A moderate pest risk potential was assigned to eleven other organisms or groups of organisms: eucalypt weevils (*Gonipterus* spp.), carpenterworm (*Chilecomadia valdiviana*) on two *Eucalyptus* species other than *E. nitens*, platypodid ambrosia beetle (*Megaplatypus parasulcatus*), yellow phorancantha borer (*Phoracantha recurva*), subterranean termites (*Coptotermes* spp., *Heterotermes* spp.), foliar diseases (*Aulographina eucalypti*, *Cryptosporiopsis eucalypti*, *Cylindrocladium* spp., *Phaeophleospora* spp., *Mycosphaerella* spp.), eucalyptus rust (*Puccinia psidii*), Cryphonectria canker (*Cryphonectria cubensis*), Cytospora cankers (*Cytospora eucalypticola*, *Cytospora eucalyptina*), Coniothyrium canker (*Coniothyrium zuluense*), and root and stem rots (*Armillaria* spp., *Phellinus* spp., *Ganoderma* sp., *Gymnopilus spectabilis*). For those organisms of concern that are associated with logs and chips of South American *Eucalyptus* spp., specific phytosanitary measures may be required to ensure the quarantine safety of proposed importations.

Keywords Pest risk assessment, Eucalyptus, South America, log importation, chip importation

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Other individuals and organizations that provided valuable contributions are named in the site visit reports in Appendix A.

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Executive Summary

Background and Objectives

Current regulations require that unprocessed temperate hardwood logs from countries in South America may be imported if they are fumigated with methyl bromide prior to arrival in the United States to eliminate pests (Title 7, CFR part 319.40-5(d)). Chips are required to be of tropical origin from healthy, plantation-grown, tropical species, or if of temperate origin, must be fumigated with methyl bromide, heat-treated, or heat-treated with moisture reduction (Title 7, CFR part 319.40-6 (c)). Because of several requests from forest industries in the United States to import chips of *Eucalyptus* species from countries in South America, Animal and Plant Health Inspection Service (APHIS) requested that the U.S. Department of Agriculture (USDA) Forest Service prepare a pest risk assessment. The objectives of the risk assessment were to identify potential pests of *Eucalyptus* in South America, estimate the likelihood of their entry on South American logs and chips into the United States, and evaluate the economic, environmental, and social consequences of such an introduction.

The Risk Assessment Team

A USDA Forest Service Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET) conducted the assessment. The team was chartered in 1995 by the Chief of the Forest Service to provide a permanent source of technical assistance to APHIS in conducting pest risk assessments. In 1998, two delegations of WIPRAMET members and an APHIS representative traveled to South America, one team to Brazil and the other team to Argentina, Chile, and Uruguay. Each team met with local agricultural, quarantine, and forestry officials, entomologists, pathologists, and forest industry representatives to gather information. Each team toured harvest areas, inspected processing plants and ports, and viewed pest problems in *Eucalyptus* plantations and forests. The pest risk assessment document prepared by the team also takes into consideration comments by individuals who provided critical reviews of an earlier draft (Appendix C).

Pest Risk Assessment

The team compiled lists of insects and microorganisms known to be associated with South American species of *Eucalyptus*. From these lists, insects and pathogens that have the greatest risk potential as pests on imported logs or chips were identified. Nineteen individual pest risk assessments (IPRAs) were prepared, 11 dealing with insects and 8 dealing with pathogens. The objective was to include in the IPRAs representative examples of insects and pathogens found on the 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 anticipated that any similar unknown organisms that inhabit the same niches would also be eliminated by the application of these mitigation measures.

Conclusions

There are numerous potential pest organisms found on *Eucalyptus* spp. in South America that have a high likelihood of being inadvertently introduced into the United States on unprocessed logs and chips. The potential mechanisms of log or chip infestation by nonindigenous pests are complex. These complex mechanisms may be affected by country-specific differences in harvesting and processing practices and differences in the distribution and prevalence of pest organisms. Differences in the distribution and prevalence of pest organisms are noted in the IPRAs. These differences may change the risk potential of organisms from one country to another. The scope of this assessment is, however, the entire South American continent. Differences in cultural and processing procedures or pest distribution and prevalence may warrant country-specific mitigation measures. Where warranted, country-specific mitigation measures would be recommended by APHIS during the risk management phase based on data provided in the IPRAs.

Among the insects and pathogens found on *Eucalyptus* spp. in South America, eight were rated a high risk potential: purple moth (*Sarsina violescens*), scolytid bark and ambrosia beetles (*Scolytopsis brasiliensis*, *Xyleborus retusus*, *Xyleborus biconicus*, *Xyleborus* spp.), carpenterworm (*Chilecomadia valdiviana*) on *Eucalyptus nitens*, round-headed wood borers (*Chydarteres striatus*, *Retrachyderes thoracicus*, *Trachyderes* spp., *Steirastoma breve*, *Stenodontes spinibarbis*), eucalyptus longhorned borer (*Phoracantha semipunctata*), Botryosphaeria cankers (*Botryosphaeria dothidea, Botryosphaeria obtusa*, *Botryosphaeria ribis*), Ceratocystis canker (*Ceratocystis fimbriata*), and pink disease (*Erythricium salmonicolor*). All of these, except *Botryosphaeria dothidea*, *Botryosphaeria obtusa*, *Botryosphaeria ribis*, and *Ceratocystis fimbriata* are nonindigenous to the United States and would be classified as quarantine pests under the log import regulations.

A moderate pest risk potential was assigned to 11 organisms (or groups of organisms) found on *Eucalyptus* spp. in South America: eucalypt weevils (*Gonipterus* spp.), carpenterworm (*Chilecomadia valdiviana*) on two *Eucalyptus* species other than *E. nitens* (*E. camaldulensis* and *E. gunnii*), platypodid ambrosia beetle (*Megaplatypus parasulcatus*), yellow phorancantha borer (*Phoracantha recurva*), subterranean termites (*Coptotermes* spp., *Heterotermes* spp.), foliar diseases (*Aulographina eucalypti*, *Cryptosporiopsis eucalypti*, *Cylindrocladium* spp., *Phaeophleospora* spp., *Mycosphaerella* spp.), eucalyptus rust (*Puccinia psidii*), Cryphonectria canker (*Cryphonectria cubensis*), Cytospora cankers (*Cytospora eucalypticola*, *Cytospora eucalyptina*), Coniothyrium canker (*Coniothyrium zuluense*), and root and stem rots (*Armillaria* spp., *Phellinus* spp., *Ganoderma* sp., *Gymnopilus spectabilis*). While some of these organisms do occur in the United States, they may be capable of further dissemination or differ in their capacity for causing damage based on the genetic variation exhibited by the species.

Several factors suggest that eucalypt logs or chips destined for export from South America may be relatively free of most damaging organisms. Commercial *Eucalyptus* plantations are well managed for maximum production, closely monitored to detect and control damaging pests, and grow under conditions that do not generally lead to a high incidence of damage by insects or pathogens. There appears to be a good working knowledge of forest insects and pathogens and the ability to recognize problem situations when they occur. However, some of the pest organisms of concern are those native to South America that have been capable of attacking introduced *Eucalyptus*. This characteristic suggests an ability to have a wider host range and adaptability for new hosts. Introduction into the United States of these organisms and the array of new hosts that would then be available could result in unforeseen consequences.

For those organisms of concern that are associated with *Eucalyptus* spp. in South America, 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 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), and Mexico (Tkacz and others 1998) 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. On November 28, 1997, APHIS requested that WIPRAMET conduct a pest risk assessment of plantation-grown *Eucalyptus* species from South America to evaluate the risks associated with the importation of logs and chips into the United States.

Statement of Purpose

The specific objectives of this risk assessment are to

- identify the potential pest organisms that may be introduced with imported unprocessed *Eucalyptus* logs and chips from South America (the baseline for this pest risk assessment is raw, unprocessed *Eucalyptus* logs 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 South American pests of *Eucalyptus*,
- 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 *Eucalyptus* logs and chips from South America. Site visits by the team and APHIS were made to Argentina, Brazil, Chile, and Uruguay (Appendix A), where the preponderance of *Eucalyptus* plantations in South America occur (Chap. 2). For other South American countries, the team relied on personal contacts and available literature rather than site visits to assess risk. 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 *Eucalyptus* logs and chips destined for export from South America 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 *Eucalyptus* logs and chips from South America. 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 Commission [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 origin, processing, treatment, and handling of *Eucalyptus* logs and chips from South America.
- Evaluate data from United States and foreign countries on the history of plant pest interceptions or introductions associated with *Eucalyptus* logs and chips from South America.

2. Catalog Pests of Concern

- Determine what plant pests or potential plant pests are associated with *Eucalyptus* logs and chips in South America. 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). The team believes that some of these organisms currently occupy a limited distribution only because they have not been afforded the opportunity to exploit additional environments.

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 South America. 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 the 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.

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

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

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 and become established in the United States. Exotic organisms are considered established once they have formed a self-sustaining, free-living population at a given location (U.S. Congress 1993).

Element 1. Pest with host or commodity at origin potential—Likelihood of the plant pest being on, with, or in *Eucalyptus* 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 apply.

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 apply.

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. Establishment 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 three or more of criteria b through f apply, including criterion b or c.

Moderate risk = Criterion a does not apply, or two or fewer of criteria b through f apply.

Low risk = None of criteria a, b, or c apply.

Rating criteria:

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

b. Organism has high probability of encountering favorable climatic conditions throughout the ranges of potential hosts(s).

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

d. Organism has demonstrated ability to utilize new hosts.

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

f. 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 apply.

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 apply.

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, etc.).

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 apply.

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, political repercussions, and implications for 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 apply.

Rating criteria:

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

b. Presence of organism would probably cause domestic political repercussions.

c. Presence of organism would probably have international trade implications.

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).

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, South America, Australia, New Zealand, South Africa, and Morocco. A preliminary list of potential organisms of concern was compiled and mailed to 124 individuals for review. Suggested revisions to the list were incorporated into the final list prepared by WIPRAMET.

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

Economic damage potential	Environ-mental damage potential	Social and political considera-tions	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.

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 likelihood of introduction are low, pest risk potential is considered low, rather than moderate, for this assessment.

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), and Mexico (Tkacz and others 1998) 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, two site visits to South America (Fig. 1) were conducted by members of WIPRAMET and APHIS officials. The first delegation traveled to Brazil (Fig. 2) from March 15 to April 2, 1998, and a second delegation traveled to Chile, Argentina, and Uruguay (Fig. 3–5) from April 13 to April 30, 1998. See Appendix A for the trip reports.

Figure 1—South America.

Resources at Risk

Eucalyptus species 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)].

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

Figure 2—Brazil.

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.

Figure 3—Chile.

Figure 4—Argentina.

Figure 5—Uruguay.

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, Simpson Timber Co. (Arcata, CA) planted 4,000 hectares (10,000 acres) of *E. camaldulensis* and *E. viminalis* in the Sacramento Valley of northern California to provide a source of pulp. This plantation has been identified as surplus to the needs of Simpson and is to be sold to a Florida company (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. A current estimate of production was not available, but consumption of cut cultivated greens in 1996 was 2.3 billion stems (billion = 10^9), of which 79% were comprised of two non-*Eucalyptus* species (Economic Research Service 1997). An estimate of *E. pulverulenta* 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.

The latest horticultural census was in 1987 and did not include *Eucalyptus* as a specific product. A census was begun in 1999 by USDA, which will include the *Eucalyptus* market (Nancy L. Swaim, National Agricultural Statistics Service, Washington, DC, 1998, personal communication). 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 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 3,728 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, 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 *Eucalyptus* may not be limited to this genus of host. 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 *Eucalyptus*.

A number of the insects and pathogens discussed in this assessment are recorded on agricultural hosts in addition to *Eucalyptus*. Most of these other hosts are woody in nature. Few herbaceous hosts were identified. A number of the damaging organisms are actually more significant economically on these agricultural hosts in South America than they are on *Eucalyptus* (for example, *Ceratocystis fimbriata, Erythricium salmonicolor*). Their introduction into the United States could have more significant economic impacts on the agricultural industry than on the forestry or floriculture industries. The greatest agricultural impacts may be on subtropical and tropical woody plants because these organisms tend to be more severe in tropical conditions. However, climate alone should not be the deciding factor when considering potential impacts because it is not known how they would react under United States conditions or how irrigation practices in the United States might influence pest epidemiology.

Chapter 2. *Eucalyptus* Resources of South America

Eucalyptus Plantations in South America

The genus *Eucalyptus* is one of the most widely propagated trees in the world. This genus contains more than 500 species (Chippendale 1988) with the most important, in terms of growth potential, being *E. grandis, E. camaldulensis, E. tereticornis, E. globulus, E. urophylla, E. viminalis, E. saligna, E. deglupta, E. exserta, E. citriodora, E. paniculata*, and *E. robusta* (Eldridge and others 1993). See Appendix B for scientific authorities of *Eucalyptus* species discussed in this assessment. While eucalypts are native to Australia and its northern neighbors, they can be grown in most of the tropical and temperate climatic regions of the world between latitudes 45ºS and 40ºN (Eldridge and others 1993). Planting of fast-growing trees, such as the eucalypts, has been encouraged by various South American governments (Table 4).

Table 4—Area of *Eucalyptus* plantations in South America by Country

Country	Area of *Eucalyptus* plantations[a] hectares (acres)
Brazil	2,900,000 (7,165,900)
Chile	317,000 (783,300)
Uruguay	302,000 (746,200)
Argentina	236,000 (583,150)
Peru	211,000 (521,400)
Colombia	50,000 (123,550)
Venezuela	50,000 (123,550)
Ecuador	44,000 (108,700)
Paraguay	8,000 (19,800)

[a] Flynn and Shield 1999.

Brazil

Brazil has the largest area of eucalypt plantations in the world, with nearly three million hectares planted with various species of *Eucalyptus* (Flynn and Shield 1999) (Table 4). The eucalypts were introduced into Brazil before 1900 to substitute for native tree species in providing firewood for the railroad companies. From 1909 to 1965, about 470 thousand hectares (1,161,370 acres) of eucalypts were planted in Brazil, with 80% of these in the state of São Paulo (Couto and Betters 1995). Two fiscal incentives introduced in 1966 and 1970 spurred a tremendous expansion of plantation area. These incentives allowed companies to use up to 50% of any tax liability for investment into tourism and afforestation projects. From 1967 to 1986, 5.5 million hectares (13.6 million acres) of forest plantations were established, mainly eucalypts (52%) and pines (30%) (Evans 1992). Eucalypts were planted throughout the country (Table 5). The most common species planted was *E. grandis*, with other significant species being *E. saligna, E. alba* (misidentified when first introduced in early 1900s; the species widely planted was actually *E. urophylla* or a *E. urophylla* hybrid), and *E. urophylla*. During the early stages of this planting spree, plantations were established in varying soil and climatic conditions, and no consideration was given to ecological zoning or use of certified seeds of correct provenance (Couto and Betters 1995). Consequently, survival was very low in some regions that have low rainfall.

Table 5—Area of *Eucalyptus* plantations in Brazil by state

State	Area of *Eucalyptus* plantations[a] hectares (acres)
Minas Gerais	1,524,000 (3,765,800)
São Paulo	574,000 (1,418,400)
Bahia	213,000 (526,300)
Espírito Santo	152,000 (375,600)
Rio Grande do Sul	116,000 (286,600)
Mato Grosso do Sul	80,000 (197,700)
Paraná	67,000 (165,600)
Para	46,000 (113,700)
Santa Catarina	42,000 (103,800)
Amapa	13,000 (32,100)
Other	129,000 (318,800)
Total	2,955,000 (7,301,800)

[a] Flynn and Shield 1999.

Productivity varied from 6 to 30 m^3 of wood per hectare per year (86 to 429 ft^3/ac/yr) depending on site quality. Yields often declined in second rotations, and intensive insect and fungal attacks occurred, especially in the *E. grandis* plantations. The situation improved in the late 1970s because of ecological zoning and provenance trials conducted by the Food and Agriculture Organization of the United Nations

(FAO) and has continued to improve with introduction of new species, better silvicultural and management practices, and genetic improvement programs. The current average productivity is approximately 35 m^3 per hectare per year (500 ft^3/ac/yr) with some plantations producing at the incredible rate of 90 to 100 m^3 per hectare per year (1,286 to 1,429 ft^3/ac/yr) (Couto and Betters 1995). The harvest of eucalypts in Brazil was estimated at 67 million m^3 (2,366 ft^3) in 1994–1995 (Flynn 1996). More than half of this volume was used to produce charcoal.

With the improved gains realized through genetic improvement, Brazil's pulp and paper companies are designing plantations to yield large volumes of long-fiber pulpwood in rotations as short as seven years. More than 100,000 hectares (247,100 acres) are being planted in the state of Amapa, north of the Amazon River, by a subsidiary of Champion International Corp. This project is expected to produce 2.6 million tons of chips a year with exports projected to begin in 2004 (Blackman 1997). The projected yields for these plantations are 28 m^3/ha/yr (400 ft^3/ac/yr) in the first rotation increasing to 36 m^3/ha/yr (514 ft^3/ac/yr) in the second. Trees being planted are *Eucalyptus uro-grandis*, a hybrid formed by crossing *E. grandis* and *E. urophylla*. Farther south, in the state of Bahia, higher yields (60 m^3/ha/yr (857 ft^3/ac/yr)) are projected by Varacruz Forestal for their 30,000-hectare (74,130-acre) pulpwood plantation. Most of the older eucalypt plantations in the state of Minas Gerais were planted to provide energy for the steel industry. As the steel industry changed over to coke, forest industries began planting eucalypts for pulpwood. Minas Gerais currently has more than 400,000 hectares (988,400 acres) of good quality plantations of *E. grandis*, *E. urophylla,* and *E. uro-grandis*. Good rail service makes these plantations attractive for commercial development. According to Brazil's Association of Pulp and Paper Manufacturers, 70% of the new pulpwood plantings will be eucalypts with an estimated annual planting rate of 90,000 to 120,000 hectares (222,390–296,520 acres) from 1995 to 2001 (Blackman 1997).

Interest is growing in using eucalypts in Brazil for the manufacture of solid wood products, such as structural components and packaging (Blackman 1997, Flynn and Shield 1999). Growing high quality logs will require longer rotations (12 to 15 years) than pulpwood (6 to 8 years). The best potential areas are in the states of Espírito Santo on the central coast and Paraná and Rio Grande do Sul in the south.

Chile

Eucalypts were introduced to Chile as early as 1823 (FAO 1982). The first species planted were *E. globulus* and *E. camaldulensis.* Between 1962 and 1974, more than 75 species of *Eucalyptus* were tested by the Instituto Forestal throughout Chile (Jayawickrama and others 1993). These trials indicated that eight species showed the greatest promise and that growth varied depending on climatic conditions (which differ in the 12 regions of Chile). The species best adapted to dry conditions in Region IV (200 to 300 mm (8 to 12 in.) annual precipitation) were *E. cladocalyx* and *E. sideroxylon*. Regions V and VI average 300 to 500 mm (12 to 20 in.) of precipitation and are subject to hot dry summers. The best species for these regions was *E. camaldulensis*, which can be planted up to elevations of 1,000 m (3,280 ft) with frost-free seasons of 7 to 12 months. The most widely planted species, *E. globulus*, grows rapidly in the coastal areas from Regions VIII to X and inland areas not subject to severe frosts. This species does best in areas with 800 mm (31 in.) or more of precipitation. *Eucalyptus regnans* and *E. fastigata* are recommended for planting in Regions VIII and IX and the northern portions of Region X. Farther south, in areas with possible occurrence of frost and snowfall during 7 months of the year, the preferred species are *E. delegatensis* and *E. nitens*. The latter species has been widely planted because of its rapid growth, desirable pulping properties, and resistance to cold.

The earliest plantings of eucalypts were for shelter on farms in coastal areas. Industrial plantings began in the 1930s in the coastal areas of Region VIII to complement coal mining (Jayawickrama and others 1993). As the global demand for wood increased, planting of eucalypts escalated in the 1980s, subsidized by government loans. The rate of planting increased from 753 hectares (1,860 acres) in 1974 to 82,000 hectares (202,622 acres) in 1992. By 1997, an estimated 300,000 hectares (741,300 acres) were planted to *Eucalyptus*, according to the Chilean Instituto Forestal (INFOR) (Blackman 1997). More than two-thirds of the plantations are under 5 years old. The highest concentrations of eucalypt plantations are in Regions V, VIII, IX, and X (Table 6). INFOR predicts that by the year 2000, the total area in eucalypt plantations may exceed 400,000 hectares (988,400 acres) (Blackman 1997). Average volume increments on god sites are 30 to 40 m^3/ha/yr (429 to 572 ft^3/ac/yr) (Jayawickrama and others 1993).

Table 6—Area of *Eucalyptus* plantations in Chile by region, 1996 (Blackman 1997)

Region	Hectares	(acres)
I–II	1,002	(2,476)
IV	2,135	(5,276)
V/MR[a]	44,471	(109,888)
VI	21,146	(52,252)
VII	21,171	(52,314)
VIII	106,637	(263,500)
IX	66,766	(164,979)
X	38,920	(96,171)
XI	—	
XII	—	

[a]MR = Santiago Metropolitan Region

Chile's eucalypt plantations primarily provide wood for pulp production and fuel. Other uses include the manufacture of parquet flooring, veneers, moldings, furniture, and structural elements. Harvest of plantation-grown eucalypts in Chile is predicted to increase from 2 million m^3 (71 million ft^3) in 1995 to more than 7 million m^3 (247 million ft^3) by 2004 (Flynn 1996).

Uruguay

Uruguay has about 302,000 hectares (746,242 acres) of eucalypt plantations and already exports eucalypt pulp logs to Europe (Flynn and Shield 1999). The dominant species now established in Uruguay are *E. grandis* and *E. globulus*, covering 42% and 46% of planted area, respectively. Productivity ranges from 21 m^3/ha/yr (300 ft^3/ac/yr) in the southeast to 45 m^3/ha/yr (643 ft^3/ac/yr) in the central north (Flynn and Shield 1999). Most of the plantations of *Eucalyptus* in Uruguay are less than 5 years old, which is the result of a very successful fiscal incentive program for plantation establishment initiated by the government of Uruguay in 1988. Uruguay has been successful in attracting substantial foreign investment for plantation management from companies in Europe, Canada, and the United States. *Eucalyptus* log harvests are projected to increase dramatically in the first decade of the 21st century. The Division Forestal anticipates that harvest volumes could achieve levels of 8 million m^3 (282.5 million ft^3) by the middle of that decade (Flynn and Shield 1999). There are no pulping or paper manufacturing facilities in Uruguay. However, mills may be constructed in the near future. Exports of pulplogs to mills in Spain, Portugal, Norway, Morocco, and Finland commenced in 1987 with combined shipments of logs from both Uruguay and Argentina. Annual volumes of exports for Uruguay and Argentina combined have varied from 0.3 million m^3 (10.6 million ft^3) to 2 million m^3 (70.6 million ft^3) (Flynn and Shield 1999).

Argentina

Grown from seeds originally imported from South Africa, *Eucalyptus grandis* is well adapted to the Mesopotamia region of Argentina in the provinces of Entre Ríos, Corrientes, and Misiones (Dalla Tea 1995). Typical planting sites include alluvial sands along the Uruguay and Paraná Rivers. Depending on soil depth, mean annual increment ranges from 20 to 50 m^3/ha/yr (286 to 715 ft^3/ac/yr). The growth and yield of *E. grandis* has been significantly increased through genetic improvement. Genetic trials have demonstrated a 20% increase in yield in plantations established with South African clonal seed orchard seed compared with local seed sources.

Plantation-grown timber is a major source of fiber for the pulp and solid wood industries in Argentina. Harvest of plantation timber had climbed to nearly 7 million metric tons by 1996, with 46% being eucalypts (Blackman 1997). The major timber-producing province is Misiones, although Corrientes is seeing a rapid increase in plantings in recent years. Growth rates for eucalypts range from 12 to 20 m^3/ha/yr (171 to 286 ft^3/ac/yr). By one projection, the United States will import 200,000 bone dry metric tons (BDMT) of hardwoods from Argentina by the year 2000, and that number will increase to 2 million BDMT by 2005 (Miklos 1997).

Peru

Peru has more than 200,000 hectares (494,200 acres) of *Eucalyptus* plantations of predominantly *E. grandis* (Flynn and Shield 1999). These plantations are all small-scale plantings to produce subsistence fuelwood and poles for indigenous communities in the Andes. Although several groups are seeking financial support to establish industrial-scale *Eucalyptus* plantations, no large-scale industrial plantations are known at this time (Flynn and Shield 1999).

Colombia

Eucalyptus in Colombia is used for fuelwood–charcoal or internal pulp production. Due to the political instability and lack of large land areas suitable for planting, there is little likelihood of any large-scale expansion in plantations (Flynn and Shield 1999).

Venezuela

There are approximately 40,000 to 45,000 hectares (99 to 111,000 acres) of *Eucalyptus* plantations in Venezuela (Flynn and Shield 1999). The most common species planted are *E. urophylla* and *E. urograndis*.

Ecuador

Most *Eucalyptus* plantations in Ecuador are small, 10 to 20 hectares (25 to 50 acres) in size. However, Ecuador has established a woodchip export business based on these scattered plantations (Flynn and Shield 1999).

Paraguay

An unstable political environment and distance from seaports have restricted the development of *Eucalyptus* plantations in Paraguay (Flynn and Shield 1999). However, several multinational companies are investing in plantation establishment to take advantage of inexpensive land available for development.

Characteristics of the Proposed Importation

APHIS has received written and verbal indication of interest to import *Eucalyptus* spp. from Brazil, Argentina, Chile, and Uruguay. The commodities proposed for import into the United States could include raw lumber, unprocessed logs, and wood chips, which would be expected to arrive by marine transport to any ports of entry in the United States. The amount of wood commodities exported from South America to the United States is unpredictable and will depend on, among other factors, market prices and demand from Asian, European, and other South American countries.

The production of forest products varies from country to country in South America (Fig. 6). Brazil has sustained the highest levels of eucalypt harvest in South America. An estimated 67 million m^3 (2,366 million ft^3) of *Eucalyptus* were harvested in 1994–1995 (Flynn 1996). Most of this volume (53%) was used to produce charcoal. Future harvests are expected to expand to almost 120 million m^3 (4,237 million ft^3) by 2002 (Flynn 1996). The harvest of *Eucalyptus* in Chile is projected to increase from 2 million m^3 (71 million ft^3) in 1995 to 7 million m^3 (247 million ft^3) by 2003. Similar expansions can be expected for Argentina and Uruguay. Argentina, Brazil, Chile, and Uruguay have registered increases in exports of roundwood, chips, and particles in recent years, primarily from plantations (Figs. 7–10). The main markets for roundwood and chips are Europe (Spain, Portugal, Finland, and Norway), Asia (Japan and Korea), and the United States.

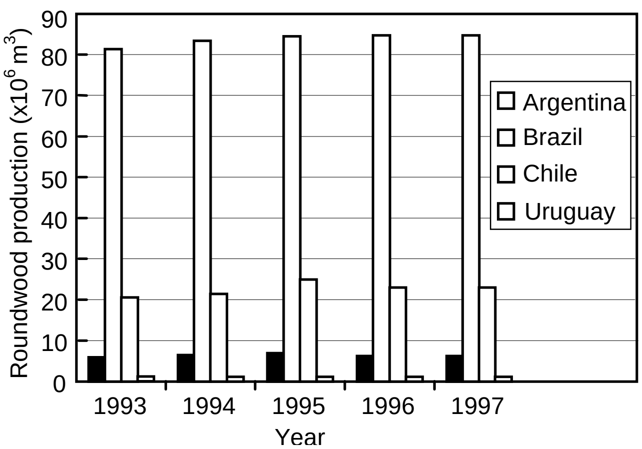

Figure 6—Industrial roundwood production in Argentina, Brazil, Chile, and Uruguay for 5 years (Source: Food & Agriculture Organization FAOSTAT Database).

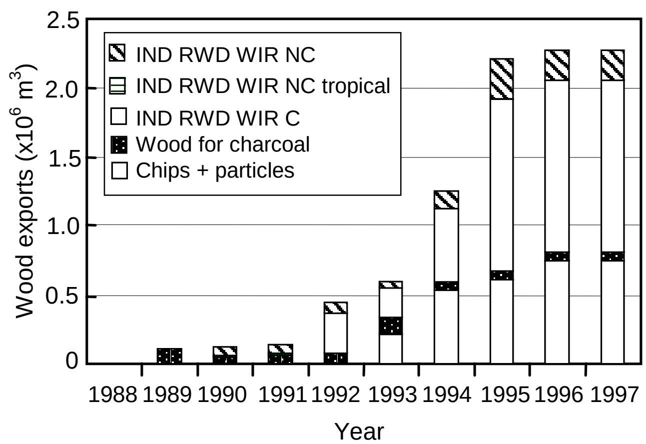

Figure 8—Volume of wood exported from Brazil (IND RWD WIR = industrial roundwood—wood in the rough, includes sawlogs, veneer logs, and pulpwood; C = coniferous, NC = nonconiferous).

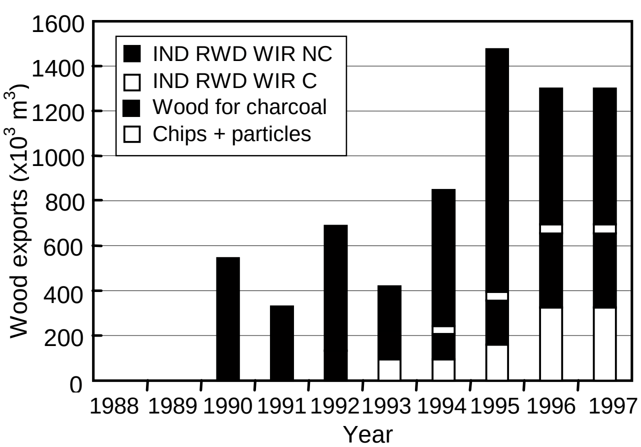

Figure 7—Volume of wood exported from Argentina (IND RWD WIR = industrial roundwood—wood in the rough, includes sawlogs, veneer logs, and pulpwood; C = coniferous, NC = nonconiferous).

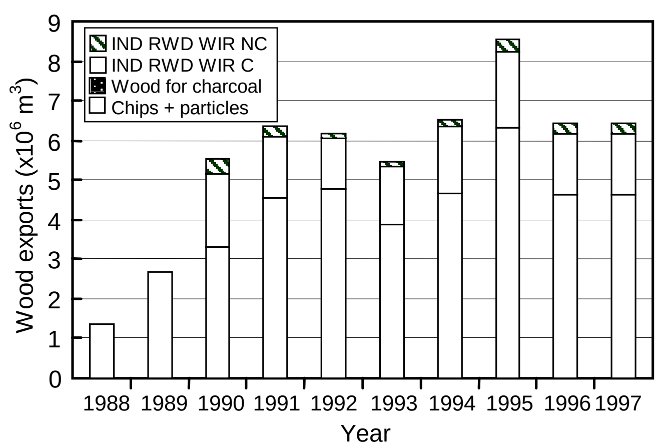

Figure 9. Volume of wood exported from Chile (IND RWD WIR = industrial roundwood—wood in the rough, includes sawlogs, veneer logs, and pulpwood; C = coniferous, NC = nonconiferous).

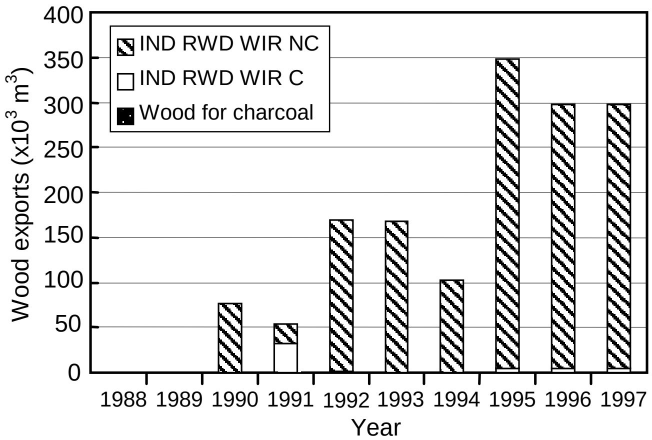

Figure 10—Volume of wood exported from Uruguay (IND RWD WIR = industrial roundwood—wood in the rough, includes sawlogs, veneer logs, and pulpwood; C = coniferous, NC = nonconiferous).

Previous Interceptions of Quarantine Organisms

Very few records of interceptions of quarantine organisms on *Eucalyptus* wood were found following inquiries with quarantine officials in Europe and Asia. Interception records for the European Plant Protection Organization since 1990 yielded only one interception of a pest on *Eucalyptus* wood, that of a nonspecified Coleoptera specimen from Argentina by Spain in 1990 (Anne–Sophie Roy, European Plant Protection Organization, Paris, France, 1998, personal communication). *Eucalyptus* wood is not a regulated material in the European Community. The Korean Plant Quarantine Service reportedly intercepted *Xyleborus* spp. on logs from Chile (Yun–Hee Kim, Information Services, APHIS, Seoul, Korea, 1998, personal communication). Japan reported only two interceptions of pests on *Eucalyptus* lumber from South America for the period from April 1992 to March 1997. Specimens were only identified to family level. One was Cerambycidae and the other was Scolytidae (Ralph Iwamoto, Information Services, APHIS, Tokyo, Japan, 1998, personal communication).

Chapter 3. Insects and Pathogens Posing Risk

Introduction

The likelihood 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 *Eucalyptus* logs or chips from South America 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 (Tkacz and others 1998; USDA 1991, 1992, 1993).

Analysis Process

Information on organisms associated with South American species of *Eucalyptus* was collected. Lists of insects and microorganisms that have been reported to inhabit *Eucalyptus* in South America were compiled from the literature, from information provided by South American forest entomologists and pathologists, from information received from reviewers of a preliminary list prepared by the team, and from information described in Chapter 1. Available information on *Eucalyptus* pests varies among the South American countries. The team broadened some of the categories identified in the log import regulations (Title 7 CFR 319.40-11) (Table 7). These organisms were assessed as described previously in Chapter 1, under the heading Pest Risk Assessment Process.

Individual Pest Risk Assessments

The species of insects and pathogens associated with *Eucalyptus* in South America and identified as potential pests of concern are presented in Tables 8 and 9. The lists include 175 insects and 58 pathogens. Tables 8 and 9 are not meant to be all-definitive or all-inclusive lists, but are a result of literature searches and information provided by colleagues in South America. The tables represent a list of potential pests of concern and do not represent, or judge, quarantine status of any of the organisms listed. Nineteen individual pest risk assessments (IPRAs) were prepared, 11 dealing with insects and 8 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 *Eucalyptus* spp. in South America. 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. Assessing the risks associated with known organisms that inhabit a variety of niches on logs and chips will enable the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) to identify effective mitigation measures to eliminate both the known organisms and any similar heretofore unknown organisms that inhabit the same niches.

Table 7—Pest categories and descriptions

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

Table 8—Potential insects of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category

Species	Country	Hosts	Location on host: Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sap-wood	Heart-wood	Pest category[a]
Acrocinus longimanus (Coleoptera: Cerambycidae)	Venezuela	*Eucalyptus* spp.				x	x	1
Acromyrmex ambiguous (Hymenoptera: Formicidae)	Argentina	*Eucalyptus* spp.; *Pinus* spp.	Up to first 2 years	x				1
Acromyrmex lobicornis (Hymenoptera: Formicidae)	Argentina	*Eucalyptus* spp.; *Pinus* spp.	Up to first 2 years	x				1
Acromyrmex lundi (Hymenoptera: Formicidae)	Argentina	*Eucalyptus* spp.	Coppice and <6 mo old	x				1
Acromyrmex octospinosus (Hymenoptera: Formicidae)	Venezuela	*Eucalyptus* spp.	Coppice and <6 mo old	x				1
Acromyrmex spp. (Hymenoptera: Formicidae)	Brazil	*Eucalyptus* spp.	Coppice and <6 mo old	x				1
Aeschoroteryx incaudata (Lepidoptera: Geometridae)	Argentina	*Eucalyptus* spp.		x				1
Aetalion sp. (Homoptera: Aetalionidae)	Ecuador	*Eucalyptus* spp.		x				1
Alchisme sp. (Homoptera: Membracidae)	Colombia	*E. globulus*		x				1
Amitermes foreli (Isoptera: Termitidae)	Colombia	*E. tereticornis*					x	1
Anomala pyropyga (Coleoptera: Scarabaeidae)	Colombia	*E. grandis; Pinus oocarpa, Pinus patula, Cupressus lusitanica, Cordia alliodora*		x				1
Anomala sp. (Coleoptera: Scarabaeidae)	Colombia	*E. grandis; Pinus oocarpa*		x				1
Apatelodes sericea (= *Hygrochroa sericea*) (Lepidoptera: Apatelodidae)	Brazil	*Eucalyptus* spp., *E. grandis*		x				1
Atta cephalotes (Hymenoptera: Formicidae)	Colombia	*E. grandis*		x				1
Atta laevigata (Hymenoptera: Formicidae)	Argentina	*Eucalyptus* spp.		x				1
Atta sexdens (Hymenoptera: Formicidae)	Argentina, Brazil, Uruguay	*Eucalyptus* spp.; *Citrus* sp.	Coppice and <6 mo old	x				1
Atta vollenweideri (Hymenoptera: Formicidae)	Argentina	*Eucalyptus* spp.		x				1
Atta sp. (Hymenoptera: Formicidae)	Colombia, Ecuador	*E. deglupta, E. grandis, E. tereticornis*	Coppice and <6 mo old	x				1
Automeris illustris (Lepidoptera: Saturniidae)	Brazil	*Eucalyptus* spp.		x				1
Automeris sp. (Lepidoptera: Saturniidae)	Venezuela	*Eucalyptus* spp.		x				1
Blera varana (Lepidoptera: Notodontidae)	Brazil	*Eucalyptus* spp.		x				1
Blycapsis brimblecombei (Homoptera: Psyllidae)	Brazil	*Eucalyptus* spp.		x				2 (California)
Bolax flavolineatus (Coleoptera: Scarabaeidae)	Brazil	*Eucalyptus* spp.	x	x				1
Callideriphus laetus (Coleoptera: Cerambycidae)	Chile, Argentina	*Eucalyptus* spp.; *Pinus radiata*, native hardwoods				x		1
Cargolia arana (Lepidoptera: Geometridae)	Colombia	*E. grandis; Pinus patula, Pinus oocarpa*		x				1
Carmenta sp. (Lepidoptera: Aegeridae)	Brazil	*Eucalyptus* spp.			x	x		1

Table 8—Potential insects of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category—con.

			Location on host					
Species	Country	Hosts	Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sap- wood	Heart- wood	Pest category[a]
Cephaisus siccifolius (Homoptera: Cercopidae)	Argentina	*E. alba, E. botryoides, E. grandis, E. saligna, E. tereticornis; Acacia* spp., *Robinia pseudoacacia*		x				1
Ceresa ustulata (Homoptera: Membracidae)	Brazil	*Eucalyptus* spp.		x				1
Ceresa vitulus (Homoptera: Membracidae)	Ecuador	*Eucalyptus* spp.		x				1
Ceresa sp. (Homoptera: Membracidae)	Colombia	*E. globulus, E. grandis; Pinus patula*		x				1
Chalcophana sp. (Coleoptera: Chrysomelidae)	Colombia	*E. grandis; Pinus* spp., *Cordia alliodora*		x				1
C*hibchacris* sp. (Orthoptera: Acrididae)	Colombia	*E. grandis*		x				1
Chilecomadia valdiviana (Lepidoptera: Cossidae)	Argentina, Chile	*E. camaldulensis, E. gunnii, E. nitens; Nothofagus* spp., fruit trees		x	x	x	x	1
Chlorocoris complanatus (Hemiptera: Pentatomidae)	Colombia	*E. grandis*		x				1
Chromacris speciosa (Orthoptera: Acrididae)	Brazil	*Eucalyptus* spp.		x				1
Chydarteres striatus (Coleoptera: Cerambycidae)	Brazil, Uruguay	*Eucalyptus* spp.*; Acacia* spp.*, Cassia* spp.*, Citrus* spp.*,* hard-woods, fruit trees					x	1
Chrysomima semilutearia (Lepidoptera: Geometridae)	Colombia	*E. grandis; Cupressus lusitanica, Pinus patula*		x				1
Citheronia lobesis lobesis (Lepidoptera: Saturniidae)	Brazil	*E. camaldulensis, E. urophylla*		x				1
Citheronia marion (Lepidoptera: Saturniidae)	Brazil	*E. camaldulensis E. urophylla*		x				1
Clastoptera biguttata (Homoptera: Clastopteridae)	Colombia	*E. saligna*		x				1
Clastoptera sp. (Homoptera: Clastopteridae)	Colombia	*E. grandis*		x				1
Colaspis spp. (Coleoptera: Chrysomelidae)	Brazil, Co-lombia	*Eucalyptus* spp.*, E. tereticornis*		x				1
Colaspoide vulgata (Coleoptera: Chrysomelidae)	Argentina	*Eucalyptus* spp.; *Salix* spp.	x	x				1
Cornitermes spp. (Isoptera: Termitidae)	Brazil	*Eucalyptus* spp.*, E. grandis*	x				x	1
Compsosoma perpulchrum (Coleoptera: Cerambycidae)	Brazil	*E. grandis*			x			1
Compsus sp. (Coleoptera: Curculionidae)	Colombia	*E. tereticornis;Tabebuia rosea*	x					1
Coptotermes havilandi (Isoptera: Rhinotermitidae)	Brazil	*Eucalyptus* spp.					x	2 (Florida)
Coptotermes testaceus (Isoptera: Rhinotermitidae)	Brazil	*Eucalyptus* spp.					x	1
Coptotermes spp. (Isoptera: Rhinetermitidae)	Colombia	*Eucalyptus* spp.					x	1
Cosmosoma auge (Lepidoptera: Arctiidae)	Brazil	*Eucalyptus* spp.		x				1
Costalimaita ferruginea vulgata (Coleoptera: Chrysomelidae)	Brazil	*Eucalyptus* spp.*, E. grandis, E. urophylla*		x				1
Crematogaster sp. (Hymenoptera: Formicidae)	Colombia	*E. tereticornis*					x	1
Cryptocephalus sp. near *anceps* (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis; Cordia alliodora*		x				1

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Species	Country	Hosts	Location on host: Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sap-wood	Heart-wood	Pest category[a]
Ctenarytaina eucalypti (Homoptera: Psyllidae)	Chile, Bolivia, Brazil, Uruguay	*E. camaldulensis, E. cinerea, E. globulus, E. gunnii, E. nitens, E. pulverulenta, E. viminalis*		x				2 (California)
Ctenarytaina spatulata (Homoptera: Psyllidae)	Uruguay	*Eucalyptus* spp.		x				2 (California)
Cyclocephala sp. (Coleoptera: Scarabaeidae)	Colombia	*E. grandis*		x				1
Diabrotica sp. (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis; Tabebuia rosea, Bombacopsis quinatum*		x				1
Dilobobderus abderus (Coleoptera: Scarabaeidae)	Argentina	*Eucalyptus* spp.	x					1
Dirphia avicula (Lepidoptera: Saturniidae)	Brazil	*E. urophylla*		x				1
Dirphia rosacordis (Lepidoptera: Saturniidae)	Brazil	*E. urophylla*		x				1
Dirphiopsis trisignata (Lepidoptera: Saturniidae)	Brazil	*Eucalyptus* spp., *E. saligna*		x				1
Eacles imperialis magnifica (Lepidoptera: Saturniidae)	Brazil	*Eucalyptus* spp., *E. grandis*		x				4
Enchenopa sp. (Homoptera: Membracidae)	Colombia	*E. grandis*		x				1
Eumolpus sp (Coleoptera: Chrysomelidae)	Brazil	*Eucalyptus* spp.		x				1
Eupseudosoma aberrans (Lepidoptera: Arctiidae)	Brazil	*E. cloeziana, E. urophylla;* fruit trees		x				1
Eupseudosoma involutum (Lepidoptera: Arctiidae)	Brazil	*E. camaldulensis, E. citriodora, E. cloeziana, E. grandis, E. saligna, E. urophylla*		x				1
Eurymerus eburoides (Coleoptera: Cerambycidae)	Argentina	*Eucalyptus* spp.					x	1
Euryscopa cingulata (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis; Bombacopsis quinatum, Cordia alliodora*		x				1
Euselasia apisaon (Lepidoptera: Riodinidae)	Brazil	*Eucalyptus* spp.		x				1
Euselasia eucerus (Lepidoptera: Riodinidae)	Brazil	*Eucalyptus* spp., *E. paniculata, E. saligna*		x				1
Fulgurodes spp. (Lepidoptera: Geometridae)	Brazil	*Eucalyptus* spp.; *Pinus* spp.		x				1
Glena bisulca (Lepidoptera: Geometridae)	Colombia, Venezuela	*Eucalyptus* spp., *E. grandis; Pinus patula*		x				1
Glena spp. (Lepidoptera: Geometridae)	Brazil	*Eucalyptus* spp.		x				1
Glyptoscelis sp. (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis, E. tessellaris, E. torreliana*		x				1
Gonipterus gibberus (Coleoptera: Curculionidae)	Argentina, Brazil, Uruguay	*Eucalyptus* spp., *E. globulus, E. saligna, E. viminalis*		x				1
Gonipterus platensis (Coleoptera: Curculionidae)	Argentina	*Eucalyptus* spp.		x				1
Gonipterus scutellatus (Coleoptera: Curculionidae)	Argentina, Brazil, Chile, Uruguay	*E. dunnii, E. eugenioides, E. fastigata, E. globulus, E. macarthurii, E. obliqua, E. viminalis*		x				2 (California)
Gryllus assimilis (Orthoptera: Gryllidae)	Brazil	*Eucalyptus* spp.		x				1

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Gryllus sp. (Orthoptera: Gryllidae)	Argentina, Colombia	*Eucalyptus* spp., *E. grandis*		x				1
Halisidota interlineata (Lepidoptera: Arctiidae)	Brazil	*E. grandis*		x				1
Halisidota sp. (Lepidoptera: Arctiidae)	Colombia	*E. grandis; Pinus patula*		x				1
Hepialus sp. (Lepidptera: Hepialidae)	Colombia, Ecuador	*E. globulus, E. tereticornis*					x	1
Heterotermes tenuis (Isoptera: Rhinotermitidae)	Brazil	*Eucalyptus* spp., *E. grandis*					x	1
Heterotermes sp. (Isoptera: Rhinotermitidae)	Colombia	*E. tereticornis; Cordia alliodora*					x	1
Homophoeta sp. (Coleoptera: Chrysomelidae)	Colombia	*E. tessellaris; Cordia alliodora, Bombacopsis quinatum*		x				1
Hylesia nigricans (= *H. nanus*) (Lepidoptera: Saturniidae)	Argentina, Brazil, Uruguay	*Eucalyptus* spp.; *Acacia* spp., *Ilex* spp., fruit trees, *Quercus* spp.		x				1
Idalus affinis (= *I. admirabilis*) (Lepidoptera: Arctiidae)	Brazil	*E. camaldulensis, E. urophylla*		x				1
Idalus herois (Lepidoptera: Arctiidae)	Argentina	*Eucalyptus* spp.		x				1
Isoneurothrips australis (Thysanoptera: Thripidae)	Argentina	*Eucalyptus* spp.		x				1
Kalotermes gracilitnathus (Isoptera: Kalotermitidae)	Chile (Juan Fer-nandez Isl.)	*Eucalyptus* spp.					x	1
Leucolopsis parvistrigata (Lepidoptera: Geometridae)	Ecuador	*E. viminalis*		x				1
Lichnoptera gulo (Lepidoptera: Noctuidae)	Colombia	*E. grandis, E. globulus; Pinus patula, Pinus oocarpa, Cupressus lusitanica, Cordia alliodora*		x				1
Megachile sp. (Hymenoptera: Megachilidae)	Argentina	*Eucalyptus* spp.		x				1
Megalostomis anacoreta (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis; Cordia alliodora, Tabebuia rosea*		x				1
Megaplatypus parasulcatus (=*Platypus sulcatus*) (Coleoptera: Platypodidae)	Argentina, Brazil, Uruguay	*Eucalyptus* spp., *E. urophylla; Pinus* spp., *Acacia* spp., *Quercus* spp., *Casuarina* spp., *Populus* spp., *Ulmus* spp., *Persea* spp., *Citrus* spp.			x	x	x	1
Melanolophia commotaria (Lepidoptera: Geometridae)	Colombia	*Eucalyptus* spp.; *Cupressus lusitanica, Pinus patula*		x				1
Membracis foliata (Homoptera: Membracidae)	Brazil	*Eucalyptus* spp.		x				1
Membracis mexicana (Homoptera: Membracidae)	Colombia	*E. grandis*		x				1
Membracis sp. (Homoptera: Membracidae)	Colombia	*E. grandis*		x				1
Metcalfiella jaramillorum (Homoptera: Membracidae)	Ecuador	*Eucalyptus* spp.; *Baccharis* spp., *Salix* spp., *Pyrus* spp., *Persea* spp., *Juglans* spp.		x				1
Metcalfiella monogramma (Homoptera: Membracidae)	Colombia	*E. grandis; Pinus patula*		x				1
Metriona sp. (Coleoptera: Chrysomelidae)	Brazil	*Eucalyptus* spp.		x				1

Table 8—Potential insects of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category—con.

Species	Country	Hosts	Location on host: Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sap-wood	Heart-wood	Pest category[a]
Mimallo amilia (Lepidoptera: Mimallonidae)	Brazil, Colombia, Ecuador	*Eucalyptus* spp., *E. deglupta, E. globulus, E. grandis, E. saligna; Cordia alliodora*		x				1
Misogada blerura (Lepidoptera: Notodontidae)	Brazil	*E. urophylla*		x				1
Naupactus spp. (Coleoptera: Curculionidae)	Brazil, Colombia	*Eucalyptus* spp.		x				1
Neotermes castenaeus (Isoptera: Kalotermitidae)	Brazil	*Eucalyptus* spp.					x	1
Neotermes chilensis (Isoptera: Kalotermitidae)	Chile	*Eucalyptus* spp.					x	1
Neotermes wagneri (Isoptera: Kalotermitidae)	Brazil	*Eucalyptus* spp.					x	1
Nodonota sp. (Coleoptera: Chrysomelidae)	Colombia	*E. grandis; Pinus patula, Pinus kesiya, Pinus oocarpa*		x				1
Nystalea nyseus (Lepidoptera: Notodontidae)	Brazil	*E. camaldulensis, E. urophylla*		x				1
Oiketicus kirbyi (Lepidoptera: Psychidae)	Brazil, Colombia	*E. globulus, E. grandis, E. saligna; Pinus oocarpa, Pinus patula, Tabebuia rosea, Tectona grandis, Bombacopsis quinatum, Cordia alliodora, Cassia siamia*		x				1
Oiketicus platensis (Lepidoptera: Psychidae)	Argentina	*Eucalyptus* spp.		x				1
Oiketicus sp. (Lepidoptera: Psychidae)	Ecuador	*E. camaldulensis*		x				1
Omophoita transversa (Coleoptera: Chrysomelidae)	Brazil	*Eucalyptus* spp.		x				1
Oncideres impulviata (Coleoptera: Cerambycidae)	Brazil	*Eucalyptus* spp.		x				1
Oncometopia sp. (Homoptera: Cicadellidae)	Colombia	*E. microcorys, E. tereticornis, E. tessellaris, E. torreliana, E. urophylla; Tectona grandis, Bombacopsis quinatum, Cordia alliodora, Albizzia falcataria*		x	x			1
Oxydia apidania (Lepidoptera: Geometridae)	Brazil	*E. camaldulensis, E. urophylla*		x				1
Oxydia platypterata (Lepidoptera: Geometridae)	Colombia	*E. saligna; Pinus patula*		x				1
Oxydia trychiata (Lepidoptera: Geometridae)	Colombia	*E. grandis, E. saligna; Cupressus lusitanica, Pinus patula*		x				1
Oxydia vesulia (Lepidoptera: Geometridae)	Brazil	*E. camaldulensis, E. urophylla*		x				1
Pachybrachis sp. near *reticulata* (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis; Cordia alliodora, Tectona grandis*		x				1
Pantomorus subbimaculatus (Coleoptera: Curculionidae)	Argentina	*Eucalyptus* spp.		x				1
Pantomorus spp. (Coleoptera: Curculionidae)	Uruguay, Brazil	*Eucalyptus* spp.		x				1
Paramallocera ilinizae (Coleoptera: Cerambycidae)	Ecuador	*E. globulus; Fraxinus* spp., *Pinus radiata, Prunus* spp., *Salix* spp.				x	x	1
Parandra glabra (Coleoptera: Cerambycidae)	Ecuador	*E. globulus*				x	x	1
Pelidnota sp. (Coleoptera: Scarabaeidae)	Colombia	*E. tereticornis; Bombacopsis quinatum, Sesbania grandiflora*		x				1

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Species	Country	Hosts	Location on host: Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sap-wood	Heart-wood	Pest category[a]
Pendeleteius sp. near *nodifer* (Coleoptera: Curculionidae)	Colombia	*E. grandis; Pinus oocarpa, Pinus patula, Cupressus lusitanica*		x				1
Pero sp. (Lepidoptera: Geometridae)	Colombia	*E. saligna; Pinus patula*		x				1
Phaedropus suturellus (Coleoptera: Curculionidae)	Brazil	*E. saligna*		x				1
Phaops spp. (Coleoptera: Curculionidae)	Brazil	*E. saligna*	x	x				1
Phobetron hipparchia (Lepidoptera: Limacodidae)	Brazil, Colombia, Venezuela	*Eucalyptus* spp., *E. grandis, E. saligna*		x				1
Phoracantha recurva (Coleoptera: Cerambycidae)	Chile	*Eucalyptus* spp.			x	x		2 (California)
Phoracantha semipunctata (Coleoptera: Cerambycidae)	Argentina, Bolivia, Brazil, Chile, Peru, Uruguay	*Eucalyptus* spp., *E. camaldulensis, E. globulus, E. gomphocephala, E. resinifera, E. saligna, E. viminalis*			x	x		2 (California)
Plusia sp. (Lepidoptera: Noctuidae)	Argentina	*Eucalyptus* spp.	x					
Porotermes quadricollis (Isoptera: Kalotermitidae)	Chile	*Eucalyptus* spp.*; Pinus* spp., *Nothofagus* spp., *Populus* spp., *Salix* spp., *Laurelia* spp., *Aextoxicon punctatum, Pseudotsuga menziesii*			x	x	x	1
Prosarthria teretrirostris (Orthoptera: Proscopidae)	Colombia	*E. tereticornis*		x				1
Psiloptera hirtomaculata (Coleoptera: Buprestidae)	Colombia	*E. tereticornis, E. tessellaris, E. torreliana*	x	x	x	x		1
Psiloptera pardalis (Coleoptera: Buprestidae)	Brazil	*Eucalyptus* spp.*; Pinus tropicalis, Casuarina* spp., citrus	x	x	x	x		1
Psorocampa denticulate (Lepidoptera: Notodontidae)	Brazil	*Eucalyptus* spp., *E. grandis*		x				1
Pteroplatus adustus (Coleoptera: Cerambycidae)	Bolivia	*Eucalyptus* spp.			x			1
Pyrrhopyge pelota (Lepidoptera: Hesperiidae)	Argentina	*Eucalyptus* spp.		x				1
Retrachyderes thoracicus (Coleoptera: Cerambycidae)	Argentina, Brazil, Uruguay	*Eucalyptus* spp.; hardwoods, fruit trees					x	1
Rhabdopterus sp. (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis; Cordia alliodora*		x				1
Sabulodes aegrotata (Lepidoptera: Geometridae)	Brazil	*Eucalyptus* spp., *E. grandis*		x				1
Sabulodes caberata (Lepidoptera: Geometridae)	Brazil	*Eucalyptus* spp., *E. grandis*		x				1
Sabulodes glaucularia (Lepidoptera: Geometridae)	Colombia	*Eucalyptus* spp.*; Pinus patula, Cupressus lusitanica*		x				1
Sabulodes sp. (Lepidoptera: Geometridae)	Colombia	*E. saligna*		x				1
Sarsina purpurascens (Lepidoptera: Lymantriidae)	Argentina	*E. alba, E. camaldulensis, E. globulus*		x				
Sarsina violascens (Lepidoptera: Lymantriidae)	Argentina, Brazil	*Eucalyptus* spp., *E. grandis*		x				1
Scaptocoris castanea (Hemiptera: Cydnidae)	Brazil	*E. uro-grandis*		x				1

Table 8—Potential insects of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category—con.

Species	Country	Hosts	Location on host: Seedlings in nursery	Foliage/ branches	Bark/ cambium	Sap-wood	Heart-wood	Pest category[a]
Scolytopsis brasiliensis (Coleoptera: Scolytidae)	Brazil	*Eucalyptus* spp.			x			1
Sonesimia grossana (Homoptera: Cicadellidae)	Argentina	*Eucalyptus* spp.	<6 mo old	x	x			1
Spodoptera frugiperda (Lepidoptera: Noctuidae)	Argentina	*Eucalyptus* spp.	x					1
Spodoptera ornithogalli (Lepidoptera: Noctuidae)	Colombia	*E. tereticornis; Bombacapsis quinatum*		x				1
Spodoptera sunia (Lepidoptera: Noctuidae)	Colombia	*E. tereticornis*		x				1
Spodoptera sp. (Lepidoptera: Noctuidae)	Colombia	*E. grandis, E. saligna; Tectona grandis*		x				1
Steirastoma breve (Coleoptera: Cerambycidae)	Argentina, Brazil	*Eucalyptus* spp.			x	x	x	1
Stenalcidia grosica (Lepidoptera: Geometridae)	Brazil	*E. urophylla*		x				1
Stenodontes spinibarbis (Coleoptera: Cerambycidae)	Argentina, Brazil, Ecuador	*Eucalyptus* spp.				x	x	1
Stephanoderes obscurus (Coleoptera: Scolytidae)	Brazil	*Eucalyptus* spp.			x			1
Sternocolaspis quatuordecim-costata (Coleoptera: Chrysomelidae)	Brazil	*Eucalyptus* spp.		x				1
Stilpnochlora quadrata (Orthoptera: Tettigoniidae)	Colombia	*E. grandis; Pinus kesiya, Pinus oocarpa*		x				1
Strepsicrates marcopetana (Lepidoptera: Tortricidae)	Argentina	*Eucalyptus* spp.		x				1
Tetanorhynchus leonardosi (Orthoptera: Proscopiidae)	Brazil	*E. urophylla*		x				1
Tettigades sp. (Homoptera: Cicadidae)	Chile	*Eucalyptus* spp.	x					1
Thyrinteina arnobia (Lepidoptera: Geometridae)	Argentina, Brazil, Columbia, Ecuador, Venezuela	*E. camaldulensis, E. grandis, E. saligna, E. tereticornis, E. urophylla; Acacia* spp.		x				1
Thyrinteina leucoceraea (Lepidoptera: Geometridae)	Brazil	*E. camaldulensis, E. urophylla*		x				1
Timocratica palpalis (Lepidoptera: Stenomatidae)	Brazil	*Eucalyptus* spp., *E. saligna*			x			1
Trachyderes succinctus (Coleoptera: Cerambycidae)	Brazil, Ecuador	*Eucalyptus* spp.; fruit trees		x				1
Trachyderes variegatus (Coleoptera: Cerambycidae)	Argentina, Brazil	*Eucalyptus* spp.		x				1
Trigona silvestriana (Hymenoptera: Meliponiae)	Ecuador	*E. globulus, E. saligna*			x			1
Tropidacris latreillei (Orthoptera: Acrididae)	Colombia	*E. tereticornis*		x				
Typophorus sp. (Coleoptera: Chrysomelidae)	Colombia	*E. tereticornis*		x				1
Xylopertha pica (Coleoptera: Bostrichidae)	Brazil	*Eucalyptus* spp.			x			1
Xyleborus retusus (Coleoptera: Scolytidae)	Argentina Brazil	*E. dunnii, E. grandis*				x	x	1

[a] = See Table 7 for pest category descriptions.

Table 9—Potential pathogens of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category

			Location on host					
Species	Country	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap- wood	Heart- wood	Pest category[a]
Armillaria spp.[b]	Argentina, Brazil[c], Chile	*Eucalyptus* spp.; hardwoods				X	X	1
Aulographina eucalypti (Cooke & Massee) v. Arx & Muller	Brazil, Chile	*E. globulus, E. punctata, E. saligna*		X				2 (Hawaii)
Botryosphaeria dothidea (Moug.:Fr.) Ces. & De Not. (anamorph *Fusicoccum aesculi* Corda)	Colombia, Venezuela, Uruguay	*E. grandis, E. uro-grandis* *E. grandis*			X	X		4a
Botryosphaeria obtusa (Schwein.) Shoemaker (anamorph *Sphaeropsis* sp.)	Chile	*Eucalyptus* sp.			X	X		4a
Botryosphaeria ribis (Tode.:Fr.) Grossenb. & Dugger (anamorph *Fusicoccum* sp.)	Argentina, Brazil, Colombia, Venezuela	*Eucalyptus* spp.; about 100 additional genera, temperate regions			X	X		4a
Calonectria clavata El-Gholl, Alfieri & Barnard (anamoprh *Cylindrocladium clavatum* Hodges & May)	Brazil	*E. saligna; Pinus* spp.*; Araucaria angustifolia;* soybeans; cowpeas; potato; lupine; alfalfa	X		X (root rot)	X		2 (Florida, Hawaii)
Calonectria ilicicola Boedijn & Reitsma (anamorph *Cylindrocladium parasiticum* Crous, Wingf. & Alfenas)	Brazil, Venezuela	*Eucalyptus* spp.		X				2 (CA)
Calonectria morganii Crous, Alfenas & M.J. Wingfield (anamorph *Cylindrocladium scoparium* Morgan)	Argentina, Brazil, Colombia	*Eucalyptus* spp.	X	X				2 (Florida)
Calonectria ovata Crous, Alfenas & Junghans (anamorph *Cylindrocladium ovatum* El-Gholl, Alfenas, Crous & T.S. Schub.)	Brazil	*Eucalyptus* spp.		X				2 (Florida)
Calonectria pteridis Crous, Wingf. & Alfenas (anamorph *Cylindrocladium pteridis* Wolf)	Brazil	*Eucalyptus* spp.		X				2 (Florida)
Calonectria pyrochroa (Desm.) Sacc. [anamorph *Cylindrocladium ilicicola* (Hawley) Boedijn & Reitsma]	Brazil	*E. alba, E. globulus, E. grandis, E. robusta, E. saligna, E. tereticornis, E. viminalis*		X				2 (Florida)
Calonectria quinqueseptatum Figueiredo & Namekata (anamorph *Cylindrocladium quinqueseptatum* Boedijn & Reitsma)	Brazil	*Eucalyptus* spp.	X					1
Calonectria scoparia Ribeiro & Matsuoka ex Peerally (anamorph *Cylindrocladium candelabrum* Viegas)	Brazil	*Eucalyptus* sp.		X				1
Calonectria spathulata El-Gholl, Kimbr., E.L. Barnard, Alfieri, & Schoult. (anamorph *Cylindrocladium spathulatum* El-Gholl, Kimbr., E.L. Barnard, Alfieri & Schoult.)	Brazil	*E. viminalis*		X				1
Ceratocystis fimbriata Ellis & Halsted	Brazil	*E. uro-grandis*			X	X		4a

Table 9—Potential pathogens of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category—con.

			Location on host					
Species	Country	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Species
Cercospora epicoccoides Cooke. & Massee	Argentina	*E. globulus*		X				2 (Florida)
Cercospora eucalyptorum Crous	Paraguay	*Eucalyptus* sp.		X				1
Coniella fragariae (Oudem.) B. Sutton (synonym *Coniothyrium fragariae* Oudem.)	Argentina, Brazil, Venezuela	*Eucalyptus* spp.; *Castanea, Fragaria; cosmopolitan*		X				2
Coniothyrium zuluense Wingfield, Crous, and Coutinho	Argentina	*E. grandis*			X	X		1
Cryphonectria cubensis (Bruner) Hodges	Bolivia, Brazil, Colombia, Peru, Venezuela	*E. angulosa, E. botryoides, E. camaldulensis, E. citriodora, E. globulus, E. grandis, E. longifolia, E. maculata, E. microcorys, E. paniculata, E. pilularis, E. propinqua, E. robusta, E. saligna, E. tereticornis, E. trabutii, E. urophylla, E. uro-grandis; Syzygium aromaticum*			X	X		2 (Florida Hawaii)
Cryptosporiopsis eucalypti Sankaran & Sutton	Brazil	*Eucalyptus* spp.		X				2 (Hawaii)
Cylindrocladiella camelliae (Venkatar. & Venkata Ram) Boesew. [= *Cylindrocladiella peruviana* (Batista, Benzerra & Herrera) Boesew.]	Brazil	*E. grandis, E. tereticornis*		X				2 (Florida)
Cytospora eucalypticola Van der Westhuizen	Uruguay, Venezuela	*E. camaldulensis, E. grandis, E. urophylla, E. uro-grandis*			X	X		1
Cytospora eucalyptina Speg.	Argentina	*E. ficifolia, E. globulus, E. grandis, E. nitens, E. viminalis*			X	X		1
Diplodia australiae Speg.	Argentina	*E. globulus*			X			2 (CA)
Erythricium salmonicolor (Berk. & Br.) Burdsall (synonym *Corticium salmonicolor* Berk. & Broome)	Brazil, Peru	*E. alba, E. grandis, E. kitsoniana, E. tereticornis*; about 104 additional genera			X	X		2 (FL, LA, MS)
Falcocladium sphaero- pedunculatum Crous, Kendrick & Alfenas	Brazil	*E. pellita x brassiana*		X				1
Fusicoccum eucalypti Sousa da Carnara	Uruguay	*Eucalyptus* sp.			X			1
Ganoderma spp.[d]	Argentina, Uruguay	*Eucalyptus* spp.					X	1
Glomerella cingulata (Stoneman) Spauld. & H. Schrenk (anamorph *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.	Brazil, Uruguay	*E. pellita*			X			1
Gymnopilus spectabilis (Fr.:Fr.) A. H. Sm. [synonym *Pholiota spectabilis* (Fr.:Fr.) A.H. Sm.]	Argentina	*Eucalyptus* spp.; widespread in northern hemisphere, on conifers and hardwoods					X	2a
Hainesia lythri (Desmaz.) Hohn.	Brazil	*E. citriodora, E. grandis;* cosmopolitan	X					4a

Table 9—Potential pathogens of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category—con.

			Location on host					
Species	Country	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap- wood	Heart- wood	Species
Innonotus rheades (Pers.) Bondartzev & Singer	Brazil	*Eucalyptus* sp.; on *Fagus, Populus,* and *Quercus* in temperate northern hemisphere					X	2
Laetiporus sulphureus (Bull.) Murrill	Brazil	*E. saligna;* widespread on *Quercus,* other hardwoods, and conifers in the U.S.					X	4a
Mycosphaerella africana Crous & M.J. Wingf.	Colombia	*E. grandis*		X				1
Mycosphaerella colombiensis Crous & M.J. Wingf. (anamorph *Pseudocercospora colombiensis* Crous & M.J. Wingf.	Colombia	*E. urophylla*		X				1
Mycosphaerella cryptica (Cooke) Hansf. [anamorph *Colletogloeopsis nubilosum* (Ganap. & Corbin) Crous.]	Chile	*E. bicostata, E. globulus, E. maidenii, E. nitens*		X				1
Mycosphaerella flexuosa Crous & M.J. Wingf.	Colombia	*E. globulus*		X				1
Mycosphaerella longibasalis Crous & M.J. Wingf.	Colombia	*E. grandis*		X				1
Mycosphaerella marksii Carnegie & Keane	Uruguay	*E. globulus*		X				1
Mycosphaerella parkii Crous, M.J. Wingf., F.A. Ferreira & A. Alfenas	Brazil Colombia	*E. dunnii, E. grandis, E. saligna*		X				1
Mycosphaerella suberosa Crous, F.A. Ferreira, A. Alfenas, & M.J. Wingf.	Brazil Colombia	*E. dunnii, E. globulus, E. grandis, E. moluccana*		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]	Argentina Brazil Uruguay Venezuela	*E. bicostata, E. camaldulensis, E. globulus, E. grandis, E. tereticornis*		X				2 (Hawaii)
Mycosphaerella walkeri R.F. Park & Keane (anamorph *Sonderhenia eucalypticola* A.R. Davis, H. Swart & J. Walker)	Chile Colombia Ecuador Peru	*E. globulus, E. maidenii, E. nitens*		X				2 (CA)
Mycovellosiella eucalypti Crous & A.C. Alfenas	Brazil	*E. saligna*		X				1
Phaeophleospora eucalypti (Cooke & Massee) Crous, F.A. Ferreira & B. Sutton [synonym *Kirramyces eucalypti* (Cooke & Massee) J. Walker, B. Sutton & Pascoe]	Argentina Brazil Paraguay Peru	*E. camaldulensis, E. globulus*		X				1
Phellinus spp.[d]	Argentina Brazil	*Myrtaceae*, hardwoods			X	X	X	1

Table 9—Potential pathogens of concern associated with *Eucalyptus* spp. in South America, including names of hosts, location on host, and pest category—con.

			Location on host					
Species	Country	Hosts	Seedlings in nursery	Foliage/ other	Bark/ cambium	Sap-wood	Heart-wood	Species
Phyllosticta eucalyptorum Crous, M.J. Wingf., F.A. Ferreira & A. Alfenas	Brazil	*E. grandis* (unidentified species reported on *E. tereticornis* in Colombia)		X				1
Pseudocercospora basitruncata Crous	Colombia	*Eucalyptus* sp.		X				1
Pseudocercospora eucalyptorum Crous, M.J. Wingf., Marasas & B. Sutton	Argentina, Brazil, Venezuela	*Eucalyptus* spp.		X				2 (Florida)
Pseudocercospora irregularis Crous	Peru	*Eucalyptus* sp.		X				1
Pseudocercospora paraguayensis (Kobayashi) Crous (synonym *Cercospora paraguayensis* Kobayashi)	Paraguay	*Eucalyptus* spp.		X				1
Puccinia psidii Winter	Argentina, Brazil	*E. camaldulensis, E. citriodora, E. cloeziana, E. grandis, E. maculata, E microcorys, E. paniculata, E. pellita, E. phaeotricha, E. pyrocarpa, E. punctata, E. saligna, E. tereticornis, E. urophylla;* additional Myrtaceae hosts include *Callistemon speciosus, Eugenia brasilensis, E. jambolana, E. malaccensis, E. uniflora, E. uvalha, Marlierea edulis, Melaleuca leucodendron, Myrcia jaboticaba, Myrcia* spp.*, Myrciaria sp., Pimenta acris, P. dioica, P. officialis, Psidium araca, P. guajava, P. pomiferum,* and *Syzygium jambos*		X				2 (Florida)
Ralstonia solanacearum (Smith) Yabuuchi, Kosako, Yano, Hotta & Nishiuchi (synonym *Pseudomonas solanacearum* Smith	Brazil, Venezuela	*E. deglupta, E. grandis*				X		4a
Sphaerotheca pannosa (Wallr.) Lev. (anamorph *Oidium eucalypti* Rostr.)	Argentina, Brazil	*Eucalyptus* spp.		X				2 (Florida)
Stereum albomarginatum Schw.	Uruguay	*Eucalyptus* sp.			X	X		2 (CA)
Thyriopsis sphaerospora Marasas	Brazil	*Eucalyptus uro-grandis, E. urophylla*		X				1
Trimmatostroma excentricum B. Sutton & Ganap.	Brazil	*Eucalyptus* spp.		X				1

[a] See Table 7 for pest category descriptions.
[b] Unknown species; see Table 11 for species of *Armillaria* in South America.
[c] Observed only once in Brazil.
[d] Unknown species; see individual pest resk assessment for root and stem rots for South America *Ganoderma* species.
[e] Unknown species; see Table 12 for species of *Phellinus* in South America

Insects

Leafcutting Ants

Assessor—William E. Wallner

Scientific name of pest—*Atta sexdens* (Linné) and *Acromyrmex lundi* (Hymenoptera: Formicidae)

Scientific names of hosts—Various *Eucalyptus* spp. and citrus are preferred, but the host list is quite extensive since leafcutting ants tend to harvest leaf tissue from a variety of plants (Craighead 1950, Cibrián–Tovar and others 1995).

Distribution—Members of this genus are widely distributed throughout South America including Argentina (Fiorentino and Medena 1991), Brazil (Edson Tadeu Iede, EMPRAPA, Curitiba, Brazil, 1998, personal communication), and Uruguay (W. Wallner, 1998, personal observation). Formicidae are considered major *Eucalyptus* pests in Chile (Ramirez and others 1992) although the genus *Atta* is not specifically mentioned. Nonetheless, the Formicidae have similar behavior and bioecology and will be discussed as a group for purposes of this assessment. *Atta texana* and *A. mexicanus* occupy limited distributions within southern United States, presumably because of an inability to survive in cooler climates (R. Scott Cameron, International Paper Company, Savannah, GA, 2000, personal communication). However, *A. texana* is a serious pest of southern pine seedlings in Texas and Louisiana (Cameron and Riggs 1985) and often requires chemical control (Moser 1984).

Summary of natural history and basic biology of the pest—As their name implies, leafcutting ants harvest foliage tissue from a variety of plants then carry these cuttings to their underground nests. Each leaf is transformed into small pellets within the nest and placed in a mass that provides the substrate for fungal growth. This fungus provides food for the colony and is routinely replenished by foraging workers who often utilize common trails, mostly at night.

Atta spp. are social insects whose colonies survive up to 20 years in underground nests some 3 to 4 m deep. Colony initiation begins with a winged mated female who flies to and selects a site. Her wings then become detached, and she lays her eggs in a small chamber in the ground. In less than a month, they give rise to the first workers who proceed to construct a nest and gather leaf portions for the developing colony. Following successful nest establishment, the colony increases in size, and after 3 years, the first reproductive females appear and disperse to form new colonies. A robust colony consists of thousands of polymorphic workers (three castes) and reproductives (winged and wingless). Wingless reproductives never leave the nest. Winged reproductives are 16 mm long, red–brown, reasonably strong flyers, and the principal dispersal life stage. While workers forage up to 200 m from the nest, they cannot found a new colony (Cibrián–Tovar and others 1995).

Leafcutting ants are capable of inhabiting a variety of sites including agricultural fields, urban areas, fruit orchards, as well as *Eucalyptus* plantations. Because they utilize a variety of host plant foliage for fungal propagation, they can colonize a range of sites. Trees of different sizes may be partially or completely defoliated, although young eucalypt plantings of less than 3 m high are most seriously affected (Ramirez and others 1992). Defoliation is not necessarily continuous out from the nest since certain trees are preferentially harvested. The principal impact is growth reduction, although repeated defoliation can kill tree parts or entire seedlings (Cibrián–Tovar and others 1995). *Atta sexdens rubropilosa* is on the quarantine pest list for Australia (Floyd and others 1998).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Low* (RC) (Applicable rating criteria, from Chap. 1: c)

   Leafcutting ants are widely distributed throughout South America in a variety of sites including eucalypt plantations. They are considered the most important pest in Brazil (Genesio Ribeiro, Federal University of Viçosa, Brazil, 1998, personal communication) and will be a common insect component in most eucalypt plantings. However, the low ranking is based on the fact that winged female reproductives constitute the principal initiator of a new colony. Since workers are incapable of founding a colony and wingless reproductives remain in the underground nests, winged reproductives are crucial to colony establishment. Thus, this life stage, which is fragile but mobile, could find a resting location on logs or their transporter. Even though the number of emerging winged reproductives from any colony might be high, they would have a low likelihood of survival.

2. Entry potential: *Low* (RC) (Applicable rating criteria, from Chap. 1: None)

   Leafcutting winged reproductives have proved to be resilient life stages capable of surviving dispersal and establishing nests in a variety of habitats. The period elapsing from harvest to shipment would determine survivability; the shorter the time the higher the anticipated adult female survival. The current practice of rapid transit after harvesting *Eucalyptus* might increase likelihood of entry for reproductive adults. Given that no *Atta* or *Acromyrmex* species have been previously intercepted at ports of entry leads one to conclude that entry potential is low.

3. Colonization potential: *High* (RC) (Applicable rating criteria, from Chap. 1: a, b, c)

Most *Atta* spp. have demonstrated a propensity to utilize a variety of hosts in different sites. Thus, a successfully transported reproductive could be expected to select a suitable founding location. The establishment of the Argentine ant *Iridodiyrmex humilis* (Mayr) in Louisiana (Craighead 1950) is evidence that Formicid ants are portable and invasive when introduced into a compatible environment.

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

   Vagile females are not likely to disperse more than several hundred meters. Once a colony is established, 3 years would elapse before winged reproductives would emerge to enlarge the infestation. Since nests are surrounded by discarded leaf tissue, this could increase the possibility of detection and lead to early eradication efforts.

B. Consequences of introduction

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

   According to Edson Tadeu Iede (EMBRAPA, Curitiba, Brazil, 1998, personal communication), ants are the most serious pest problem in plantation *Eucalyptus* in Brazil. Annual costs to eliminate nests or protect foliage are more than US$600,000; previously, it cost US$3 million annually when all plantations were treated. Fertilization of seedling eucalypts is done to accelerate growth to avoid attack by ants but at an additional cost. The *Eucalyptus* resources at risk in the United States are not commercial fiber plantations as in South America, but rather, they are urban and foliage plantings. Given the polyphagous habits of *Atta* spp., it is likely that other plant associates of these U.S. plantings might be attacked at an unknown cost. Mortality and growth reduction of *Eucalyptus* probably would be secondary to the defoliation disfigurement that would severely impact a relatively small (1,215 hectares (3,000 acres)) but highly valuable U.S. cut-foliage industry (Dahlsten and others 1998). Still another potential high value resource that might be threatened is the citrus industry since citrus is a preferred host.

6. Environmental damage potential: *High* (RC) (Applicable rating criteria, from Chap. 1: a, e)

   Colonization by leafcutting ants could seriously disrupt ecosystems leading to the displacement or exclusion of native plants and organisms. An example of this can be found with another group of introduced ground nesting ants, the imported fire ants *Solenopsis* spp. in the southern United States, which have caused enormous economic and ecologic damage (Williams 1998). These ants, like *Atta* spp., spread as reproductives or by humans and their activities. Thus, if established, leafcutting ants would require application of chemicals to eliminate nests and protect foliage (Moser 1984), thereby risking environmental disruption and damage, and risking such programs as biological control for pests of citrus. The extended geographic distribution of *Atta* spp. in South America and the presence of two *Atta* species in the southern United States portends that introduction of additional leafcutting ants would have undesirable environmental impacts.

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

   This genus of pests would cause aesthetic damage to high value cut-foliage plantations as well as pose a much broader environmental risk. Establishment of these two *Atta* spp. is unlikely to cause debilitating economic losses. However, they could constitute a major threat to fragile ecosystems by their aggressive colonization potential. The introduction of yet another ground nesting highly visible ant species would be unacceptable to most people.

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

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Williams, D.F. 1998. Imported ants in the Southeast. In: Britton, K.O. (tech. coord.) Exotic pests of eastern forests. 1997 April 8–10; Nashville, TN; 115 p.

Reviewers' comments—"The bottom line is that 'pest with host at origin' is low and, more importantly, the entry potential for *Atta* and *Acromyrmex* is extremely low if not zero. Thus, unlike bark beetles, wood borers, and certain lepidopterous pests, these insects pose an extremely low risk to the U.S." (Billings)

"The assigned probabilities of establishment and environmental damage consequences for leaf-cutting ants are probably too high. Leaf-cutting ant queens are particularly vulnerable to mortality factors during the nuptial/dispersal flight. Although queens are long lived, they fly only once, during one day, and do not spend any time above ground in association with *Eucalyptus* trees. The nuptial flight is precisely timed to coincide with appropriate weather and soil conditions so that mated females can immediately burrow into the soil to establish new nests. In addition, leaf-cutting ants are tropical and sub-tropical in distribution. *Atta texana*, and *A. mexicanus* have limited distributions in the southern U. S., presumably due to an inability to survive in cooler climates. If introduced, leaf-cutting ants are not likely to become widely distributed throughout the U.S." (Cameron)

"No *Atta* or *Acromyrmex* adults have been intercepted at U.S. ports of entry and never will be unless brought in intentionally by humans." (Moser, USDA Forest Service, Pineville LA, 2000, personal communication)

"Even though three of the risk elements are met with reasonable certainty, it is unlikely that this defoliator would be associated with host logs or chips at origin and this is supported by the author's remarks. None of the entry elements seem to apply, including 'd' as this organism would be a contaminant thus capable of detection by visible inspection. Under colonization potential, the elements listed apply only if reproductives are successfully introduced. Therefore a rating of high with reasonable certainty is misleading absent an ability to represent that critical element. Under spread potential, in California element 'e' applies as well. After its introduction, the eucalyptus borer spread naturally via contiguous freeway landscape plantings of Eucalyptus. Indeed continuous ornamental plantings of Eucalyptus occur throughout southern and coastal California. Even with nests surrounded by leafy material, it is unlikely that public awareness would lead to early detection." (Zadig)

"Though economic damage to the US cut foliage industry is mentioned, there is no mention of the potential economic impact to the citrus industry even though this is listed as a preferred host. In this case the disruption of biological control programs for citrus would result in environmental damage and disruption as well." (Zadig)

Response to comments—We assessed the risk of *Atta* spp. and *Acromyrmex* spp. host at origin and entry potential as moderate based upon the common occurrence of these ants in most South American *Eucalyptus* plantations. However, after considering the comments and opinions of Cameron, Billings, Zadig, and Moser, the association with host at origin and entry potential that were initially rated as moderate were reduced to low. This changed the overall pest risk potential to low. As suggested, the potential impact on the citrus industry was referenced even though no direct assessment of the resource was undertaken.

Eucalyptus Weevil

Assessor—William E. Wallner

Scientific names of pests—*Gonipterus scutellatus* Gyllenhal (synonymous with *G. platensis*) and *G. gibberus* (Boisduval) (Coleoptera: Curculionidae)

Scientific names of hosts—*E. globulus* and *E. viminalis* are preferred, but various other eucalypts are attacked including *E. robusta, E. sideroxylon, E. radiata, E. gunnii, E. eugenioides, E. fastigata, E. macarthurii,* and *E. obliqua*. Narrow-leafed species such as *E. linearis* and *E. amygdalina* are seldom attacked.

Distribution—*Gonipterus scutellatus* is generally distributed throughout Brazil. Outbreaks occurred in Rio Grande do Sul in 1956, Santa Catarina and Paraná in 1978, and São Paulo in the 1990s (Edson Tadeu Iede, EMBRAPA, Curitiba, Brazil, 1998, personal communication), as well as Argentina and Uruguay; it has only recently been introduced into Chile from Argentina. *Gonipterus gibberus* shares the same distribution except it does not occur in Chile. The genus *Gonipterus* is not endemic to the United States, but *G. scutellatus* was introduced into California in 1994 (Cowles and Downer 1995) and is now found in Ventura, Los Angeles, and Santa Barbara Counties (Hanks and others 2000). *Gonipterus scutellatus*, native to Australia, also was introduced into the European Mediterranean in 1975 where it has been principally a pest of ornamental eucalypts along the French and Italian Riviera.

Summary of natural history and basic biology of the pest—*Gonipterus scutellatus* and *G. gibberus* belong to the order Coleoptera, family Curculionidae, which contains numerous forest pests. Curculionids have various feeding habits. Some feed on the foliage of trees and shrubs, while others feed in wood or under the bark or on seeds. The most destructive species attack young trees or new foliage on older trees. Eucalyptus snout beetles have life history traits peculiar to this subfamily of which there are no examples native to North America (Cowles and Downer 1995). Both *Gonipterus* spp. feed on the foliage of *Eucalyptus* as adults and larvae, have similar biologies and habits, and will be discussed accordingly. There usually are two generations each year in neotropical regions and only one in more temperate regions. Winter is spent as hibernating adults under loose bark on *Eucalyptus* trunks, especially *E. globulus*. In the spring, adults emerge and lay clusters of 7 to 16 eggs in small black cases (3 mm long) on the foliage. Eggs hatch in 7 to 15 days, and the legless, green–yellow larvae feed on the leaf blades causing characteristic slits. The presence of several larvae on a leaf completely destroys the leaf. As larvae mature (they have four instars), they consume entire leaves starting at the edge and feeding inward. It is at this time that they produce a black trail of excrement. Larvae mature in 4 to 5 weeks, drop to the soil, and pupate. Adults emerge in approximately 30 days. Adults feed on the leaf margins of young foliage, giving them a scalloped appearance. Adults also may feed on the bark of young shoots (Pedrosa–Macedo and others 1993, Clark 1937, Bain 1977, Freitas 1991).

Both *Gonipterus* spp. weaken trees by defoliating them and give trees a stunted appearance. Trees weakened by feeding of *Gonipterus* spp. were considered to be more susceptible to attack by the eucalyptus longhorned beetle, *Phoracantha semipunctata* (Fab.) (Cowles and Downer 1995). However, Hanks and others (2000) found no evidence that attack by the weevil increases susceptibility to attack by the eucalyptus longhorned borer. Although *Gonipterus* spp. are acknowledged only as a pest of *Eucalyptus*, adults have been observed feeding on the stems of apples when orchards and *Eucalyptus* plantations are adjacent to one another. Major problems with *Gonipterus* spp. occur in regions with frequent frosts. New shoots are most susceptible after frost damage (José Henrique Pedrosa-Macedo, Federal University of Paraná, Paraná, Brazil, 1998, personal communication). Thus, *Gonipterus* spp. are likely to be a problem if introduced into temperate climates.

These weevils have demonstrated a propensity to be translocated. For example, *G. scutellatus* was introduced from Australia into New Zealand in 1890 (Bain 1977), into South Africa in 1916 (Tooke 1955), into Argentina in 1925 (Fiorentino and Medina 1991), into Mauritius in 1935–1940 (Williams and others 1951), into Madagascar in 1950 (Frappa 1950), into Mediterranean Europe in 1975 (Cadahia 1986), into Spain in 1992 (Vasquez 1992), into Brazil in 1992 (Neto 1993), into California in 1994 (Cowles and Downer 1995), and into Chile in 1998 (Miguel Angel Poisson, Ministry of Agriculture (SAG), Santiago, Chile, 1998, personal communication). This genus of weevils has consistently demonstrated a close affiliation with *Eucalyptus* and its defoliation as well as a capacity to get around. They must, therefore, be considered a serious invasive group.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (RC) (Applicable rating criteria, from Chap. 1: a, c, d, e, f, h)

   The extensive global redistribution of these eucalyptus weevils, their common association with a number of *Eucalyptus* spp., and their past successful incursions into new environments attest to their potential threat. There is little evidence of polyphagy, and all life stages other than pupae are associated with *Eucalyptus* foliage.

2. Entry potential: *High* (RC) (Applicable rating criteria, from Chap. 1: a, c, d)

The long-lived adults (3–6 months) as hitchhikers on or under the bark or in shipping containers or vessels of transport would be the principal pathway for introduction. The cryptic-colored adults would be difficult to detect and could be located on logs or vehicles related to their transport.

3. Colonization potential: *High* (RC) (Applicable rating criteria, from Chap. 1: a, b, c, e)

   Gonipterus spp. have demonstrated their capacity to be transported and established on a global scale. While most adult weevils are not renowned for long-distance flight, *Gonipterus* spp. have demonstrated strong dispersal capability. They also actively crawl and seek resting sites under loose bark or other secretive locations. Despite the genus-specific host habits, the capacity to colonize new environments is judged to be high based on the past history of these two weevil species. Temperate climates, or those regions that are subject to the cold-stressing of *Eucalyptus* spp., appear to be most amenable to colonization. Availability of suitable hosts and synchronized emergence and mating of adult pairs are major factors that will influence successful colonization.

4. Spread potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: a, b, e)

   Natural movement by adults in California has demonstrated an ability for infestations to spread rapidly (Cowles and Downer 1995). Larval dispersal is not an important factor. Human activities facilitate spread. It is believed that the establishment of *G. scutellatus* in Los Andes, Chile, occurred from vehicular transport of adults over the Andes from Argentina (Miguel Angel Poisson, Ministry of Agriculture, (SAG), Santiago, Chile, 1998, personal communication).

B. Consequences of introduction

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

   Narrow-leafed eucalypts are not preferred as hosts. Therefore, others, such as *E. globulus, E. viminalis,* and *E. gunnii*, would be threatened with defoliation. *Gonipterus* spp. are regarded as serious defoliators in New Zealand (Clark 1937, Bain 1977), Brazil (Pedrosa-Macedo and others 1993), and Africa (Naude 1940), often requiring chemical intervention. Defoliation reduces growth rate and tree vigor, making trees more susceptible to attack by other organisms. The seriousness of defoliation by *G. scutellatus* has prompted the importation and release of the Australian egg parasite *Anaphes nitens* (Girault) into New Zealand and Africa. In the absence of these and other natural enemies, *Gonipterus* spp. could be a serious problem. Presently, Chile has *Gonipterus* sp. listed as a quarantine pest.

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

   Both *Gonipterus* spp. feed exclusively on broad-leafed eucalypts. Thus, impacts on other plant species seem unlikely. In the event of an introduction, chemical controls could cause environmental impacts, but this would probably be confined to the foliage industry and ornamental plantings. Following any *Gonipterus* establishment, a program for releasing its native parasites would need to be undertaken with the potential risk to endemic North American insects.

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

   Defoliation would have only modest impact on a limited number of *Eucalyptus* spp. The major threat would be to the floral industry and urban and ornamental plantings. Evidence in California suggests that defoliation can be severe in *Eucalyptus* windbreaks and urban plantings (Hanks and others 2000). The removal of foliage will not kill trees but can weaken them and destroy their appearance. The fact that they have already been introduced into the United States is evidence of the portability of *Gonipterus* spp. However, *G. scutellatus* has not yet achieved its full geographic range in North America.

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

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Reviewers' comments—"I suggest adding a reference that presents information on the distribution of this pest, host range, and biological control in California: Hanks, L.M.; Millar, J.G.; Paine, T.D.; Campbell. C.D. 2000. Classical biological control of the Australian weevil *Gonipterus scutellatus* Gyll. (Coleoptera: Curculionidae) in California. Environmental Entomology (in press)." (Hanks)

"P.52: Authors listed in the above reference did not find any evidence that attack by the weevil increases susceptibility to attack by the eucalyptus longhorned borer This was a speculation in the early literature." (Hanks)

"Suggest adding 'a' to applicable risk criteria for element #7, Social and political considerations." (Hanks)

"The egg parasitoid *Anaphes nitens* only attacks weevil species in the family *Gonipterinae*, of which there are no native species in North America; therefore, introduction of the parasitoid would pose little threat to native species." (Hanks)

Response to comments—Since there is evidence that the Eucalyptus weevil can cause substantial defoliation in windrows in California (Hanks and others 2000), it has the potential to cause concerns to the public. As suggested, "a" was added to this element, which raised its rating from low to moderate.

In response to the second comment, while it may be true that *A. nitens* may not present any risk to endemic North American insects, the point still stands that it may not be the only biocontrol agent introduced. There still would be attendant risk with other introduced biocontrol organisms.

Flea of the Tifa Leaf

Assessor—William E. Wallner

Scientific name of pest—*Cephisus siccifolius* Walker (Homoptera: Cercopidae)

Scientific names of hosts—Native hosts include *Tipuana tipa* (Benth.) Kuntze (Tipa), *Acacia* spp., *Ceiba pentandra* (L.) Gaertner (Kapok tree), *Caesalpina peltophoroides* Benth. (false Pernambucco), and *Erythrina cristagalli* L. (seibo). *Eucalyptus* species commonly attacked are *E. saligna, E. grandis, E. alba, E. botryoides, E. rostrata,* and *E. tereticornis* (Fiorentino and Medina 1991, Golfari 1963).

Distribution—A species native to Argentina, *Cephisus siccifolius* is generally distributed throughout the provinces of Misiones, Corrientes, La Pampa, Catamarca, and Buenos Aires (Fiorentino and Medina 1991). The only other reports of its presence were for São Paulo, Brazil (Paschoal and others 1985, Berti Filho 1981).

Summary of natural history and basic biology of the pest—Typically, cercopids, or spittlebugs, produce copious masses of foamy froth beneath which the immature nymphs can be found. In North America, the most important genus is *Aphrophora*, which includes the pine spittlebug, western pine spittlebug, and Saratoga pine spittlebug, which are serious pests of pines (Craighead 1950). The genus *Clastoptera* has more than 20 species in western North America that feed on broad-leaved plants (alder, dogwood, etc.) and conifers (juniper, pine, etc.) (Furniss and Carolin 1977). However, the genus *Cephisus* has no known representatives in North America.

Most spittlebugs feed on succulent vegetation and may or may not be monophagous. The "flea of the Tifa leaf" demonstrated its polyphagy by adapting its feeding from native broad-leaved trees to a number of introduced *Eucalyptus* spp. Leaf wilting on mature *Eucalyptus* trees and death of seedlings is caused by *C. siccifolius* adults feeding on twigs and branches less than 3 cm in diameter (Cozzo 1960). Feeding damage by sap-sucking nymphs and adults can cause partial or complete defoliation of *Eucalyptus* (Fiorentino and Medina 1991). Certainly, feeding on succulent new growth inhibits shoot elongation and reduces and distorts foliage. Only sporadic outbreaks have been noted, namely in Argentina (Missiones 1960, Paraná 1984) and in Brazil (São Paulo 1930 and 1984) (Edson Tadeu Iede, EMBRAPA, Curitiba, Brazil, 1998, personal communication; Paschoal and others 1985, Cozzo 1960). Past infestations of *C. siccifolius* have not killed large tracts of *Eucalyptus* in South America, and *C. siccifolius* is unlikely to be any different in the United States. More likely, high value trees such as those in the cut-foliage industry and ornamental or streetside trees would be most adversely affected. More worrisome is the potential impact on additional, yet unknown, host affiliates of *Eucalyptus*; *C. siccifolius* already has demonstrated its capability to colonize several tree genera (Fiorentino and Medina 1991, Paschoal and others 1985).

Lack of specific studies on the biology of *C. siccifolius* makes a definitive description of its biology difficult. However, generalizations can be made in respect to the bioecology of cercopids. Winter is passed as eggs laid by ovipositing females in sites they cut in twigs. The egg stage can last 8 to 9 months. Nymphs hatching from these eggs in the spring commence feeding by inserting their beak-like mouthparts into leaves or twigs and sucking out plant sap. Subsequently, they produce a white frothy covering on *Eucalyptus* leaves that covers their hyaline bodies and protects them as they develop through five nymphal stages. These masses often contain several nymphs. Once mature, nymphs move out from under the spittle and molt into gray-brown wedge shaped adults 6 to 12 mm long. Adults actively fly or jump when disturbed. They are very mobile and may migrate from *Eucalyptus* to feed on other hosts.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Low* (RC) (Applicable rating criteria, from Chap. 1: d)

   The limited geographic distribution of *C. siccifolius* in Argentina (Fiorentino and Medina 1991) and in Brazil (Paschoal and others 1985) indicates that the likelihood is low that it occurs routinely on *Eucalyptus* elsewhere in South America. Being a polyphagous species is of concern since native forests are reported to harbor abundant populations (Golfari 1963).

2. Entry potential: *Low* (RU) (Applicable rating criteria, from Chap. 1: None)

   Despite the fact that *C. siccifolius* would have a low likelihood of being introduced on logs based on its feeding and oviposition habits, its adult behavior could be more troublesome. Adult *C. siccifolius* are active (jumping and flying), which increases the possibility of being transported in the process of yarding and shipping. Cercopids are attracted to lights, which could attract them to storage and transportation centers and provide an entry pathway on shipping vehicles and containers as a hitchhiker. Since adults are gray–brown, they would not be easily detected. Still, the potential for any life stage being present on logs is low because nymphs and adults are foliage inhabitants and eggs are likely to be deposited within small (<0.3-cm-diameter) twigs.

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

Mobile adults, polyphagous feeding habits, and endophytic ovipositional habits would ensure that cercopids would find suitable hosts for establishment. Spittle bugs are noted for utilizing a variety of hosts (woody and herbaceous). Thus, colonization is perceived to be moderately possible.

4. Spread potential: *Moderate* (RC) (Applicable risk criteria, from Chap. 1: e, h)

   Adults would be the sole life stage for enlarging populations. Active adults could disperse several hundred meters per dispersal episode, which suggests that spread could be reasonably rapid. In fact, Golfari (1963) recommended planting *Eucalyptus* as far away as possible from native forests because of the mobility of *C. siccifolius*.

B. Consequences of introduction

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

   Spittlebugs seldom cause extensive economic losses. In the case of *C. siccifolius*, only limited reversible damage to mature trees and occasional seedling mortality occur (Golfari 1963). Damage to ornamental and shade tree eucalypts in the United States probably would be ephemeral and limited. However, the cut-foliage industry could be impacted by this insect because it would reduce and deform growth and diminish the ornamental value of *E. pulverulenta*.

6. Environmental damage: *Low* (RC) (Applicable rating criteria, from Chap. 1: None)

   Damage to native subtropical South American forests is not serious. The major noticeable damage is to nonnative *Eucalyptus*, suggesting that the natural resistance inherent in native forests renders it benign. Several plant genera can be attacked by *C. siccifolius*, and its host range is unknown. Thus, there is a threat that, if established, this insect could utilize other subtropical species in the United States. This threat is considered minimal since few cercopids native to North America are serious pests.

7. Social and political considerations: *Low* (RC) (Applicable rating criteria, from Chap. 1: None)

   Infestations would have only modest impact on ornamental and urban plantings. The most serious threat would be to *E. pulverulenta* and *E. globulus* plantings, but the performance of *C. siccifolius* on these species is unknown. Introduction of another spittle bug probably would result in low to moderate social concern.

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

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Reviewers’ comments—“The probability of pest establishment is low based on the association of this organism with leaves and twigs, therefore it is unlikely to be associated with the pathway, yet the elements provided for assessment do not provide for this.” (Zadig)

Response to comments—This statement is most applicable to entry potential (element 2) and has been moved from element 1.

Purple Moth

Assessor—William E. Wallner

Scientific name of pest—*Sarsina violascens* Herrich-Schaeffer (Lepidoptera: Lymantriidae)

Scientific names of hosts—Various *Eucalyptus* spp. but especially *E. cloeziana, E. citriodora, E. nesophilia, E. grandis, Psidium* spp., *Mikania* spp. (Compositae), and *Osmanthus* spp. (Oleacae)

Distribution—Brazil: widely distributed from Rio Grande do Sul to northern Brazil. It is most important in Brazil's central regions. It also has been reported defoliating *Eucalyptus* in various regions of Argentina, Peru, and Paraguay (Zanuncio and others 1993), as well as Mexico (C.S. Hodges, North Carolina State University, personal observation).

Summary of natural history and basic biology of the pest—*Sarsina violascens* belongs to the order Lepidoptera, family Lymantriidae, which includes numerous pest species from around the world (gypsy moth, nun moth, browntail moth, pine caterpillar, etc.). The name purple moth is ascribed to this moth despite the fact that it apparently has two adult color forms, brown and the more common violet (Zanuncio and others 1993). It is not possible to discriminate between these color forms based on larval appearance since all larvae are light brown to beige. *Sarsina violascens* is one of several lepidopterans endemic to Brazil's Myrtaceae that seriously defoliate introduced *Eucalyptus* (Berti Filho 1983, Zanuncio 1976). The genus *Sarsina* is considered neotropical with no known species north of Mexico (Ferguson 1978).

Sarsina violascens, reported as a major pest in southeastern Brazil, also is found in Argentina, Peru, and Uruguay (Zanuncio and others 1993). In Brazil, adults are active from March to December depending on the regional climate. The spherical, milky-white eggs are deposited singly or in one layer of up to 40 eggs on *Eucalyptus* leaves. In Mexico, egg masses were commonly found on the lower trunks of trees. Eggs in heavily infested areas were 90% parasitized while those outside defoliated plantations were not parasitized (C.S. Hodges, North Carolina State University, personal observation). Embryonic development is completed in 11 days and larval development in 37 days. The brown–beige hairy larvae are voracious nocturnal feeders that congregate on the lower third of the tree trunks during the day. Pupation lasts 11 days and occurs on the leaves of dry branches, tree trunks, or understory plants. The humpbacked, reddish-brown pupae are 17 mm long for the male and 34 mm for the female (Zanuncio and others 1993). While not stated in any of the literature reviewed, it is assumed to be univoltine and that eggs are the sustaining intergenerational life stage, as it is with other Lymantriidae.

In Brazil, *S. violascens* is one of the most important defoliators of *Eucalyptus* plantations (Zanuncio and others 1992, Berti Filho 1983); populations fluctuate widely due to control by parasites (Evóneo Berti Filho, Universidad de São Paulo, Piracicaba, Brazil, 1998, personal communication). Trees are weakened by defoliation, their growth rate is reduced, and they are susceptible to further attack by secondary organisms. Clearly, this insect has been among the top five defoliators of *Eucalyptus* plantations in South America. It also is on the potential quarantine pest list for Australia (Floyd and others 1998).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (RC) (Applicable rating criteria, from Chap. 1: b, c, d, e, h)

   The large geographical range of this insect and its broad host range are guarantors that it will be affiliated with *Eucalyptus* or other subtropical hardwoods. All life stages are found on the tree (eggs, larvae, and pupae on the foliage and eggs and larvae on the trunk, but pupae can be found anywhere on or off the tree) (Jose Cola Zanuncio, Federal University of Viçosa, Viçosa, Brazil, 1988, personal communication). Despite its high rating due to host affiliation, it tends to be episodic in its outbreaks within defined areas and apparently is susceptible to natural controls.

2. Entry potential: *High* (RC) (Applicable rating criteria, from Chap. 1: b, c, d)

   Eggs or egg masses would appear to be the major risk for providing entry and, because of their small size and color, would be difficult to detect. Little information is extant on this insect's bioecology but it is likely that it will behave as other lymantriids; oviposition sites will vary with little fidelity to a specific location. Evidence of this was reported for *S. violascens* (Zanuncio and others 1993) in rearing studies where egg masses were deposited on flat sheets of paper rearing material. In general, lymantriid adults are attracted to lights and that can result in egg masses being transported into the United States on nonhost material and vehicles (Wallner and others 1995). An enclosed lymantriid egg mass, comparable in appearance to *S. violascens*, was found on the cut end of a *Eucalyptus* log in a Montevideo, Uruguay, port by members of the Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET). Pupae can be found anywhere on the tree, but the probability of both sexes surviving and emerging concurrently to ensure mating is of low probability. Late stage larvae tend to rest on the lower trunk and could be transported, but the likelihood of successful translocation is believed to be low.

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

   Sarsina violascens is a polyphagous, neotropical species that has already demonstrated its ability to attack a new host, such as *Eucalyptus* (Zanuncio 1976). Thus, when encountering a *Eucalyptus* species or another myrtaceous or oleaceous host, colonization would be reasonably certain. Given that most lymantriids are very mobile in the larval and adult stages, host finding would be aggressive. Hosts growing under cool, dry conditions would be most vulnerable to colonization (Zanuncio and others 1994a).

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

   Dispersability of lymantriids has been well documented; both neonates and adults can be expected to disperse several hundred meters to a kilometer or more with each episode. Populations would be expected to expand rapidly following initial colonization, and spread could be accelerated if adult females are attracted to artificial lighting.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: a, b)

   The impact of defoliation on plantation *Eucalyptus* in South America is poorly understood. Defoliation is likely to reduce vigor and growth, temporarily despoil the appearance of trees, and could weaken them making attack by other organisms more likely. Perhaps the biggest impact would be on the U.S. *Eucalyptus* foliage industry, although it is not known if *S. violascens* attacks *E. globulus* or *E. pulverulenta*.

6. Environmental damage potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: d)

   Because *S. violascens* is an episodic defoliator, its damage would not be expected to be protracted. In South America, populations are regulated by natural enemies (Zanuncio and Lima 1975). If *S. violascens* were introduced into the United States, it is not known if its dynamics would change in the absence of these natural controls. This could necessitate application of chemical controls, presenting an environmental hazard. One bothersome feature of *S. violascens* is its polyphagy, which could have serious impacts on U.S. forest–plant ecosystems other than *Eucalyptus*.

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

   Most lymantriid moths are outbreak species and tend to be periodically numerous. The majority of species have urticating hairs that can cause irritating encounters with humans. *Sarsina violascens* has caused localized defoliation in Brazil (hundreds of hectares) (Zanuncio and Lima 1975). Defoliation probably would not kill *Eucalyptus* but would reduce growth rates and could be aesthetically unsightly. The major impact would be on high value urban plantings and those used for the floral industry. A major unknown is the impact on other trees or shrubs since *S. violascens* is so polyphagous.

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

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Reviewers' comments—"The species *Sarsina violascens* (Herrich–Schaeffer, 1856) (Lepidoptera: Lymantriidae) deserves a special item. Justifiably, the family Lymantriidae contains a species (*Lymantria dispar*) (=gypsy moth) of high risk to the United States and Canada. For this reason the authors of this report have done a detailed analysis of this insect. Accordingly, the species *Thyrinteina arnobia* (Stoll., 1782) (Lepidoptera: Geometridae) should have warranted, also, a special item, given that it is a major defoliator of *Eucalyptus* spp. in Brazil. It is currently also one of the defoliators of *Eucalyptus* 'eurograndis' in Venezuela. In this manner, I justify my suggestion that it be included in the same category of risk as *S. violascens.*" (Pedrosa-Macedo)

Response to comments—We concur with reviewer comments that there are numerous potentially dangerous defoliators of *Eucalyptus* that might be introduced. While it is agreed that *Thyrinteina arnobia* also is a serious pest, it is among a long list of potential defoliating pests that would be impossible to cover comprehensively in this assessment. Many lepidopterous defoliators share similar habits relative to pathway analysis and potential pest risk. Hence, analysis of *Sarsina violascens* is representative of this extremely large group of defoliating pests for the purpose of this assessment. We believe our comprehensive analysis of *S. violascens* serves as an example for other lepidopterous defoliators in pest–pathway evaluation for mitigation purposes.

Scolytid Bark and Ambrosia Beetles

Assessor—Andris Eglitis

Scientific names of pests—*Scolytopsis brasiliensis* Eggers; *Xyleborus retusus* Eichhoff; *X. biconicus* Eggers; *Xyleborus* spp. (Coleoptera: Scolytidae)

Scientific names of hosts—*Xyleborus* spp.: *Eucalyptus grandis*, *E. dunnii*, *E. citriodora*, *Pinus elliottii* Engelm. (slash pine), *Acacia mearnsii* Willd. (black wattle), *Mimosa scabrella* Benth. (Bracatinga);

Scolytopsis brasiliensis: *Eucalyptus grandis, Prunus sellowii* Koehne (pessegueiro-bravo)

Distribution—*Xyleborus retusus*, *X. biconicus*: northeastern provinces of Argentina (Formosa, Misiones), Brazil (Rio Grande do Sul); *Scolytopsis brasiliensis*: southern Brazil

Summary of natural history and basic biology of the pests—Scolytids are generally not common in South America, largely because there are few native conifers on the continent (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication). Only 300 species have been identified and only one (*Scolytopsis brasiliensis*) is a bark beetle specifically associated with *Eucalyptus* (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication). *Scolytopsis brasiliensis* attacks cut logs and limbs and has been found killing its *Eucalyptus* host on one occasion (José Henrique Pedrosa-Macedo, Federal University of Paraná, 1998, Brazil, personal communication). With regard to the *Eucalyptus* host in South America, ambrosia beetles (*Xyleborus* spp.) tend to be slightly more common than bark beetles. In general, however, *Eucalyptus* does not appear to be a common host for ambrosia beetles either (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication).

Viana (1964) reported that 120 species of scolytids occur in Argentina and described some of those host associations. Among these, he lists four species of *Xyleborus* (*X. biconicus*, *X. fuscobrunneus, X. retusus,* and *X. linearicollis*) that also occur in Brazil, occasionally in association with *Eucalyptus.* Many of the ambrosia beetles are polyphagous, and *Eucalyptus* is typically just one of the many hosts that these beetles infest. For example, Nunes Marques (1999) reported *X. retusus* as a secondary beetle in *Acacia mearnsii* and *Mimosa scabrella*, both heavily infested by cerambycid beetles. Pedrosa-Macedo (Federal University of Paraná, Brazil, 1998, personal communication) says that *X. retusus* is associated with *Eucalyptus* in Brazil. Fiorentino and others (1988) reported capturing *Xyleborus linearicollis* and other species of *Xyleborus* in "scolytid traps" placed in young plantations of *Eucalyptus tereticornis* and *E. camaldulensis* in Santiago del Estero, Argentina. *Xyleborus linearicollis* was also captured in traps placed in a plantation of *Pinus halepensis* (Fiorentino and others 1988). Other unidentified scolytids were also common in the traps.

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, in part because of 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 brood helps to enlarge the galleries, which can sometimes be highly complex and branched or may be much simpler in some species (Wood 1982). In the North American species, the mature brood overwinters in the galleries (Furniss and Carolin 1977).

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 of 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 ensure 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 the 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 ferrugineus, considered the most destructive scolytid in the tropics (Wood 1982) attacks a wide variety of woody plants. Although common host material includes cut logs and unhealthy trees and stumps, the insects will also attack living trees on occasion and hasten their death (Wood 1982). Economic effects are greatest in cut logs where the insect tunnels reduce the value of the sapwood (Wood 1982). In addition to the damage it produces directly, *X. ferrugineus* is a principal vector of *Ceratocystis fimbriata*, which causes a wilt disease of cacao (Wood 1982).

The life cycles of most Brazilian species of *Xyleborus* are not well known. A *Eucalyptus*-inhabiting species in New Zealand (*X. truncatus*) is thought to have a life cycle of less than one year and may complete two generations in a year (Zondag 1977). José Henrique Pedrosa-Macedo (Federal University of Paraná, Brazil, 1998, personal communication) stated that *X. biconicus* has a 4- to 5-week life cycle in Brazil.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (MC) (Applicable rating criteria, from Chap. 1: a, d, f, g, h)

   In Brazil, scolytids are seldom associated with logs and are not considered to be a significant problem in *Eucalyptus* (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication). The bark beetle *Scolytopsis brasiliensis* only occurs in Brazil and would not be associated with *Eucalyptus* logs from the other countries under consideration. While the *Xyleborus* ambrosia beetles are more widespread, they appear to have a weak association with *Eucalyptus* and occur more commonly with their other hosts. Although there is insufficient information available to rate these specific organisms as High, the scolytids as a group warrant a high degree of concern for their potential to be associated with recently cut, untreated host material.

2. Entry potential: *High* (MC) (Applicable risk criteria, from Chap. 1: a, b, c, d)

   As a group, the scolytids are the most commonly intercepted family of beetles in association with wood commodities coming into the United States. Some members of the genus *Xyleborus* have been intercepted in ports of the United States and other countries, in association with various commodities including solid wood packing material (15 interceptions in the United States between 1995 and 1998). José Henrique Pedrosa-Macedo (Federal University of Paraná, Brazil, 1998, personal communication) stated that *X. biconicus* could infest freshly cut *Eucalyptus* logs. However, these insects have a very short life cycle of 4- to 5-weeks (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication), which reduces their chances of being transported to a new environment. Other unidentified species of *Xyleborus* may represent a higher risk of entry than *X. biconicus*.

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

   Within the genus *Xyleborus*, there are at least two species that have been introduced into the United States from elsewhere. One of these, *X. dispar*, has a very wide host range. Even though they are polyphagous, most of the South American species of *Xyleborus* appear to be tropical, which would limit the possible locations of successful establishment within the United States.

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

   The high reproductive potential and polyphagous nature of the *Xyleborus* ambrosia beetles would be important factors in their ability to spread. The bark beetle *S. brasiliensis* would be less likely to spread due to fewer host species.

B. Consequences of introduction

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

   With the exception of *X. ferrugineus*, the ambrosia beetles in the genus *Xyleborus* native to the United States are not considered to be very serious damage agents (Furniss and Carolin 1977). Damage by *X. ferrugineus* and other ambrosia beetles is primarily caused by the tunneling of adults and developing brood as they construct their tunnels and chambers in cut wood or in severely wounded or weakened hosts. These tunnels are stained by the darkly colored ambrosia fungus that lines the walls of the tunnels and degrades the quality of the wood. Some other ambrosia beetles *(Trypodendron* sp.; *Gnathotrichus* sp.) are important as pests of conifers in the forest industry and cause serious losses each year in Canada (Nijholt 1978). For logs, the degree of value loss through lumber degrade is a function of the degree of infestation by ambrosia beetles and the original grade of the log (McBride and Kinghorn 1960). Typically, even a light level of infestation can cause dramatic value loss in a high-value log (McBride and Kinghorn 1960). It is not known whether foreign species of *Xyleborus*, if introduced into the United States, would behave more like native *X. ferrugineus* or like the less aggressive native species of *Xyleborus*.

   Another area of concern for insects such as *Xyleborus* is the capacity of some of them to vector disease organisms. If exotic *Xyleborus* became associated with the wilt disease pathogen *Ceratocystis fimbriata* that occurs in California and were to become an efficient vector of this pathogen, there could be important implications to California agriculture.

6. Environmental damage potential: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: d)

   Despite having numerous hosts in South America, ambrosia beetles do not appear to be a significant problem in their local environments. With the exception of *X. ferrugineus* (already present in the United States), the genus presents few problems in terms of environmental damage. Potential problems could arise, however, if an introduced species were to infest a U.S. host with limited distribution.

7. Social and Political Considerations: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: c)

   The introduction of new scolytids could affect international trade for the United States.

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

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Reviewers’ comments—“Purple moth/Scolytid Bark and Ambrosia Beetles. Even though in the case of the scolytids tendency to be associated with recently cut and untreated host material, the probability of pest association with host at origin and entry for these pests is dependent upon whether or not debarking is a standard harvesting practice and the probability of pest establishment assessment hinges on this element.” (Zadig)

“. . .I believe that *C. fimbriata* is also a wilt disease of apricots in the Central Valley of CA (it is vectored in part by nitidulid beetles). This connection might be important if exotic *Xyleborus* beetles are reunited with the disease in California and then impact California agriculture. It would be good to bring out this scenario here.” (Seybold)

Response to comments—In this assessment, we do not presume that logs will be debarked. Thus, the likelihood of association between the organism and host is considered as if bark were present on the logs. The standards for debarking still permit a small percentage of bark to be present in a shipment, and history has shown that phloem feeders such as bark beetles can be associated with and survive on logs even when they are considered to be “well-debarked” (Schroeder 1990). Even though South American *Eucalyptus* logs are normally debarked, either before felling (*E. grandis* in Argentina) or shortly thereafter, we observed numerous log decks where small pieces of bark remained on some logs, and occasionally some smaller logs still contained all of their bark.

The comment referring to the possibility of a connection between exotic *Xyleborus* and *C. fimbriata* and a potential effect on agriculture in California was included in the Economic Damage Potential element of the risk assessment.

Carpenterworm

Assessor—Andris Eglitis

Scientific names of pest—*Chilecomadia valdiviana* (Philippi) (Lepidoptera: Cossidae)

Scientific names of hosts—Chile: *Eucalyptus nitens*; occasionally *E. gunnii* and *E. camaldulensis*; *Nothofagus pumilio* (Poepp. et Endl.) Krasser; *N. dombeyi* (Mirb.) Oerst.; *N. antarctica* (Forst.); *N. alpina* (Poepp. et Endl.) Krasser; *Salix babilonica* L.; *Salix* spp.; *Alnus glutinosa* Gaertn.; *Quercus robur* L.; *Maytenus boaria* Mol.; *Weinmannia trichosperma* Cav.; *Trevoa trinervis* Miers; *Ulmus glabra* var. *pendula*; numerous fruit trees including *Malus*, *Persea*, *Pyrus*, *Prunus*, *Olea*. Argentina: *Nothofagus antarctica* (Forst.); *Weinmannia trichosperma* Cav.; various other forest and fruit trees.

Distribution—Occurs on a variety of sites and hosts throughout Chile from Region III to Region XII (Copiapo to Punta Arenas). Within this range in Chile, *C. valdiviana* is found on its *Eucalyptus* hosts in Regions VIII and IX (Concepción to Osorno). Also occurs in Argentine provinces of Neuquen, Rio Negro, and Santa Cruz. Elevation ranges from sea level to 1,700 m above sea level.

Summary of natural history and basic biology of the pest—The carpenterworm has been known in the native hardwood forests of Chile for more than 150 years. The insect has an extremely broad host range, feeding on several of the native beeches (Petersen 1988), other hardwoods, various fruit trees (Gonzalez 1989), and some shrubby species. Until recently, however, there has been little known about the basic behavior and life cycle of this insect (Cerda 1996). After *C. valdiviana* was discovered in an economically important host (*Eucalyptus nitens*) in 1992, there was increased interest in studying the biology of the insect.

Within the *Eucalyptus* host, *C. valdiviana* is found in the foothills of the Andes, the central valley, and the coast range. The insect infests live trees from 4 cm diameter at breast height (dbh) and larger, with attacks occurring in all portions of the bole. Tree stress is not a prerequisite for attack.

The life cycle of the carpenterworm is still not entirely clear, but is believed to require more than one year. In one instance, experimentally induced attacks produced a generation in 14 months (Luis A. Cerda, University of Concepción, Chile, 1998, personal communication). Overlapping generations are also suspected, since there are several months during the year when all four life stages can be found in the same tree (Cerda 1996). The adult stage is found from early spring to late summer (mid-August to mid-February). In Argentina, adults have been reported in March and April as well (Gentili 1989). Eggs can be found during the same months as the adults. The larval stage is present throughout the entire year and pupae are found from the beginning of May through the end of January (fall to mid-summer).

Attacks on host trees begin in the spring. The female lays eggs in groups of 30 to 50 at branch axils or in natural bark crevices. Each female is capable of laying up to 200 eggs. The recently hatched larvae feed gregariously beneath the bark near the point of oviposition. Their feeding produces a sap flow on the bark that is an ideal substrate for the development of sooty mold fungi. Trees with multiple attacks are easily recognized from a distance by the darker color of the bole resulting from the sooty mold. Toward the end of summer, the larvae leave the phloem and begin boring deeply into the heartwood. They feed individually and orient their galleries upward. These galleries, up to 27 cm long and 1 cm wide, are kept free of frass and are open until the mature larvae plug them prior to pupation. With time, the boring dust expelled from the gallery accumulates at the base of the tree and serves as another diagnostic clue of carpenterworm infestation. Pupation takes place within the larval gallery, with the pupa protruding slightly outside. The nocturnal adults mate shortly after emerging from their host, and lay eggs within 24 h of mating. The females, heavy with eggs, are considered to be weak fliers (Luis A. Cerda, University of Concepción, Chile, 1998, personal communication) but males of the cossid family are strong fliers (Solomon 1995).

The open larval galleries provide easy entry for a number of stain and decay fungi that grow rapidly in the moist wood. Stain and decay within infested trees have been measured as far as 4 m beyond the end of the larval gallery (Luis A. Cerda, University of Concepción, Chile, 1998, personal communication). (This feature of rapid staining and decay appears to be much more pronounced in *E. nitens* than in other species infested by the carpenterworm). The species of stain and decay fungi associated with the galleries of *C. valdiviana* have not been identified. Cerda (1995) believes that the fungi may serve as a food source for developing larvae.

Infestation by *C. valdiviana* does not kill the host tree directly, although the larval galleries often weaken the bole and make it more susceptible to wind breakage. Staining and decay damage produced by the fungi also reduces the wood value of infested eucalypts. Reinfestation of the same trees is common, which can lead to extensive damage over time.

The distribution of carpenterworm infestation centers appears to be random. The first infestation centers to be found in *E. nitens* were close to native host forests (beeches and willows), but subsequent infestations have been found in areas not particularly close to these native hosts. Within an infested stand, the percentage of trees attacked has not exceeded 5%.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Moderate* (MC) (Applicable rating criteria, from Chap. 1: d, e, g, h)

   Since the only commercial *Eucalyptus* host for *C. valdiviana* is *E. nitens*, the assumption for this element is that *E. nitens* is the only substrate being evaluated. (This element would be rated low for other commercial species of *Eucalyptus* in Chile). Advanced or heavy infestations are easily recognized by sawdust at the base of the tree and sooty mold on the bark. It is reasonable to assume that heavily infested trees would be recognized during harvest and separated out from uninfested trees. However, incipient or light attacks may be more difficult to recognize, especially if the host material is not debarked. Even though the current level of occurrence of the carpenterworm seems to be low in plantations of *E. nitens*, the association with this host is fairly recent, and the insect populations cannot be presumed to have stabilized yet.

2. Entry potential: *High* (MC) (Applicable rating criteria, from Chap. 1: b, c)

   Advanced larval stages can probably survive in a log and develop to adulthood. The biology of *C. valdiviana* seems to compare well with the leopard moth, *Zeuzera pyrina*, which entered the United States in 1882 (Anderson 1966).

3. Colonization potential: *High* (MC) (Applicable rating criteria, from Chap. 1: b, c, d)

   Chilecomadia valdiviana has a very broad host range and a wide geographic distribution within various environments. Host genera for the carpenterworm are found throughout most of the United States, such that finding a host could be possible in most geographical regions of introduction. The association of the insect with *Eucalyptus* is a strong testimonial to its adaptability and is a factor that also elevates concern about potential hosts to which it has not yet been exposed. The introduction of the leopard moth, *Zeuzera pyrina*, into the United States from Europe (Anderson 1966) also shows the adaptability of some cossids to new environments.

4. Spread potential: *High* (RU) (Applicable rating criteria, from Chap. 1: c, d, e, f, g)

   The rate of spread of the carpenterworm would depend largely on the nature and distribution of host material in the United States. Contiguous stands of hosts would be more conducive to spread than scattered or isolated hosts. The inherent spread potential of *C. valdiviana* seems to be limited by poor flight capability of the female, particularly when carrying her full load of eggs. In Chile, the same trees are often reinfested, which also suggests a slower rate of spread.

   In Chile, *C. valdiviana* in its eucalypt host was initially found close to native host stands but subsequently has been found in plantations of *E. nitens* where native hosts are not particularly close by. This observation suggests that the dispersal capabilities of the insect may be fairly good.

B. Consequences of introduction

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

   Even though Chileans have known about the association of *C. valdiviana* with its many hosts for a long time, there have not been any control measures developed, even in fruit trees, which have always been economically important for Chile. This suggests that in its native environment, the insect has not produced intolerable losses. Nonetheless, the pest potential is now being recognized for one species of *Eucalyptus*. The association of the carpenterworm with its *Eucalyptus* host is a very recent one that probably has not realized its full potential. At this time, however, this insect is more common in its other hosts than in *E. nitens*.

   The broad native host range of the carpenterworm is of concern if the insect were to become established in the United States. Comparable potential hosts in the United States have importance in the agricultural industry (fruit trees) and as ornamentals (eucalypts, oaks, beeches).

   An important consideration for this element is the strong association of the carpenterworm with numerous unidentified fungi that are considered to produce even more damage than the insect in *E. nitens*. Even though the behavior of these fungi is more pronounced in *Eucalyptus* than in native hosts, we are concerned about the lack of information on them and their damage potential if introduced into a new host in the United States.

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

   The biggest concern for this element is the association of the insect with several fungi that have not been identified. We were told that the rapid rate of staining and decay were a function of the wetness of the wood of *Eucalyptus* and that a comparable rate of decay does not occur in other hosts (Luis A. Cerda, University of Concepción, Chile, 1998, personal communication). Nonetheless, the fact that these fungi are not known but seem to be present in all eucalypts infested by the carpenterworm elevates this element to a moderate. An additional environmental concern with this and all other introductions is the inevitable increase in pesticide use and inadvertent misuse by homeowners and others concerned with protecting their plants from pests.

7. Social and Political Considerations: *Moderate* (MC) (Applicable rating criteria, from Chap. 1: a)

   The greatest concern would probably come from homeowners interested in protecting their ornamental plantings.

C. Pest risk potential*: High* for *E. nitens* (Likelihood of introduction = *Moderate*; Consequences of introduction = *High*); *Moderate* for two other host species of *Eucalyptus (E. camaldulensis* and *E. gunnii)* (Likelihood of introduction = *Low*; Consequences of introduction = *High*)

Selected bibliography

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

Cerda M., L. 1995. Estudio y seguimiento del taladrador de la madera *Chilecomadia valdiviana* (Lep.: Cossidae) en plantaciones de *Eucalyptus nitens* en el patrimonio de FORMIN S.A. Informe de Avance Temporada 1994–1995. Concepción, Chile. 15 p.

Cerda M., L. 1996. *Chilecomadia valdiviana* (Philippi) (Lepidoptera, Cossidae). Insecto taladrador de la madera asociado al cultivo del *Eucalyptus* spp. en Chile. Nota Técnica, Año 16. Corporación Nacional Forestal, Depto. de Programas y Proyectos, Programa Protección, Sanitaria Forestal. No. 32. 7 p.

Gentili, P. 1989. Revisión sistematica de los Cossidae (Lepidoptera) de la Patagonia andina. Buenos Aires, Argentina: Revista de la Sociedad de Entomología de Argentina. 45(1–4): 3–75.

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

Petersen, J. 1988. *Chilecomadia valdiviana* (Philippi) (Lepidoptera: Cossidae), asociado a *Nothofagus pumilio* (Poepp. et Endl.) Krasser (lenga) en la región de Magallanes. Anuales del Instituto de Patagonia. 18: 51–55.

Solomon, J.D. 1995. Guide to insect borers in North American broadleaf trees and shrubs. Agric. Handb. AH–706. Washington, DC: U.S. Department of Agriculture, Forest Service. 735 p.

Reviewers' comments—"In the evaluation of the Pest Risk Potential of *Ch*. *valdiviana*, it was determined that this insect has a Pest Risk Potential of *Moderate* for other species of *Eucalyptus* [besides *E*. *nitens*], among them, *E*. *globulus*. We believe that the Pest Risk Potential for *Ch*. *valdiviana* in *E*. *globulus* should be non-existent because this insect has never been associated with this species of eucalypt, the principal species of this genus being cultivated in Chile." (Peña Royo) (translated from Spanish)

"The lack of presence of *Ch. valdiviana* in plantations of *E*. *globulus* is something that has been studied in Chile [including] in situations where infested plantations of *E. nitens* have been found growing adjacent to plantations of *E*. *globulus* without ever having observed the moth attacking the latter species."

"In the process of Pest Risk Assessment, special attention must be given to pest/host associations, considering that even when the pest being examined is an insect with a wide host range, as is *Ch*. *valdiviana*, it cannot be assumed that plant species in which the pest has never been observed will be hosts for the pest. This is the case for *Ch*. *valdiviana* with respect to *E*. *globulus*, in which a Pest Risk Potential of Moderate has been assumed without the existence of observations and/or publications that support an association between both species." (Peña Royo) (translated from Spanish)

"Like the WIPRAMET Team, we are very concerned about the unknown pathogens found associated with the carpenterworm damage in Chile and with the unidentified bluestain observed on logs in Argentina (Appendix A – Reports on Team's site visits to South America). Their presence suggests that APHIS should require the heat treatment (71.1 degrees C for 75 min at the core) of all shipments of prior to entering the U.S. Heat treatment is the only mitigation method proven effective against all potential pests." (Johnson and Osterbauer)

Response to comments—The pest risk potential rating of moderate for "other species" of *Eucalyptus* was clarified to refer to the other two occasional hosts in which *C. valdiviana* has been reported – *E. camaldulensis* and *E. gunnii*. The pest risk potential for other species of *Eucalyptus* including *E. globulus* would be low.

The unknown fungi associated with *C. valdiviana* are an important factor in rating this organism as having a high pest risk potential.

Platypodid Ambrosia Beetle

Assessor—Andris Eglitis

Scientific names of pest—*Megaplatypus parasulcatus (=Platypus sulcatus* Chapuis*)* (Coleoptera: Platypodidae)

Scientific names of hosts—Argentina: Various conifers and hardwoods including *Populus* and occasionally *Eucalyptus*
Brazil: *Populus*, *Eucalyptus urophylla* (São Paulo), *E. robusta* (Rio Grande do Sul)
Uruguay: *Populus* and occasionally *Eucalyptus*
Other South American hosts include *Casuarina*, *Pinus*, *Acacia*, *Citrus*, and *Persea*.

Distribution—Argentina (region of Paraná River Delta); Brazil (states of Rio Grande do Sul, Paraná, Santa Catarina, and São Paulo); Uruguay

Summary of natural history and basic biology of the pest—Most members of the Platypodidae are tropical and subtropical. They are generally larger than scolytid ambrosia beetles and tend to bore more deeply into the wood (Solomon 1995) where they cultivate and feed on fungi as larvae and adults.

Biological information on *M. parasulcatus* is scarce. In Argentina, Santoro (1967) reports that attacks occur between November and March. Pedrosa–Macedo (1993) describes the biology of "*P. sulcatus*" in Brazil as follows: Between November and January, the adults abandon the galleries in which they developed and search for a new host. Females construct galleries in the wood of the new host and lay eggs. Egg-laying begins in March and continues for several months. Up to 100 eggs may be laid by each female. The males make galleries at the rate of 10 to 15 cm per month and mate in these tunnels. The total development time is one year. As such, an infested host may contain various developmental stages from eggs to larvae and adults of both sexes. Larvae develop for 5 to 6 months and then construct pupal chambers, beginning in July. Symbiotic fungi associated with *M. parasulcatus* belong to the genus *Raffaela* (Pedrosa-Macedo 1993).

This ambrosia beetle will attack live trees through wounds or when they are unhealthy for other reasons. In Brazil, *M. parasulcatus* is native and highly polyphagous (Edson Tadeu Iede, EMBRAPA, Curitiba, Brazil, 1998, personal communication). It attacks stressed trees, usually not killing them but causing degrade in the wood through fungal staining. Clark (1937**,** cited by Gibson [1979]) reported that in Minas Gerais, Brazil, eucalypts between 5 and 9 years old suffered 1% mortality after the tops of infested trees snapped off 2 m above the ground. (Numerous species of Scolytidae, Platypodidae, and Bostrichidae were involved in the infestation, but their roles as primary or secondary agents were not identified). Although *M. parasulcatus* aggressively infests other hosts in Brazil, Jose C. Zanuncio (Federal University of Viçosa, Brazil, 1998, personal communication) stated that the only place it was a problem in *Eucalyptus* was where a tree had been climbed with spikes. In this case, concentrated attacks by *M. parasulcatus* caused weakening and wind breakage of the bole. Gibson (1979) says that damage has been reported in eucalypt plantations in Argentina and Uruguay, but the association with this host appears to be far less common than with *Populus* in both countries (Norma Vaccaro, INTA-Concordia, Argentina, 1998, personal communication; Juan F. Porcile, Ministry of Livestock, Agriculture and Fisheries, Uruguay, 1998, personal communication).

In Brazil, José H. Pedrosa-Macedo (Federal University of Paraná, Brazil, 1998, personal communication) stated that *M. parasulcatus* must have a live host or it will exit infested material within a week or two.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: f, g)

   The association of the ambrosia beetle is much stronger with poplars than with *Eucalyptus*, according to the forestry professionals we contacted in Brazil, Argentina, and Uruguay. The typical commercial plantation with healthy trees is rarely infested by *M. parasulcatus*.

2. Entry potential: *Low* (MC) (Applicable rating criteria, from Chap. 1: none)

   Megaplatypus parasulcatus appears to require live or very fresh host material to complete its development (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication). Servicio Agricola y Ganadero (SAG) officials reported that although *M. parasulcatus* is often intercepted at the Chilean border in crating material (presumably made from poplar), the insects have always been dead (Marcos A. Beeche, SAG, Chile, 1998, personal communication).

3. Colonization potential: *High* (MC) (Applicable rating criteria, from Chap. 1: c, d, e)

   Given the polyphagous nature of this insect, its broad range of hosts, and the fact that it has adapted to a new host (*Eucalyptus*), there is a reasonable likelihood that it could find a suitable host in the southern portions of the United States.

4. Spread potential: *High* (MC) (Applicable rating criteria, from Chap. 1: c, d, e, f, g)

The polyphagous nature of this insect and its dispersal capability could aid in spread potential once introduced into a new environment.

B. Consequences of introduction

5. Economic damage potential: *High* (RU) (Applicable rating criteria, from Chap. 1: a, c, d, f)

   Although *M. parasulcatus* is generally not considered a serious mortality agent, it can on occasion be damaging enough to warrant special control programs. Such a program is being implemented in Argentine poplar plantations in the Paraná River Delta, where biological control agents are being used to combat the insect. Some potential hosts for *M. parasulcatus* within the United States have important economic value (for example, pines, citrus, and avocado), and the establishment of the ambrosia beetle in these resources could lead to the need for expensive control programs. Within the United States, this ambrosia beetle is likely to become established only in those areas with a subtropical climate.

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

   Damage could occur in poplar plantations and on citrus trees and could require special control measures (for example, application of insecticides to bark surface) with potentially unacceptable environmental consequences.

7. Social and Political Considerations: *Moderate* (MC) (Applicable rating criteria, from Chap. 1: c)

   Megaplatypus parasulcatus is on the quarantine pest list for some countries including Chile. Its presence in the United States could affect trade with those countries where the ambrosia beetle does not occur.

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

Selected bibliography

Gibson, I.A.S. 1979. Diseases, pests and disorders. Ch. 9. In: Food and Agriculture Organization. Eucalypts for planting. United Nations FAO Forestry Series 11: 215–241.

Pedrosa–Macedo, J.H., coord. 1993. Pragas florestais do Sul de Brasil. Vol. 2, Manual de pragas em florestas. Programa Cooperativo de Monitoramento de Insetos em Florestas. Instituto de Pesquisas e Estudios Florestais. 111 p.

Santoro, F.H. 1967. Nuevo antecedente sobre lucha manual contra *"Platypus sulcatus"* Chapuis (Coleoptera–Platypodidae). IDIA—Suplemento Forestal. 4: 70–74.

Solomon, J.D. 1995. Guide to insect borers in North American broadleaf trees and shrubs. Agric. Handb. AH–706. Washington, DC: U.S. Department of Agriculture, Forest Service. 735 p.

Reviewers' comments—"As this organism is known to also attack pine, citrus and avocado while biological information is scarce, it seems imprudent in this case to state that there are relatively few places within the US where it could become established. Moreover this appears to be in contradiction with a high colonization potential based on the likelihood of finding suitable hosts in the southern U.S. If special control measures for citrus would potentially produce unacceptable environmental conditions, impacts to citrus production, including biological control, should be considered under economic damage potential." (Zadig)

Response to comments—Some changes were made in the draft narrative for Economic damage potential, and the rating for this element remains high.

Round-Headed Wood Borers

Assessor—Andris Eglitis

Scientific names of pests—*Chydarteres striatus* (Burmeister); *Retrachyderes thoracicus* (Olivier); *Trachyderes* spp; *Steirastoma breve* Sulzer; *Stenodontes spinibarbis* (Linnaeus) (Coleoptera: Cerambycidae)

Scientific names of hosts—*Eucalyptus grandis*; many fruit trees including *Citrus*, *Ficus*, *Prunus*, and others; *Populus* spp.; many native hardwoods including *Myrciaria*, *Psidium guajava* L. (guava), *Caesalpinea echinata* Lamarck (pau-brasil), *Pyrus*, *Castanea*, *Morus alba* L. (white mulberry), *Acacia mearnsii* de Wild. (black wattle), *Mimosa scabrella* Benth. (Bracatinga), and others.

Distribution—*Steirastoma breve*: Brazil (Rio Grande do Sul, Paraná), Argentina. *Stenodontes spinibarbis*, *Chydarteres striatus*, and *Retrachyderes thoracicus*: Argentina, Brazil, Uruguay. *Trachyderes* spp.: Argentina, Brazil, Ecuador. *T. succinctus*: Argentina, Ecuador.

Summary of natural history and basic biology of the pests—Most of the wood borers considered in this group have tree species other than *Eucalyptus* as their primary hosts but have on occasion been reported in association with *Eucalyptus*. As a general rule, there is little biological information available on their life cycles or host selection behavior, even for those cases where they have some economic importance (fruit trees, ornamentals). Most of the published information does little more than list collection points and report host associations. Some of these host associations are either disputed or might be based on a single observation.

These round-headed borers generally infest the boles or branches of recently cut trees or are associated with trees under extreme stress. Hosts that have wounds or are affected by some other biological agent may also be secondarily infested by these borers. For example, in Uruguay, we were told that certain cerambycids attacking *Eucalyptus* were only found in those trees previously infested by *Phoracantha semipunctata* (Juan F. Porcile, Ministry of Livestock, Agriculture and Fisheries, Uruguay, 1998, personal communication).

Duffy (1960) lists three species of *Trachyderes* as being associated with citrus in Argentina; all are secondarily associated with *Eucalyptus*. (Two have since been placed in different genera [*Chydarteres striatus* and *Retrachyderes thoracicus*]). Both *C. striatus* and *R. thoracicus* also occur in Uruguay where they have very broad host ranges that include fruit trees, acacias, willows, and occasionally *Eucalyptus*. Both species appear to be common, but little is known about the damage they might produce (Bentancourt and Scatoni, n.d.). *Retrachyderes thoracicus* attacks live *Ficus* in Argentina and often kills host trees by burrowing in the bole (Duffy 1960). The *Trachyderes* species occurring in Brazil (probably including *Retrachyderes thoracicus* and *Chydarteres striatus*) are also secondary beetles with a broad host range, which occasionally includes the larger branches of *Eucalyptus* (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication) but are not found in logs (Edson Tadeu Iede, EMBRAPA, Curitiba, Brazil, 1998, personal communication). Adults of *R. thoracicus* emerge in January and February in Brazil and in December and January in Argentina (Duffy 1960). Several specimens of *Trachyderes sulcata* were captured in young plantations of *Eucalyptus camaldulensis* in Santiago del Estero, Argentina (Fiorentino and others 1988). In this Argentine trapping study, adult beetles were found between February and April.

In the United States, the genus *Stenodontes* is represented by three species of large wood borers that attack live trees (Solomon 1995). One species not found in the United States, *S. spinibarbis*, occurs in South America where it has a large host range that includes *Eucalyptus*. In Ecuador, *S. spinibarbis* is typically associated with diseased and dead trees (Gara and Onore 1989). The insect does not appear to have economic importance in South America.

In Brazil, *Steirastoma breve* has a broad host range including cacao and palm but is uncommon in *Eucalyptus* (José Henrique Pedrosa-Macedo, Federal University of Paraná, Brazil, 1998, personal communication; Edson Tadeu Iede, EMBRAPA, Brazil, 1998, personal communication). Little biological information is available on this insect although it is considered an important pest of cacao in the tropics. In southern Brazil, *S. breve* requires 16 months to complete its life cycle; further north in the tropical portion of the country, there are four generations per year (Edson Tadeu Iede, EMBRAPA, Curitiba, Brazil, 1998, personal communication). Further north in Ecuador, *S. breve* is widely distributed from sea level to 1,800 m in elevation and completes its development in 3 to 5 months (Gara and Onore 1989). In Ecuador, *S. breve* has hosts from five genera, but *Eucalyptus* is not among them (Gara and Onore 1989).

Since very little specific information is available about the biology of these insects, the evaluation of the following risk elements 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: *High* (RU) (Applicable rating criteria, from Chap. 1: d, e, f, g, h)

   The host association of wood borers with *Eucalyptus* appears to be a weak one, even though some of these insects are fairly common. Interception records from 1995 to 1998 indicate that there has been only one interception of any of these beetles in U.S. ports. That interception was of a *Stenodontes* sp., associated with solid wood packing material of unspecified origin. In general, however, cerambycids are among the most commonly intercepted insects in association with solid wood. The biological requirements of these insects 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.

2. Entry potential: *High* (MC) (Applicable rating criteria, from Chap. 1: b, c, d)

   Although the biology of these South American cerambycids is poorly known, it is likely that they have a life cycle that includes a prolonged period in the larval stage within the wood that is sufficient to survive transport to a new location.

3. Colonization potential: *High* (MC) (Applicable rating criteria, from Chap. 1: a, b, c, e)

   Most of these beetles have a broad host range that covers numerous genera. Even if *Eucalyptus* were the medium for transport into the United States, there could be numerous other potential hosts such as fruit trees and assorted other hardwoods closely related to hosts in the native range of these wood borers. Within the United States, these borers would probably be restricted to the warmer parts of the country, comparable with the warmer climates of their native habitats in South America.

4. Spread potential: *High* (MC) (Applicable rating criteria, from Chap. 1: a, b, d, e, g, h)

   A broad host range together with strong flight capabilities and prolonged survival within host material would all aid in the spread of some of these wood borers.

B. Consequences of introduction

5. Economic damage potential: *High* (RU) (Applicable rating criteria, from Chap. 1: a, c, d, f)

   Most of these beetles attack recently cut wood and would probably not kill trees. Some, such as *Steirastoma breve* and possibly species of *Stenodontes* could potentially infest live trees, as *S. breve* occasionally does in its native environment and as *Stenodontes* does in the United States. Infestations in recently cut logs could reduce the value of lumber cut from this material.

6. Environmental damage potential: *Low* (RU) (Applicable rating criteria, from Chap. 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.

7. Social and political considerations: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: c)

   The presence of a new wood borer could have implications on international trade.

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

Selected bibliography

Bentancourt, C.M.; Scatoni, I.B. [n.d.] Catálogo de insectos y ácaros de importancia agrícola y forestal en el Uruguay. Notas Técnicas No. 10. Montevideo, Uruguay.

DiIorio, O.R. 1994. Phytophagous insects of Argentina. Chapter: Cerambycidae, host plants, parasitoids and predators. (unpublished data)

Duffy, E.A.J. 1960. A monograph of the immature stages of neotropical timber beetles (Cerambycidae). London. England: Commonwealth Inst. Ent., British Museum of Natural History. 327 p.

Fiorentino, D.C.; Iturre de Toscano, M.C.; Darchuk de Durant, G.E. 1988. Inventario de insectos forestales en plantaciones de *Pinus* y *Eucalyptus* en Santiago del Estero. In: Proceedings of the “6to Congreso Forestal Argentino”, Santiago del Estero, Argentina: p. 714-718.

Solomon, J.D. 1995. Guide to insect borers in North American broadleaf trees and shrubs. Agric. Handb. AH–706. Washington, DC: U.S. Department of Agriculture, Forest Service. 735 p.

Reviewers’ comments—“P. 79, bottom of page: Applicable risk criteria, add ‘d’.” (Hanks)

“P. 80, paragraph 2: Applicable risk criteria, add ‘e’ to be consistent with #1.” (Hanks)

“P. 80, paragraph 3: Applicable risk criteria, add ‘g’ to be consistent with #1.” (Hanks)

“As these species generally infest the boles or branches of recently cut trees, at least one species is known not to infest logs, and the association of these borers with *Eucalyptus* is weak, the assignment of high risk for the pest with host at origin and entry potential elements seems unsupported by the assessment provided.” (Zadig)

“With respect to the list of Potential Insects Associated with the commodity of *Eucalyptus* cited for Argentina (Table 8), we have the following comments:

Callideriphus laetus, Eu[ry]merus eburoides,…, Steirastoma breve …,

From the bibliography consulted there are no references that mention these as being present in the country, not have these pests been detected in areas where eucalypts are grown in Argentina.” (Guille (translated from Spanish)

“*Retrachyderes thoracicus*

Borer of fruit trees. Observed in Argentina producing damage only in peach and fig trees.” (Guillen) (translated from Spanish)

“Perhaps you might comment that these roundheaded borers might be more restricted to the warmer parts of the U.S.?” (Seybold)

Response to comments—The applicable rating criteria relating to difficulty in detection, broad host range, and active host-finding capability were added to the appropriate elements.

While it is true that each of these wood borers is weakly associated with its *Eucalyptus* host, the cerambycid family is one of the two groups most well represented in port interceptions with solid wood products. The criteria that we use to evaluate the risk potential of organisms consistently led to ratings of high risk for these insects as a group, due to their strong association with freshly cut host material, capacity for survival in drying wood, polyphagous nature, etc. Our criteria for likelihood of introduction are such that cerambycids, when considered as a group, fit all of the criteria, and most individuals within the group fit enough of the criteria to be rated as high for each of the four establishment elements.

The reference that lists the cerambycids mentioned above as being associated with eucalypts in Argentina is Duffy (1960). A second reference, DiIorio (1994) lists *Eurymerus eburoides* on *Eucalytpus saligna* in Argentina and was added to the literature citations as the draft assessment was revised. Duffy (1960) also lists *R. thoracicus* (then called *Trachyderes thoracicus*) as being associated with *Eucalyptus* in Argentina.

A sentence was added to the Colonization Potential section to indicate that the borers would probably be more likely to colonize the warmer parts of the United States, consistent with their native habitats in South America.

Eucalyptus Longhorned Borer

Assessor—Andris Eglitis

Scientific names of pest—*Phoracantha semipunctata* (Fabricius) (Coleoptera: Cerambycidae)

Scientific names of hosts—Chile: Various species of *Eucalyptus* including *E. globulus, E. camaldulensis, E. gomphocephala, E. viminalis, E. resinifera, E. oleosa*
Argentina: *E. grandis, E. saligna, E. camaldulensis, E. globulus, E. viminalis*
Uruguay: *E. grandis, E. globulus*
Brazil: *E. viminalis*
United States: *E. globulus, E. viminalis, E. diversicolor, E. grandis, E. nitens, E. saligna*

Distribution—In Brazil, the eucalyptus longhorned borer occurs in the states of Rio Grande do Sul and São Paulo. In Chile, the insect is distributed from Region III (Copiapó) in the north to Region IX (Temuco) in the south.

Summary of natural history and basic biology of the pest—The eucalyptus longhorned borer is typically associated with trees under moisture stress. As such, the greatest damage occurs in semiarid regions. Trees in other areas are also affected during drought periods. These wood borers infest recently dead trees, freshly cut logs (Scriven and others 1986), and are also able to kill weakened trees. Early signs of infestation include branch dieback and flagging or sprouting from inactive buds along the bole (Solomon 1995). Heavily infested trees may die suddenly with leaves discoloring and remaining on the tree for a month (Solomon 1995). When healthy trees are infested, they may produce a dark brown exudate (kino) that stains the bark.

Wood from infested trees loses some of its mechanical properties and is not suitable for certain uses such as mining timbers and flooring (Servicio Agricola y Ganadero 1998).

Not all species of *Eucalyptus* have the same level of susceptibility to *P. semipunctata*. In California, the most susceptible species are *E. diversicolor, E. globulus, E. grandis, E. nitens, E. saligna,* and *E. viminalis* while *E. camaldulensis, E. citriodora, E. cladocalyx, E. robusta, E. sideroxylon*, and *E. trabutii* appear to be more resistant (Hanks and others 1995). Nonetheless, most species can be infested if they are exposed to severe moisture stress or are growing in poor soils. In Chile, *E. globulus* is among the more susceptible species and *E. camaldulensis* is considered susceptible as well (Artigas 1994).

Species grown in Chile that can tolerate dry conditions and hence are considered more resistant include *E. astringens, E. brockwayi, E. campaspe, E. flocktoniae, E. lesouefii,* and *E. stoatei*. In Chile, there is a strong relationship between the regional moisture regime and significance of *Phoracantha*; mortality from the eucalyptus borer is far more important in the drier northern regions than in the south where there are virtually no dry months. Similarly, entomologists from Argentina, Brazil, and Uruguay report that *P. semipunctata* is opportunistic in their countries as well, colonizing recently dead or moribund trees.

The life cycle of *P. semipunctata* is variable, ranging from one year in most countries of South America to two to three overlapping generations per year in southern California. Adults can be found during a long portion of the year (August to May in Chile; February to November in California). These beetles are nocturnal, hiding under loose bark during the daytime and feeding on the flowers of eucalypts at night. Individual females may live for 40 days in the summer and up to 180 days in the winter (Solomon 1995) and are capable of laying up to 300 eggs. The eggs are laid beneath the bark in small groups of 3 to 30 and hatch within 10 to 14 days. The newly hatched larvae penetrate the bark and move into the phloem where they feed until maturity. The larval galleries in the cambium are gradually widened to three times the head width of the larva and may be a meter or more in length (Solomon 1995). Extensive larval feeding eventually girdles the tree (Pérez 1998). Larval development requires about 70 days in fresh host material and extends to about 180 days in dry logs (Solomon 1995). When mature, the larvae burrow 6 to 10 cm into the wood and construct pupation chambers. The pupal stage lasts about 3 weeks.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (RC) (Applicable rating criteria, from Chap. 1: a, c, d, e, f, g, h)

   Although widespread, *P. semipunctata* does not occur with high frequency throughout much of its range. Chileans report low incidence of the wood borer within some of the moister regions and a low percentage of trees affected even in some of the semiarid regions. Forest insect specialists in Argentina and Uruguay have said that *P. semipunctata* infested trees are readily identified and separated out from uninfested ones. In Argentina, the primary species of *Eucalyptus* (*E. grandis*) is routinely debarked before the trees are harvested. Since the larvae spend most of their time feeding in the phloem and only enter the wood when they are mature, debarking reduces the likelihood of association of *P. semipunctata* with the host. (However, late-instar larvae and pupae could still be associated with the host in the wood).

   In spite of these considerations, we must give weight to the fact that this insect has been successfully transported throughout the world and consider this as compelling evidence of its introduction potential into new environments.

2. Entry potential: *High* (VC) (Applicable rating criteria, from Chap. 1: a, b, c, d)

   The insect has been introduced into many countries in both hemispheres, indicating that it can survive in its host even as this material is drying out. Native to Australia, the insect has become established throughout the world [New Zealand (1870); South Africa (1906); Argentina (1917); Israel (1945); Egypt (1950); Brazil (1952); Turkey (1959); Tunisia (1962); Peru (1967); Chile (1970); Italy (1971); Algeria (1976); Portugal (1980); United States (1984)]. It has also been detected in Angola, Bolivia, Cyprus, Spain, Morocco, Mozambique, Lesotho, Uruguay, Zambia (Barria 1994), Ethiopia, Mauritius, and Zimbabwe.

3. Colonization potential: *High* (VC) (Applicable rating criteria, from Chap. 1: a, b, c, e, f)

   The eucalyptus longhorned borer has a fairly broad range of host species and has shown its adaptability by becoming established in many countries around the world.

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

   Once established in its new environment, *P. semipuctata* has spread very rapidly. In particular, this spread potential has been demonstrated in Chile and the United States. In Chile, the first damaged trees were found in 1973 in the northern city of San Felipe, and a survey conducted 8 years later found that the insect was present throughout the country's *Eucalyptus* plantations (Pérez 1998). In California, the insect spread within 5 years from the southern portion of the state into the San Francisco Bay area.

B. Consequences of introduction

5. Economic damage potential: *High* (VC) (Applicable rating criteria: a, b, c, d, f)

   Considerable effort has been expended in California in studying and combating the eucalyptus longhorned borer. Many of the hosts grow in areas where moisture availability is a problem in the summer, and drought effects will increase the susceptibility of these trees. Damage to trees has been severe, especially in urban areas.

6. Environmental damage potential: *High* (VC) (Applicable rating criteria, from Chap. 1: d, e)

   Eucalypts have become valuable for more reasons than just their economical value. They have become accepted as a part of the landscape, and their loss is not acceptable. Although most chemical controls are impractical, some homeowners and other caretakers of the eucalypt resource apply these measures against *P. semipunctata* (for example, fumigation of firewood) and may produce undesirable environmental effects in the process.

7. Social and Political Considerations: *High* (VC) (Applicable rating criteria, from Chap. 1: a, d)

   The U.S. public is very concerned about the apparently increasing rate at which exotic organisms are becoming established in the nation's forests. The introduction of *P. semipunctata* into new areas cultivated with eucalypts would be viewed as very undesirable by many people.

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

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Reviewers' comments—"The wood borers *Phoracantha semipunctata* and *P. recurva* limit their attacks to species of *Eucalyptus* under moisture stress and are already established in California where much of the *Eucalyptus* is found. The threat of these insects to forests or urban landscape outside California would be less than for other insect pests that have a much wider host range that cover multiple genera (e.g. scolytid bark and ambrosia beetles, carpenter worm, etc.). Thus, from a national perspective, I would rank the colonization potential, consequences of pest establishment and environmental change potential as moderate, rather than high, for these potential pests." (Billings)

"Common name is 'Eucalyptus longhorn<u>ed</u> borer;' correct throughout." (Hanks)

"P. 83, paragraph 2: 'The newly hatched larvae feed initially in the bark. . .'; only penetrate the bark to reach the cambium where they restrict their feeding." (Hanks)

"Pest with host at origin potential, Applicable risk criteria, add 'h'." (Hanks)

"Entry potential, Applicable risk criteria, add 'd'." (Hanks)

"Colonization potential, Applicable risk criteria, add 'e'." (Hanks)

"Spread potential, Applicable risk criteria, add 'a' and 'd'." (Hanks)

"The two species of the genus *Phoracantha* present in Chile are also present and established in the United States; as such, it is believed that the probability of dissemination of both pests, starting from the populations already established in said country [U.S.], should be greater than the eventual introduction through infested wood coming from South America. It is important to point out that Chile has been exporting logs of *Eucalyptus* for many years with no reports of *Phoracantha* in commercial loads arriving in the country of destination." (Peña Royo) (translated from Spanish)

"If neither species of *Phoracantha* is being subjected to official control in the United States, as established by the International Plant Protection Convention (IPPC), then they do not qualify as quarantine pests and as such it would not be appropriate to establish mitigation measures of phytosanitary risk against them, for wood coming from South America." (Peña Royo) (translated from Spanish)

"It is appropriate to point out as well that in the specific case of Chile, during next February there will be an introduction one of the principal natural enemies of *Phoracantha* spp., known as *Avetianella longoi*, with the expectation that the populations of *Phoracantha* will be reduced significantly." (Peña Royo) (translated from Spanish)

Response to comments—The editorial comments and additions of rating criteria proposed by Dr. Hanks were incorporated into the assessment.

Even though *P. semipunctata* may have less dramatic consequences than some other organisms associated with *Eucalyptus*, we believe the longhorned borer merits a rating of high based on the damage it has caused and on the amount of resources that have been dedicated to its control and management. Although the insect is widely distributed in California and occurs throughout the distribution of *Eucalyptus* in that state, it is not as strongly associated with other *Eucalyptus* plantings established in Arizona and Florida. As such, *P. semipunctata*, although widely distributed, is not established throughout the range of its potential hosts.

At this time, APHIS is in the process of reviewing the control programs of individual states to eventually sanction those programs as "official control" as defined by the IPPC. Once this is done, *P. semipunctata* and *P. recurva* will be considered under official control in the state of California.

Yellow Phoracantha Borer

Assessor—Andris Eglitis

Scientific names of pests—*Phoracantha recurva* (Newman) (Coleoptera: Cerambycidae)

Scientific names of hosts—*Eucalyptus globulus, E. grandis, Eucalyptus* spp., *Angophora, Syncarpia, Cupressus lindleyi* Klotsch

Distribution—Native to Australia; recently introduced into Chile in 1997 (Santiago) and the United States in 1995 (California). The distribution within Chile is still limited to Metropolitan Park in the capital city of Santiago because of an aggressive eradication program that began almost immediately after the insect was detected. In California, the borer now occurs in Riverside, San Bernardino, Orange, San Diego, and Los Angeles Counties.

Summary of natural history and basic biology of the pest—As with *P. semipunctata*, the yellow phoracantha borer is typically associated with trees under moisture stress. In California where the two borers occur together, it has been observed that both species infest large branches and boles of their host trees (Tim Paine, University of California-Riverside, CA, 2000, personal communication).

The life cycle of *P. recurva*, as reported from South Africa, involves two partially overlapping generations. Adult beetles are present in spring (September to November) and late summer and autumn (February to April). The eggs require 2 weeks to develop. Larvae feed for 2 to 6 months and represent the most common stage found during the winter. The pupal stage lasts for 10 days prior to the emergence of the new adults.

In California, *P. recurva* is supplanting *P. semipunctata* in areas where the two species occur together (Tim Paine, University of California-Riverside, CA, 1998, personal communication). The primary reason for the competitive advantage of *P. recurva* is the fact that it emerges earlier in the spring and is prepared to colonize available host material before *P. semipunctata* has taken flight. In California, *P. recurva* is proving to be more difficult to manage than *P. semipunctata*. *Phoracantha recurva* does not appear to require diapause and thus is active whenever temperatures are suitable. As such, the tree management guidelines recommended to minimize the effects of *P. semipunctata* (timing of pruning, etc.) are not as effective for *P. recurva* (Tim Paine, University of California-Riverside, CA, 1999, personal communication). An additional problem is that the egg parasitoid *Avetianella longoi*, introduced for biological control, is less effective against *P. recurva* than *P. semipunctata* for eggs more than 12 h old (Tim Paine, University of California-Riverside, CA, 1999, personal communication).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Low* (RC) (Applicable rating criteria, from Chap. 1: d, e, f)

   Although three of the rating criteria apply, this element is still rated low due to the extremely limited distribution of *P. recurva* in Chile (Servicio Agricola y Ganadero 1998). The yellow phoracantha borer does not occur in the production forests of *Eucalyptus*. As such, *P. recurva* would have a lower likelihood of being associated with export logs than *P. semipunctata*. However, if the eradication efforts in Chile are not successful and if *P. recurva* becomes established outside the Santiago metropolitan area, the risk it poses would increase significantly.

2. Entry potential: *High* (VC) (Applicable rating criteria, from Chap. 1: b, c)

   The yellow phoracantha borer has recently been introduced into several countries in both the northern and southern hemispheres, indicating that it can survive in its host even as this material is drying out.

3. Colonization potential: *High* (VC) (Applicable rating criteria, from Chap. 1: a, b, c, d, e, f)

   The yellow phoracantha borer may not have as broad a host range as *P. semipunctata* but nonetheless has shown its adaptability by becoming established in several countries around the world. In South Africa, the phoracantha borer has been recorded in noneucalypt hosts including gum myrtle (*Angophora* sp.), turpentine tree (*Syncarpia* sp.), and *Cupressus lindleyi*. In the southern counties of California, the yellow phoracantha borer has been found in the same eucalypt hosts as those infested by *P. semipunctata* (Tim Paine, University of California-Riverside, CA, 1999, personal communication).

4. Spread potential: *High* (VC) (Applicable rating criteria, from Chap. 1: a, b, c, d, e, f)

   Once established in its new environment, *P. recurva* has spread very rapidly. In particular, this spread potential has been demonstrated in South Africa and in the United States. The borer now occurs in five counties in southern California after initially being detected in the mid-1990s.

B. Consequences of introduction

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

Considerable effort has been expended in California in studying and combating both *P. semipunctata* and *P. recurva*. Many of the hosts grow in areas where moisture availability is a problem in the summer and drought effects will increase the susceptibility of these trees. Damage to trees has been severe, especially in urban areas. *Phoracantha recurva* may be even more difficult to control than *P. semipunctata* due to its ability to take advantage of warm temperatures and become active earlier and later in the year than the eucalyptus borer.

6. Environmental damage potential: *High* (VC) (Applicable rating criteria, from Chap. 1: d, e)

   Eucalypts have become valuable for more reasons than just their economical value. Eucalypts have become accepted as a part of the landscape, and their loss is not acceptable. Although most chemical controls are impractical, some homeowners and other caretakers of the eucalypt resource apply these measures against the wood borer (for example, fumigation of firewood) and may produce undesirable environmental effects in the process.

7. Social and Political Considerations: *High* (VC) (Applicable rating criteria, from Chap. 1: a, c, d)

   The U.S. public is very concerned about the apparently increasing rate at which exotic organisms are becoming established in the nation's forests. The introduction of these borers into new areas cultivated with eucalypts would be viewed as very undesirable by many people.

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

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Reviewers' comments—"The wood borers *Phoracantha semipunctata* and *P. recurva* limit their attacks to species of *Eucalyptus* under moisture stress and are already established in California where much of the *Eucalyptus* is found. The threat of these insects to forests or urban landscape outside California would be less than for other insect pests that have a much wider host range that cover multiple genera (e.g. scolytid bark and ambrosia beetles, carpenter worm, etc.). Thus, from a national perspective, I would rank the colonization potential, consequences of pest establishment and environmental change potential as moderate, rather than high, for these potential pests." (Billings)

"P. 87, top: host ranges includes several other *Eucalyptus* species besides two listed." (Hanks)

"P. 87, natural history section: Both *P. semipunctata* and *P. recurva* attack branches and the bole where they co-occur in California." (Hanks)

"P. 88, paragraph 1: Pest with host at origin potential, change rating to 'Moderate' and add 'f' to Applicable risk criteria." (Hanks)

"P. 88, paragraph 2: Colonization potential, Applicable risk criteria, add 'e'." (Hanks)

"P. 88, paragraph 3: Spread potential rating should be 'High' and add 'a' and 'd' to Applicable risk criteria." (Hanks)

"P. 89, paragraph 4: Pest risk potential, change rating to 'Moderate'." (Hanks)

"p. 90: *P. recurva* has proven to be a very significant problem in California because it emerges earlier and flies longer than *P. semipunctata*. Consequently, the timing period for pruning activities when beetles are most active is much narrower than for *P. semipunctata*. Our experience [in California] also suggests that the host range for the two beetles is not different, particularly because they both concentrate on stressed trees. It is probably not appropriate to suggest that *P. recurva* has a narrower host range. We also have not observed the anecdotal distinction in what parts of the tree are colonized in a new environment. Consequently, I think *P. recurva* represents at least as significant a threat as *P. semipunctata*." (Paine)

"As indicated in the report of the specialists that visited Chile, *Phoracantha recurva* has a very restricted distribution and is the subject of an intensive campaign of control, [reasons] for which we believe the Risk Potential is low for chips and wood of *Eucalyptus* coming from Chile." (Peña Royo) (translated from Spanish)

Response to comments—The additions of applicable rating criteria (suggested by Dr. Hanks) were made to the appropriate elements in the assessment. However, the Pest with Host at Origin element was still judged to be low due to the extremely limited distribution of *P. recurva* in Chile and its absence from production areas of *Eucalyptus* in that country. The combination of a low rating for Likelihood of Introduction and a high rating for Consequences of Introduction result in a Pest Risk Potential of moderate for *P. recurva*.

Other changes were made in the text regarding the host range and biology of *P. recurva* as suggested by Paine and Hanks.

At this time, APHIS is in the process of reviewing the control programs of individual states to eventually sanction those programs as "official control" as defined by the IPPC. Once this is done, *P. semipunctata* and *P. recurva* will be considered under official control in the state of California.

Phoracantha recurva is not currently distributed throughout the range of its potential hosts.

Subterranean Termites

Assessor—Dennis Haugen

Scientific name of pest—Subterranean termites (Isoptera: Rhinotermitidae) in the genera *Coptotermes* [including *C. havilandi* Holmgren and *C. testaceus* L.] and *Heterotermes* [including *H. tenuis* (Hagen) and *H. longiceps* (Snyder)]. These genera have species that can be found in the boles of trees, while other subterranean termites (Isoptera: Termitidae) are found below ground level (Berti Filho 1993).

Scientific names of hosts—Most hardwoods and softwoods can be infested. All species of *Eucalyptus* are probably susceptible.

Distribution—*Coptotermes* and *Heterotermes* are pantropical genera. *Coptotermes havilandi* is native to Southeast Asia. It is well established in Brazil and very recently established in Florida (Su and others 1997). *Coptotermes testaceus* occurs in northern South America, including the Brazilian states of Amazonas and Pará. *Heterotermes tenuis* is endemic to South America, and it is found in the Brazilian states from Rio de Janeiro to Pará (Berti Filho 1993). Also, subterranean termites have been documented on *eucalyptus* in Colombia (Madrigal 1989a).

Summary of natural history and biology of the pest— Subterranean termites are the most destructive and economically important insect pests of wood products. The costs of control have been estimated from US$2 billion to US$3.5 billion per year in the United States (billion = $\times 10^9$) (Beal and others 1989, Potter 1997). They are found throughout the tropical and temperate regions of the world, but they are more prevalent in tropical and subtropical areas. In the United States, the highest hazard areas are in the southeastern states and California.

All species of *Coptotermes* and *Heterotermes* are subterranean termites, which means that they must have access to moisture. The moisture source is usually maintained by a connection with the soil. However, these termites can survive long-distance transportation in moist wood. *Coptotermes* species generally occur in tropical or subtropical areas. *Coptotermes havilandi* has been introduced into new localities and has caused extensive damage to buildings. This species can feed on live trees, causing damage to the root system. *Heterotermes* species feed on wood in contact with the soil but they can bridge gaps with foraging tubes to reach wood above ground level. In Brazilian eucalypt plantations, termite nests are found in the heartwood within the first meter of the tree bole (Jose C. Zanuncio, Federal University of Viçosa, Brazil, 1998, personal communication).

Termites are social insects and live in colonies. Each colony has a highly organized caste system, which includes workers, soldiers, and reproductives. New colonies are initiated by alate reproductives from parent colonies at a particular time of the year. This flight period may be as brief as a few days to a few weeks. In general, the reproductives are weak fliers, and the flight is short in distance and duration. After alighting, the wings are shed, and a suitable site is sought for colony initiation. The founding reproductives (king and queen) may live for many years. It takes several years for the colony to mature and produce alate reproductives (Watson and Gay 1991).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: c, e, g, h)

   These species of subterranean termites can be found in eucalypt plantations in tropical and subtropical areas of South America. However, the infestation rate is very low in vigorously growing plantations. Attacks are usually confined to dead and dying trees (Genesio Ribeiro, Federal University of Viçosa, Brazil, 1998, personal communication). When trees are harvested, inspection should reveal any evidence of a termite colony in the butt ends of the logs.

2. Entry potential: *High* (MC) (Applicable rating criteria, from Chap. 1: b, c)

   Subterranean termites could survive the transit from South America to the United States, especially with rapid transit after harvesting. However, eucalypt logs dry out while on log decks, which would lower the survivability of a colony. Also, a colony would be very evident during inspection of the cut surface of a butt log. *Coptotermes formosanus* Shiraki has been introduced into the United States from Asia, and was found established in the southeastern states during the 1960s and later in southern California (Potter 1997).

3. Colonization potential: *High* (MC) (Applicable rating criteria, from Chap. 1: a, b, c, d)

   Colonization in the United States would depend greatly upon climate and food resources at the destinations of the imported logs. The highest risk would be in the southeastern states, due to the warm moist climate in that area. Suitable moist wood for colony establishment would probably be abundant at most destinations. The critical condition for colonization is the maturity of the colony. So, not only must the colony survive transit, but it must have matured to a stage when reproductives are being produced. Next, favorable conditions must occur to trigger and synchronize the flight period among the colonies. *Coptotermes havilandi*, an exotic in South America and Florida, has demonstrated the ability to establish and adapt to new environments.

4. Spread potential: *High* (VC) (Applicable rating criteria, from Chap. 1: b, c, d, e, f, g)

   Alate reproductives are generally weak fliers, so new colonies are likely to be within a few hundred meters of the founding colonies. A new colony takes years to grow and mature before it can produce its own reproductives. Thus, natural spread of an established termite population would be very slow. However, once established in other commodities, the colonies would be less obvious and could be further distributed by human transportation.

B. Consequences of introduction

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

   Subterranean termites are serious pests of untreated wood in use. The greatest economic impact is to wooden houses and other structures. Considerable damage may occur to wooden poles and posts. However, the addition of another species of subterranean termite to the fauna of the United States may or may not increase the economic impact. Damage would depend on the aggressiveness of the new species and how well it can adapt to a new niche. The Formosan subterranean termite, *C. formosanus*, is a very aggressive termite that has become established in the United States. It is the major termite pest where it has become established, often displacing the native species of subterranean termites (Potter 1997). Control methods for infestations of subterranean termites can be expensive, so any expansion of a niche would have a significant economic impact. Preventative measures (for example, insecticidical barriers) currently used for subterranean termites also would be effective for any of these potential new species.

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

   Though these termites infest eucalypt trees, they usually only attack dead and dying trees. They are unlikely to cause significant mortality to tree species in the United States. Potentially, these termites could infest urban trees in poor vigor, causing a more rapid decline and greater risk of tree failure. Competition and displacement of native termite species is also a possibility. Introduction of a new termite species may increase the use of insecticides for termite control and potentially have some environmental impacts.

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

   Introduction and establishment of an exotic species of termite could cause concerns among homeowners. Use of insecticides for termite control would probably increase. Also potential regulatory actions could disrupt movement and increase the cost of commercial wood products, if quarantines were implemented.

C. Pest risk potential: *Moderate* (Likelihood of introduction = *Moderate*, Consequences of introduction = *Moderate*)

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Reviewers' comments—"It is interesting to note that in this individual pest risk assessment the consequences of establishment is considered moderate, whereas in the draft risk assessment for solid wood packing materials the consequences of establishment is rated high. The species under consideration are largely the same; the difference appears to be in the estimation of the economic damage potential." (Zadig)

Response to comments—The economic damage potential for this assessment was rated moderate, while the economic damage potential for the draft risk assessment for solid wood packing material was rated high. The assessment for solid wood packing material was based on more genera and species of subterranean termites than this assessment. The potential economic damage would vary depending upon which species actually became established and its adaptability to a new environment.

Pathogens

Foliar Diseases

Assessor—John Kliejunas

Numerous fungi have been described on foliage of *Eucalyptus* spp. in South America and throughout the world. In this section, the name of the fungus and its hosts, the distribution, and a summary of natural history and basic biology for five foliar diseases are described. *Aulographina*, *Cryptosporiopsis*, *Cylindrocladium*, *Phaeophleospora* (*Kirramyces*), and *Mycosphaerella* are used as examples. Foliar diseases of *Eucalyptus* spp. are then discussed as a group for specific information relating to risk elements.

Aulographina leaf spot

Scientific name of pest—*Aulographina eucalypti* (Cooke & Massee) v.Arx & Muller (Dothideales, Dothideaceae)

Scientific names of host—many *Eucalyptus* spp.

Distribution—Australia, Brazil, Chile, Great Britain, Madagascar, New Zealand, South Africa, 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. Rain and low temperatures (15°C to 20°C) predispose trees to infection. Splashing rain and blowing wind are the major routes for fungal spore dispersal. Infection occurs primarily in the lower crown.

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-anglicae*, *E. robusta*, *E. tereticornis*, and *E. viminalis*

Distribution—On *Eucalyptus* spp. in Australia, Brazil, India, Japan, Thailand, Vietnam, and Hawaii.

Summary of natural history and basic biology of the pest—The pathogen infects leaves and occasionally small twigs. 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 name of pest, hosts, and distribution— *Cylindrocladium clavatum* Hodges & May [teleomorph *Calonectria clavata* El-Gholl, Alfieri & Barnard]; *E. grandis* (leaf spot, blight; seedling blight, damping off), *E. saligna* (root rot), *E. tereticornis* (leaf spot, blight; seedling blight), *Eucalyptus* sp. (seedling decay); Brazil, India, South Africa; numerous additional hosts in the genera *Araucaria*, *Callistemon*, and *Rhododendron* in Florida and Hawaii (Moniliales, Moniliaceae).

Cylindrocladium ilicicola (Hawley) Boedijn & Reitsma [teleomorph *Calonectria pyrochroa* (Desm.) Sacc.]. Worldwide in tropical regions; on *E. alba*, *E. globulus*, *E. grandis*, *E. robusta*, *E. saligna*, *E. tereticornis*, and *E. viminalis* in Brazil; worldwide on species of *Araucaria*, *Cissus*, and *Vaccinium* in tropical regions (Moniliales, Moniliaceae).

Cylindrocladium ovatum El-Gholl, Alfenas, Crous & T.S. Schub. [teleomorph *Calonectria ovata* El-Gholl, Alfenas, Crous & T.S. Schub.]; Brazil, Florida; *E. grandis* (leaf, stem), *E. tereticornis* (leaf, stem), *E. torelliana* (stem), *E. urophylla* (leaf spot) (Moniliales, Moniliaceae).

Cylindrocladium quinqueseptatum Boedijn & Reitsma (teleomorph *Calonectria quinqueseptatum* Figueiredo & Namekata); on *Eucalyptus* spp. in Brazil (Moniliales, Moniliaceae).

Cylindrocladium scoparium Morgan [syn. *Cylindrocladium scoparium* var. *brasiliense* Bat. & Cif.] (teleomorph *Calonectria morganii* Crous, Alfenas & M.J. Wingfield); on *Eucalyptus* spp. in Argentina, Brazil, and Florida; cosmopolitan on *Abies*, *Pinus*, and numerous genera of hardwoods (Moniliales, Moniliaceae).

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. throughout the world. 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.

Phaeophleospora leaf spot

Scientific name of pest—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 destructans (M.J. Wingf. & Crous) Crous, F.A. Ferreira & B. Sutton (syn. *Kirramyces destructans* Wingfield and Crous);

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—*E. bicostata*, *E. camaldulensis*, *E. globulus*, *E. grandis*, *E. tereticornis*, *Eucalyptus* spp.

Distribution—*Phaeophleospora epicoccoides* (syn. *Kirramyces epicoccoides*) is found in Argentina, Australia, 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. *Phaeophleospora eucalypti* (syn. *K. eucalypti)* is found in Argentina, Australia, Brazil, India, Italy, New Zealand, Paraguay, Peru, Taiwan, and Zaire. *Phaeophleospora destructans* (syn. *K. destructans*) is found in Indonesia.

Summary of natural history and basic biology of the pests—These pathogens are capable of causing severe premature defoliation, which affects growth and vigor of seedlings. Infection results in characteristic purple to brownish-purple amphigenous spots that are angular and marked by veins. Infection gradually progresses upward in the crown. Late in the season, spots occur on younger leaves and all mature leaves drop. Dispersal is by airborne conidia. Warm weather and heavy dew favor infection.

Mycosphaerella leaf spot

Scientific name of pest—Numerous species of *Mycosphaerella* have been described on *Eucalyptus* foliage; Crous (1998) covers 57 species in a recent monograph. *Mycosphaerella molleriana* (Thum.) Lindau. and *M. cryptica* (Cooke) Hansf. are the most common and damaging. *Mycosphaerella cryptica* (Cooke) Hansf. occurs in Chile. *Mycosphaerella africana* Crous & M.J. Wingf., *M. colombiensis* Crous & M.J. Wingf., *M. flexuosa* Crous & M.J. Wingf., and *M. longibasalis* Crous & M.J. Wingf. have been reported in Colombia; *Mycosphaerella parkii* Crous, M.J. Wingf., F.A. Ferreira & A. Alfenas and *M. suberosa* Crous, F.A. Ferreira, A. Alfenas, & M.J.Wingf. have been reported in Brazil and Colombia; and *M. walkeri* R.F. Park & Keane has been described in Chile, Colombia, Ecuador, and Peru. (Dothidiales, Dothidiaceae)

Scientific names of hosts—*Eucalyptus* spp.

Distribution—The fungal genus is worldwide wherever *Eucalyptus* is grown, common in native eucalypt forests as well as in *Eucalyptus* 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 between fungal species and host. Infection of leaves results in necrotic spots or patches and presence of crinkled and distorted foliage. Occurrence is most severe in summer rainfall areas.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: d, e, g)

   Although most of these fungi are restricted to leaf tissue, some do occur in young shoots and twigs. These leaf fungi are rarely damaging in mature plantations (A.C. Alfenas, Federal University of Viçosa, Brazil, 1998, personal communication; C.G. Auer, EMBRAPA, Curitiba, Brazil, 1998, personal communication; F.A. Ferreira, Federal University of Viçosa, Brazil, 1998, personal communication). However, if present, they may survive for extended time periods.

2. Entry potential: *High* (VC) (Applicable rating criteria, from Chap. 1: b, 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. Because some of these fungi survive in soil, propagules may also be transported in any soil adhering to the logs. The spores of these leaf pathogens are microscopic and would be undetectable.

3. Colonization potential: *High* (RC) (Applicable rating criteria, from Chap. 1: a, b, c, f)

   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 Chap. 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 rating criteria, from Chap. 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 *Eucalyptus* spp. 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 rating criteria, from Chap. 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 rating criteria, from Chap. 1: none)

   If *Eucalyptus* leaf diseases were to successfully establish in new locations as a result of log importation, perceived damage potential would be low. Because numerous leaf fungi are already present on *Eucalyptus* spp. in the United States, social and political impact would be minimal.

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

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Reviewers' comments—"Probability of pest establishment: I have trouble lumping all these groups of pathogens together since they vary so much in part of the hosts affected, and in factors influencing their spread and modes of infection." (Hodges)

"I would agree with most of this assessment but I am worried that these pathogens may move to other hardwood species in NA. This was not addressed as I can see."(Jacobi)

"Foliar Diseases and Eucalyptus rust. The pest with host at origin and entry potential elements do not seem to warrant a moderate and high rating respectively in these two situations. Here it would again be helpful to know the standard harvesting practices to get an idea of the likelihood that leaf and twig material accompanying log shipments as contaminants. For eucalyptus rust, it is worth noting that the assessor noted that the rating criteria did not include the environmental requirements for infection and colonization." (Zadig)

Response to comments—Although this risk assessment discusses 14 species of leaf-infecting fungi as a group, there is little variation in part of the host affected or in factors influencing their spread and mode of infection. *Cylindrocladium* spp. differ in causing shoot blight of young stems, but they were included here because most species also infect leaves. All leaf pathogens evaluated for risk here have similar modes of spread (rain-splashed and wind-blown spores) and have similar requirements for infection (relatively warm, moist microenvironment).

Species of *Cylindrocladium* have a wide host range while other leaf pathogens included here are generally restricted to *Eucalyptus* spp. Additional hosts for species of *Cylindrocladium* were added to the text.

The moderate rating for pest with host–commodity at origin potential is based on the association of the pest with the host. Risk is assigned without regard to available mitigation measures or harvesting practice; thus, the presence of bark, which could harbor leaf or twig material infested with these pathogens, is assumed. The high entry potential rating is based on the ability of these fungi to survive on the host during transit and the difficulty of detection. Rating criteria for entry potential do not consider the likelihood of association of the pest with the host.

Eucalyptus Rust

Assessor—John Kliejunas

Scientific name of pest—*Puccinia psidii* Winter (Uredinales, Pucciniaceae)

Scientific names of hosts—*Eucalyptus* spp.; other hosts, all in the Myrtaceae, include *Callistemon speciosus* (Sims) DC, *Eugenia brasilensis* Lam., *E. jambolana* Lam, *E. malaccensis* L. (ataheite apple), *E. uniflora* L. (Surinam cherry), *E. uvalha* Camb., *Marlierea edulis* Niedz., *Melaleuca leucodendron* (L.) L., *Myrcia jaboticaba* Berg, *Myrciaria* sp., *Pimenta acris* Kostel. (bay rum), *P. dioica* (L.) Merr. (allspice), *P. officialis* Lindl. (pimento), *Psidium araca* Raddi, *P. guajava* L. (guava), *P. pomiferum* L., and *Syzygium jambos* (L.) L. (rose apple).

Distribution—On *Eucalyptus* spp. in Argentina (A.C. Alfenas, Federal University of Viçosa, Brazil, 1998, personal communication) and Brazil (Ferreira 1989). Reports of the rust on *E. nitens* in South Africa (Knipscher and Crous 1990) and on *E. camaldulensis* in Taiwan (Wang 1992) have not been confirmed as *P. psidii*. *Puccinia psidii* has been reported on *Callistemon speciosus, Eugenia sp., Marlierea edulis*, *Melaleuca leucodendra*, *Myrciaria* sp., and *Myrciaria jaboticaba* in Brazil (Puttemans 1930, Thurston 1940); *Eugenia* spp. in Brazil, Colombia, Cuba, Jamaica, Puerto Rico (Spaulding 1961); *Pimenta dioica* and *P. racemosa* in Jamaica (MacLachlan 1936); *Syzygium jambos* in Columbia (Kern and Chardon 1927); and *Pimenta dioica* (Marlatt and Kimbrough 1979) and *Melaleuca quinquenervia* (Rayachhetry and Elliott 1997) in Florida. A complete host distribution with citations is given in Coutinho and others (1998).

Summary of natural history and basic biology of the pest—The autoecious, macrocyclic, rust, first described by Winter (1884) on *Psidium pomiferum* in Brazil can be severely limiting to the growth of highly susceptible species and provenances of *Eucalyptus* in Brazil. Eucalypts less than 2 years of age are most susceptible. Aeciospores are unknown in nature and have been produced only once in the laboratory. Eucalypts 4 years and older are rarely infected (T. Krügner, University of São Paulo, Piracicaba, Brazil, 1998, personal communication). Urediniospores penetrate susceptible tissues directly. Presence of free water for more than 3 h and temperatures of 18°C to 23°C are favorable for urediniospore germination. First symptoms appear 2 to 4 days after infection. Sporulation starts 2 to 5 days later, with a peak 10 days after infection. Three weeks later, dried pustules and necrosis are observed on the affected organs. Symptoms include golden yellow uredial pustules on branches and terminal shoots as well as on young sprouts or leaves. Severity of infection varies with susceptibility of the host and weather conditions. Most spread is by urediospores, and to a much lesser degree, by sporidia. Spores are spread by wind, insects, and splashed rain (Ferreira 1989). Because *P. psidii* is autoecious, no alternate host is involved in the disease cycle.

The rust rarely kills its host. Plants recover by producing new growth that may become infected under favorable environmental conditions. Stunting may result from continued infection.

Eucalyptus spp. vary in their susceptibility to *P. psidii* (Dianese and others 1984, 1986). From most to least susceptible are *E. cloeziana, E. phaeotricha, E. grandis, E. citriodora, E. camaldulensis, E. tereticornis, E. urophylla, E. maculata, E. paniculata, E. punctata, E. pyrocarpa, E. microcorys, E. pellita,* and *E. saligna*. The disease is controlled in Brazil by selecting and planting resistant clones of *Eucalyptus*.

Evidence of races of *P. psidii* exists. Cross inoculations among hosts indicate considerable physiological variability within the species (Ferreira 1989).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Moderate* (VC) (Applicable rating criteria, from Chap. 1: d, e)

   The rust pathogen is rarely seen and is not damaging in *Eucalyptus* plantations older than 4 years (T. Krügner, University of São Paulo, Piracicaba, Brazil, 1998, personal communication). That, along with the fact that *P. psidii* infects only leaves and occasionally petioles (J.C. Dianese, Federal University of Brasilia, Brazil, 1998, personal communication) makes it unlikely that inoculum of the pathogen would be present on harvested logs.

2. Entry potential: *High* (VC) (Applicable rating criteria, from Chap. 1: b, d)

   Spores of *P. psidii* could survive in transit, in bark crevices, or on attached leaf tissues. The microscopic spores would be undetectable.

3. Colonization potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: a, d)

   Even though *P. psidii* has successfully established in locations outside its native distribution, the environmental requirements needed by the pathogen for infection to occur would limit colonization potential. Inoculum would have to reach susceptible species of Myrtaceae, and favorable environmental conditions (free water; temperatures between 18°C and 23°C) would have to occur for infection and colonization to take place. Therefore, the colonization potential is rated as moderate. The rust has demonstrated ability to utilize new hosts within the Myrtaceae.

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

   If infection did occur, the limited distribution of Myrtaceae hosts in the continental United States would limit spread of the disease. However, the occurrence of numerous Myrtaceae in Hawaii, the rust's known ability for natural spread, and its high reproductive potential increases spread potential to moderate.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (VC) (Applicable rating criteria, from Chap. 1: c, e)

   The current distribution of the disease in the United States is limited to southern Florida on two species of *Pimenta* (species of allspice grown as ornamentals). The rust fungus has demonstrated the ability to develop races or strains. The pathogen has been damaging on non-*Eucalyptus* hosts, for example, on *Pimenta dioica* in Jamacia and *Melaleuca quinquenervia* in Florida. Costs may be incurred to control the disease if it became established on an economically significant host or on *Eucalyptus* species used in the foliar industry.

6. Environmental damage potential: *High* (RC) (Applicable rating criteria, from Chap. 1: e, d, f)

   Species of Myrtaceae have limited distribution in the continental United States but are common, both as endemic and as introduced species, in the state of Hawaii. Establishment of the rust could have an effect on the biodiversity of Hawaiian plants or on the ecosystem as a whole. The use of systemic, protectant fungicides to control the disease in the *Eucalyptus* foliar industry may occur and could result in increased risk of environmental damage. Races of the pathogen that differ in pathogenicity exist.

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

   Economic or environmental damage following successful establishment of the disease in new locations, or on new hosts, as a result of log importation would have a moderate social and political impact. Presence of the rust in the United States in areas other than its present distribution may affect export of the host(s) to countries where the rust is not yet present; Australia for example.

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

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Reviewers' comments—"Probably should be mentioned somewhere that aeciospores of the fungus have only been produced once in the laboratory and that they are unknown in nature. Most spread is by urediniospores, and to a much less degree, sporidia." (Hodges)

"I was not clear as to what parts of the tree this rust attacked. Maybe I missed it somewhere. I assume it was a leaf rust. Maybe you could state that up front somewhere."(Jacobi)

"Foliar Diseases and Eucalyptus rust. The pest with host at origin and entry potential elements do not seem to warrant a moderate and high rating respectively in these two situations. Here it would again be helpful to know the standard harvesting practices to get an idea of the likelihood that leaf and twig material accompanying log shipments as contaminants. For eucalyptus rust, it is worth noting that the assessor noted that the rating criteria did not include the environmental requirements for infection and colonization." (Zadig)

Response to comments—Reviewers' comments regarding the role of aeciospores in the life cycle and on the parts of the tree attacked were incorporated. As with foliar diseases, risk of pest with host–commodity at origin for this rust is assigned without regard to available mitigation measures or harvesting practices, and risk of entry potential is based on the ability of the pathogen to survive during transit and difficulty of detection.

Cryphonectria Canker

Assessor—John Kliejunas

Scientific name of pest—*Cryphonectria cubensis* (Bruner) Hodges (Diaporthales, Diaporthaceae) (= *Diaporthe cubensis* Bruner) [≡ *Endothia eugeniae* (Nutman & Roberts) Reid & Booth]

Scientific names of hosts—Table 10 lists *Eucalyptus* hosts by geographic location. In addition to *Eucalyptus*, *Cryphonectria cubensis* has been reported on *Psidium cattleianum* Sabine (Hodges 1988) and, as *Endothia eugeniae*, on clove [*Syzygium aromaticum* (L.) Merr. & Perry] (Hodges and others 1986). A nonMyrtaceous host, *Tibouchina granulosa* (in the family Melastomataceae) was found near Visçosa, Minas Gerais in 1974 (C.S. Hodges, North Carolina State University, 1999, personal communication). *Cryphonectria cubensis* has since been collected on the same host in Brazil (F.A. Ferreira, Federal University of Viçosa, Brazil, 1998, personal communication) and on a *Tibouchina* sp. in Venezuela (M.J. Wingfield, University of Pretoria, Republic of South Africa, 1999, personal communication).

Distribution—In South America, *C. cubensis* has been reported in Bolivia, Brazil, Colombia, Peru, and Venezuela. It occurs in all major *Eucalyptus* growing areas between 30° north and south of the equator. Table 10 shows distribution by geographic location. On clove, *C. cubensis* has been reported as a weak pathogen in most areas where clove is grown, including, among others, Africa, Brazil (states of Bahia and Espírito Santo), Indonesia, Malaysia, Sumatra, and Zanzibar (Hodges and others 1986).

Summary of natural history and basic biology of the pest—The fungus is taxonomically closely related to the chestnut blight fungus, *Cryphonectria parasitica* (Murrill) Barr. Infection is through wounds or natural openings in the bark and is favored by high rainfall and humidity distributed throughout the year as well as temperatures that average 23°C or higher (Hodges and others 1979). Natural growth cracks at the bases of young trees are an important infection court. The most common infection propagules appear to differ in different parts of the world, with both ascospores and conidia being common in South America but conidia predominant in South Africa. Perithecia have not been

Table 10—Geographical distribution and species names of major *Eucalyptus* hosts of *Cryphonectria cubensis*

Location	Host	Reference
Africa (Cameroon)	*E. urophylla*	Gibson 1981
Australia	*E. marginata*	Davidson and Coates 1991
Bolivia	*Eucalyptus* spp.	Condori 1980
Brazil	*E. angulosa, E. botryoides, E. camaldulensis, E. citriodora, E. grandis, E. longifolia, E. maculata, E. microcorys, E. paniculata, E. pilularis, E. propinqua, E. robusta, E. saligna, E. tereticornis, E. trabutii, E. urophylla*	Hodges and others 1973, 1976, Hodges 1980
China	*Eucalyptus* spp.	Hodges unpublished
Colombia	*Eucalyptus* spp.	Sankaran and others 1995a
Cuba	*Eucalyptus* spp.	Bruner 1916
Florida	*E. camaldulensis, E. grandis*	Hodges and others 1979, Hodges 1980
Hawaii	*E. deglupta, E. grandis, E. saligna*	Hodges 1980
Hong Kong	*Eucalyptus* spp.	Hodges and others 1986
India	*E. brassiana, E. camaldulensis, E. citriodora, E. cloeziana, E. deglupta, E. grandis, E. pellita, E. saligna, E. tereticornis, E. torelliana*	Florence and others 1986, Sharma and others 1985a, b
Mexico	*Eucalyptus* spp.	Hodges unpublished
Peru	*Eucalyptus* spp.	Sankaran and others 1995a
Puerto Rico	*E. deglupta*, *E. urophylla*	Hodges and others 1979
Surinam	*E. citriodora, E. grandis, E. maculata, E. saligna*	Boerboom and Maas 1970, Hodges 1980
Trinidad	*E. saligna*	Hodges 1980
Venezuela	*Eucalyptus* spp.	Condori 1980
Vietnam	*Eucalyptus* spp.	Hodges unpublished
Western Samoa	*E. saligna*	Hodges 1980

reported in South Africa. Conidia, formed in pycnidia produced on the dead bark, are dispersed by rain splash; and ascospores, formed in perithecia, are dispersed by wind (Ciesla and others 1996).

Infection results in elongated cankers, either at the base of trees or on the main trunk. In Brazil, the principal symptom is basal cankers (Hodges and others 1976). Basal cankers are almost always present, but cankers higher on the tree only occur in areas where the climate (humidity) is very favorable for infection. The cankers higher on the tree usually occur through infection of senescing branches. Infections are also occasionally observed at the site of branch stubs on the lower bole. The pathogen attacks the cambium and sapwood, causing a depression in the bark. As the infection spreads, the sapwood becomes stained brown and longitudinal cracks appear in the bark. Gummosis, due to injury of the cambium, is generally observed. Infection and resulting cankers can kill young trees during the first 2 years of growth or can result in extensive and long-lived cankers that extend from the base to breast height and higher on the bole. Multiple cankers are occasionally found on trunks. Girdled trees wilt and appear to die suddenly in summer during hot dry periods.

Variation in resistance to *C. cubensis* exists within and among *Eucalyptus* spp. (Alfenas and others 1983, Hodges and others 1979, Krügner 1983). Alfenas and others (1983) showed that the variation in resistance of *Eucalyptus* spp. is quantitatively isolate specific and the variation in virulence is quantitatively host specific. Isolates of *C. cubensis* with the same isoenzyme patterns showed a similar degree of virulence to *Eucalyptus* spp. (Alfenas and others 1984). In Brazil, stable resistance to *C. cubensis* has been obtained by intensive field selection of *E. grandis* that displayed some measure of resistance to the pathogen followed by vegetative propagation (Campinhos and Ikemori 1983).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (RC) (Applicable rating criteria, from Chap. 1: c, d, e, g, h)

   The pathogen is common and widely distributed in many Brazilian *Eucalyptus* plantations and is found in the tropical and subtropical areas of all countries in South America. Although it is unlikely that trees with obvious stem cankers would be harvested for sawlog exports, stem infections would remain on any infected tree harvested.

2. Entry potential: *High* (VC) (Applicable rating criteria, from Chap. 1: b, c, d)

   Cryphonectria cubensis would survive in logs in transit. Inspectors would have difficulty detecting incipient cankers.

3. Colonization potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: a, b, f)

   Substantial inoculum may be present on logs, and the pathogen has successfully established in locations outside its native distribution. However, a suitable host would need to be present near the port of entry for the pathogen to colonize and maintain a population. Infection of *Eucalyptus* hosts would require the development of fruiting bodies of the fungus and subsequent spread of the spores to suitable hosts. The pathogen produces spores adapted to dispersal by rain splash and wind-blown rain. Infection of susceptible hosts would depend on favorable environmental conditions at the time of inoculum availability.

4. Spread potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: a, c)

   If colonization by *C. cubensis* occurred on *Eucalyptus*, the pathogen would spread principally on trees in situations where environmental conditions are conducive for infection. The current world distribution is probably determined by the tropical climate needed for growth and spread of the pathogen (Conradie and others 1990). The lack of continuity of hosts in the United States would permit only limited spread.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (VC) (Applicable rating criteria, from Chap. 1: a, b, c)

   The disease is a limiting factor in the commercial cultivation of certain species of *Eucalyptus* growing in climates suitable for infection. In Brazil, 30% of the stems in some plantations of *Eucalyptus* spp. have been killed by this pathogen (Alfenas and others 1983). Infection rates in high rainfall and high temperature areas of Brazil can reach 80%. In cooler or drier areas of the country, infection rates are much lower, as is the extent of canker development (Hodges and others 1979). In addition to mortality as a result of girdling, infection can result in reduced coppicing. Basal cankers reduce the sprouting of stumps 10% to 20% in Brazil (Hodges and Reis 1974) and about 35% in Kerala (Sharma and others 1985a). In a southern Florida plantation, *C. cubensis* was associated with coppice failure of 44% of *E. grandis* stumps (Barnard and others 1987).

   The current distribution of the disease in the continental United States is limited to southern Florida. Because the disease causes heavy losses only in areas where high rainfall occurs most of the year and temperatures average 23°C or higher, damage has not been great in southern Florida (Hodges and others 1979). Hodges and others (1979) did not find the disease in southern Georgia or northern Florida. If the pathogen were introduced into California, damage would probably be minimal because of the state's Mediterranean climate, and because *E. globulus*, the principal species planted there, is resistant to the pathogen.

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

   The potential environmental impact if the canker pathogen were to become established in the United States in areas where it is not already present would be low. Spread of the pathogen to areas in California where *Eucalyptus* has become naturalized may result in some deformity and possible mortality, but climatic conditions unfavorable to the pathogen would limit its affect on the ecosystem.

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

   Environmental damage following successful establishment of the disease in new locations as a result of log importation would have a moderate social and political impact. An increase in the number of deformed *Eucalyptus* as a result of cankers may increase public concern in areas where the host is grown as an ornamental, such as in urban plantings.

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

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Reviewers' comments—"Host Names: Add *Psidium cattleianum* Sabine (Hodges, Charles S. 1988. Preliminary Exploration for Potential Biological Control Agents for *Psidium cattleianum*. Cooperative National Park Resources Unit, Hawaii, Tech. Rep. 66. Mimeo. The fungus was quite common on this host in one area of the state of Santa Catarina in Brazil. (Mike Wingfield has successfully inoculated *Psidium guajava* with the fungus. This has been published, but I can't readily find the reference." (Hodges)

"Add also *Tibouchina granulosa*, collected near Viçosa, Minas Gerais in 1974 by C. S. Hodges, This was never published, but the specimen is listed on p. 31 in Roane, et al. 1986. Chestnut Blight, Other Endothia Diseases, and the Genus *Endothia*. APS Press, St. Paul, MN. Francisco Ferreira has since collected it on this host in Brazil, and Mike Wingfield has collected it on a *Tibouchina* sp. in Venezuela where he is currently doing some inoculation studies. *Tibouchina* is in the Melastomataceae, which I believe is closely related to the Myrtaceae. As far as I know, this is the only host for the fungus outside the Myrtaceae." (Hodges)

"P. 108, Section A 3: I don't believe there would be a high colonization potential since susceptible hosts are not very likely to be in the vicinity of the port of entry." (Hodges)

"This seems like a good assessment." (Jacobi)

"Cryphonectria Canker and Pink Disease. If these pathogens primarily cause damage to very young trees, it seems likely that it could have an impact on nursery stock. If so, this impact should be addressed under the economic damage potential element." (Zadig)

Response to comments—Reviewer's comments regarding additional hosts for *C. cubensis* were incorporated. The rating criteria used in the draft automatically gave a high risk for colonization potential if the organism had successfully established outside its native distribution. The reviewer is correct in pointing out that the rating criteria used in the draft did not take into account the need for a suitable host to be present at the port of entry. The rating criteria were changed to reflect the need for suitable climatic conditions and suitable host material to be present if risk is to be high. This change in the rating criteria changed colonization potential from high to moderate.

Botryosphaeria and Cytospora Cankers

Assessor—Gregg DeNitto

Scientific names of pests—*Botryosphaeria dothidea* (Moug.:Fr.) Ces. & De Not. [= *Botryosphaeria berengeriana* de Not. = *Physalospora suberumpens* Ellis & Everh.] (anamorph = *Fusicoccum aesculi* Corda); *Botryosphaeria obtusa* (Schwein.) Shoemaker [=*Physalospora corni* Ellis & Everh. = *Physalospora everhartii* Sacc. = *Physalospora obtusa* (Schwein.) Cooke] (anamorph = *Sphaeropsis* sp.); *Botryosphaeria ribis* (Tode.:Fr.) Grossenb. & Dugger (anamorph = *Fusicoccum* sp.) (Pleosporales, Botryosphaeriaceae); *Cytospora eucalyptina* Speg. (Coelomycetes); *Cytospora eucalypticola* Van der Westhuizen (teleomorph = *Valsa ceratosperma* (Tode:Fr.) Maire) (Coelomycetes)

Scientific names of hosts—*Botryosphaeria* spp.: *Eucalyptus* spp.; wide range of woody plants, including forest and agricultural trees (for example, *Acer, Betula, Carya, Citrus, Malus, Picea, Pinus, Prunus, Quercus, Salix*); *Cytospora eucalyptina*: *Eucalyptus ficifolia, E. globulus, E. grandis, E. nitens, E. viminalis*; *C. eucalypticola*: *E. camaldulensis, E. grandis, E. urophylla, E. uro-grandis* hybrid

Distribution—*B. dothidea*: Colombia, Venezuela, United States
B. obtusa: Chile, United States
B. ribis: Argentina, Brazil, Colombia, Venezuela, United States
C. eucalyptina: Argentina
C. eucalypticola: Uruguay, Venezuela

Summary of natural history and basic biology of the pest—Each of the *Botryosphaeria* spp. have been reported in different parts of the United States on an array of hosts, as well as elsewhere in the world (Farr and others 1989). They cause a stem canker and may also cause a twig canker and dieback (Smith and others 1994). These species tend to be associated with weakened or stressed hosts and infect through fresh wounds. Canker development in *Botryosphaeria* may take many months from the time of infection, suggesting an endophytic relationship (Bettucci and Alonso 1997b, Smith and others 1996). *Botryosphaeria dothidea* is considered one of the most important pathogens of *Eucalyptus* in South Africa, especially of stressed trees (Smith and others 1996). Dispersal of conidia of the anamorphs of *Botryosphaeria* is by rain splash. Ascospores are dispersed by wind and water. Conidia probably initiate most infections. There is debate on the validity of species differences and genetic variability within these groups. For example, *B. dothidea* and *B. ribis* are 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 characters. They considered them subspecific variants of *B. dothidea* sensu lato until more data supporting separation becomes available. Recent genetic work within *Botryosphaeria* in the United States suggests that *B. ribis* and *B. dothidea* are distinct groups, possibly species. Preliminary isozyme and RAPD work in *Botryosphaeria* suggests a very diversified group of organisms possibly with sufficient differences to be considered separate species (J. Micales, USDA Forest Service, Forest Products Laboratory, Madison, WI, 2000, personal communication; G. Stanosz, University of Wisconsin–Madison, 2000, personal communication). 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. The anamorphs of *B. dothidea* and *B. ribis*, which are *Fusicoccum aesculi* and *Sphaeropsis* sp., respectively, have also been debated with uncertainty about the relationships without further studies (Morgan-Jones and White 1987, Rayachhetry and others 1996). The taxonomic debate within this group only helps to demonstrate the uncertainty in species identification and what genetic material may be present in other parts of the world that has morphological similarities to that present in the United States but may differ in hosts and pathogenicity.

Little information is available on *Cytospora eucalyptina*. It was originally described from decaying branches of *E. globulus* in Argentina (Farr 1973). It has not been identified elsewhere. A teleomorph state has not been clearly identified, but other *Cytospora* species have teleomorphs that are in the genus *Valsa*. There are questions about the nomenclature of this fungus. Sankaran and others (1995a) identify *C. eucalyptina* and *C. sacculus* (Schwein.) Gvritischvili as anamorphs of *Valsa ceratosperma*. *Cytospora sacculus* has been identified mainly in Russia, including on *Eucalyptus* (Farr and others 1989). It has not been reported in South America, however. Spielman (1985) associated *V. ceratosperma* with *C. sacculus* as its anamorph and as being found worldwide. She did not believe there was conclusive evidence of the association between the two. A closer study of this group is needed to clarify the situation. It is not known if *C. eucalyptina* is pathogenic, but many *Cytospora* species are at least facultative pathogens that invade weakened tissue. Another *Cytospora*, *C. eucalypticola*, has been recorded as a stem pathogen of *Eucalyptus* in South Africa, and it has been reported on symptomatic twigs of *E. grandis* in Uruguay (Bettuci and Alonso 1997b). Pathogenicity tests of this species indicated that it is not aggressive and is capable of only limited invasion of *Eucalyptus* in Australia (Old and others 1991, Yuan and Mohammed 1999). *Valsa ceratosperma* has been identified as its possible teleomorph in Australia on eucalypts (Old and others 1991). This association of the same teleomorph with three anamorphs raises the question of validity of identification of the correct species. The taxonomic uncertainty in this group of fungi is similar to that in *Botryosphaeria*. Old and others (1991) suggested that the anamorph of *V. ceratosperma* on eucalypts be referred to as

C. eucalypticola until further studies are completed. *Valsa ceratosperma* is widely distributed, including in the United States (Spielman 1985). The biology of spore dissemination and infection processes of *Valsa* species is generally similar to that of *Botryosphaeria*.

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential:

   Botryosphaeria spp.—*High* (MC) (Applicable rating criteria, from Chap. 1: c, d, e, g, h)

   C. eucalyptina and *C. eucalypticola—Moderate* (MC) (Applicable rating criteria, from Chap. 1: d, e, h)

   Botryosphaeria spp. have been reported in Argentina, Brazil, Chile, Colombia, and Venezuela. They are generally considered to be worldwide in distribution on a wide range of woody hosts and are probably present in most South American countries, although not necessarily on *Eucalyptus*. Infections can occur on both branches and main stems. *Botryosphaeria dothidea* is of some significance on *Eucalyptus* in Brazil. *Cytospora eucalyptina* and *C. eucalypticola* appear to be of limited occurrence on *Eucalyptus*.

2. Entry potential: *High* (MC) (Applicable rating criteria, from Chap. 1: b, c, d)

   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. The cankers that are produced could be small and virtually invisible on logs. There would not be anything recognizable in chips.

2. Colonization potential:

   Botryosphaeria spp.—*High* (MC) (Applicable rating criteria, from Chap. 1: b, c, f)

   C. eucalyptina and *C. eucalypticol —Moderate* (MC) (Applicable rating criteria, from Chap. 1: b, f)

   The colonization potential for *Botryosphaeria* spp. is high because of their wide host range and range of environments they could encounter upon entry. Following transport in a container or hold of a ship, it is probable that fructifications would have developed and be ready for spore dispersal. Since only *Eucalyptus* spp. are known as hosts for *C. eucalyptina* and *C. eucalypticola*, there is a lowered probability that a suitable host would be present at ports of entry.

3. Spread potential:

   Botryosphaeria spp.—*High* (MC) (Applicable rating criteria, from Chap. 1: a, c, d, e, f, g)

   C. eucalyptina and *C. eucalypticola—Moderate* (MC) (Applicable rating criteria, from Chap. 1: a, c, e, f)

   Most canker fungi that are air and water 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. The broad host range of *Botryosphaeria* would minimally limit its spread. The limited host range for *C. eucalyptina* and *C. eucalypticola* would certainly limit their spread unless unknown hosts were encountered. 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

4. Economic damage potential:

   Botryosphaeria spp.—*Moderate* (Applicable rating criteria, from Chap. 1: a, c)

   C. eucalyptina and *C. eucalypticola—Low* (Applicable rating criteria, from Chap. 1: a)

   The *Botryosphaeria* species are present in the United States. They tend 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. The limited host range of the *Cytospora* spp. reduces the economic damage potential to low. This limited range and their apparent low level of pathogenicity would result in minimal economic damage to a relatively minor industry.

6. Environmental damage potential: *Low* (Applicable rating criteria, from Chap. 1: none)

   Because of the lack of information on potential hosts and the degree of pathogenicity, the environmental damage is unknown. The amount of recognized damage from these fungi on *Eucalyptus* in South America is limited. Exposure to new hosts in more temperate climates 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 rating criteria, from Chap. 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. Similarly, the *Cytospora* spp. do not appear to be particularly damaging in South America. Exposure to new hosts and new environments in the United States could result in increased levels of damage and increased social and political considerations.

C. Pest risk potential:

Botryosphaeria spp.: *High* (Likelihood of introduction = *High*; Consequences of introduction = *Moderate*)

Cytospora spp.: *Moderate* (Likelihood of introduction = *Moderate*; Consequences of introduction = *Low*)

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Reviewers’ comments—“p. 114, last p., 1.3: *Valsa* or *Leucostoma*. I think the paragraph on *Cytospora* spp. may have to be revisited….” (Hodges)

“Pest Names: Why was *Botryosphaeria obtusa* not included? It has been reported on eucalyptus from Chile (See table). Anamorphs of *B. dothidea*, *B. obtusa* and *B. ribis* are *Fusicoccum aesculi* Corda, *Sphaeropsis* sp., and *Fusicoccum* sp., respectively. Some consider *B. dothidea* and *B ribis* synonymous, and I am inclined to agree.”(Hodges)

“Distribution: There are reports of *B. dothidea* from Venezuela and Colombia as well. It is probably universally present in South America.” (Hodges)

“As a general comment, I am having trouble with several of the chapters, especially this one and the preceding one on *Cytospora* and *Coniothyrium* that include together diseases with greatly differing symptoms and basic biologies. Writing a coherent summary is therefore made very difficult. In the cases at hand, *Botryosphaeria* and *Valsa* cankers would have made a much more logical pairing with regard to their symptomatology and biology.” (Hodges)

“Well done, but having worked with *Cytospora* sp. over the last decade makes me more apprehensive about importing new genetic material that may have other NA hosts. *Cytospora* fungi are more aggressive than we give them credit when trees are mildly stressed.” (Jacobi)

“Coniothyrium and Cytospora Cankers; Botryosphaeria and Ceratocystis Cankers. It is unclear from the assessment what part of the tree these diseases infect. If infection were limited to branches it would seem less likely that these would be present on logs.” (Zadig)

Response to comments—The IPRAs on *Botryosphaeria–Ceratocystis* and *Cytospora–Coniothyrium* were reorganized to better reflect similarities in biology rather than in pest categories. This results in differences in pest ratings within this IPRA, but the fungi act similarly enough to be considered together. *Ceratocystis fimbriata* and *Coniothyrium zuluense* differ and are analyzed in separate IPRAs. This should improve the understanding of the basic biologies and how this affects the pest ratings. It was clarified in the IPRA what parts of the tree are affected by each of these fungi. Also, *B. obtusa* was added to the assessment, although it did not alter the pest risk elements. Likewise, the range of *B. dothidea* was expanded to include Venezuela and Colombia. The discussion on the species differences and genetic variability within these groups was expanded to explain the complexity and uncertainty related to the associations between anamorphs and teleomorphs. This explanation did not result in a more positive identification of the actual teleomorphs and anamorphs because those relationships remain uncertain.

Ceratocystis Canker

Assessor—Gregg DeNitto

Scientific names of pests—*Ceratocystis fimbriata* Ellis & Halstead [= *Sphaeronaema fimbriatum* (Ellis & Halstead) Sacc. =*Ceratostomella fimbriata* (Ellis & Halstead) Elliot, =*Ophiostoma fimbriata* (Ellis & Halstead) Nannf. =*Endoconidiophora fimbriata* (Ellis & Halstead) Davidson =*Rostrella coffeae* Zimmerman =*Endoconidiophora variospora* Davidson =*Ceratocystis variospora* (Davidson) Moreau =*Ophiostoma variosporum* (Davidson) von Arx]. anamorph = *Chalara* (Microascales, Ophiostomataceae)

Scientific names of hosts—*Eucalyptus uro-grandis*; *Coffea arabica* L.*; Hevea brasiliensis* (Willd.) Muell.-Arg.*; Mangifera indica* L. are some of the significant hosts in South America

Distribution—Brazil, United States

Summary of natural history and basic biology of the pest—*Ceratocystis fimbriata* has been identified on *Eucalyptus* in Brazil and has also been reported in different parts of the United States on an array of hosts, as well as elsewhere in the world. In addition to numerous woody hosts, it also causes a serious disease of sweet potato (*Ipomea batatas* (L.) Lam.). *Ceratocystis fimbriata* may be better considered a wilt pathogen in *Eucalyptus*, although cankers can develop. It tends to be associated with weakened or stressed hosts and infects through fresh wounds. *Ceratocystis fimbriata* can be an aggressive primary pathogen in native plant communities on some hosts (Kile 1993). Ascospores and conidia of *C. fimbriata* appear to be transmitted by insects, mainly members of the Nitidulidae (Hinds 1972, Kile 1993). Local spores may disperse by splashing water. Moist conditions are needed for fruit body development and spore formation. Spores and fruiting bodies are produced on canker faces and on the cut surfaces of infected wood. In addition to canker formation, wood affected by *C. fimbriata* becomes darkly stained.

Recent genetic work suggests that identified morphological species may in fact be comprised of several to numerous distinct strains or variants. A form species, *C. fimbriata* f. sp. *platani,* has been recognized primarily on *Platanus* spp. in North America (Walters and others 1952). Differences in pathogenicity, growth rate, colony type, and conidial states have been identified among isolates of *C. fimbriata*; however, these strains are cross-fertile, suggesting they comprise the same species (Webster and Butler 1967). Molecular taxonomic work in *Ceratocystis* has identified a South American clade that includes the *Eucalyptus* strain. Various representatives from this clade have been found in other parts of the world on a variety of hosts, including rubber in Malaysia, *Acacia* in South Africa, and sweet potato in Asia and in the United States (T. Harrington, University of Iowa, 1999, personal communication).

Ceratocystis fimbriata f. sp. *platani* is native to sycamores in the United States and has been introduced to Europe where it is a major pathogen of *Platanus* × *acerifolia*. It is suspected that *C. fimbriata* was introduced to Malaysian rubber and to Australia (Kile 1993).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (MC) (Applicable rating criteria, from Chap. 1: c, d, e, f, g, h)

   Ceratocystis fimbriata has only recently been observed in Brazil on *Eucalyptus*, and it is unknown to what extent it will spread or become better established. Losses are significant in plantations where it is present. *Ceratocystis fimbriata* is vectored by insects with host-finding abilities. Because limbs and branches will be removed at harvest, only stem infections will remain on the logs. If chips are produced in the field and include branch material, then those infections would be included. Visual evidence of cankers would also not be present with chips.

2. Entry potential: *High* (RC) (Applicable rating criteria, from Chap. 1: b, c, d)

   Transit of logs will not affect fungus survival. The likelihood that inspectors would detect the fungus is low. The pathogen can cause some staining in the wood and may be present in material without canker formation. Sporulation on the wood surface would probably occur in ship holds and containers.

3. Colonization potential: *High* (RU) (Applicable rating criteria, from Chap. 1: b, c, d, e, f)

   The presence of *Eucalyptus* hosts near possible ports of entry will be minimal, except ports in California, Hawaii, and Florida. Other host species in the United States are uncertain because of questions about genetic variability and host susceptibility. Numerous hosts are reported for *C. fimbriata* in the United States (Farr and others 1989), and this species is reported to have a wide host range around the world (Kile 1993). This wide range of hosts, including herbaceous species, could significantly increase the potential for colonization around port areas in the United States. *Ceratocystis fimbriata* is vectored by insects with host-finding abilities. Introduced hosts, especially those from subtropical areas, may be more vulnerable if new strains or geographic variants of this species are introduced from South America.

4. Spread potential: *High* (MC) (Applicable rating criteria, from Chap. 1: a, b, c, d, f, g)

If *C. fimbriata* colonizes hosts in the United States, spread would occur mainly to trees that are stressed. This assumes a level of virulence similar to the genotypes already present in the United States. Landscape trees and vegetation may be more at risk since they tend to be introduced species that are planted in situations less than conducive to optimum growth. The rate and extent of spread would depend on the environmental conditions and insect vectors the particular genetic variants might require.

B. Consequences of introduction

5. Economic damage potential: *High* (RU) (Applicable rating criteria, from Chap. 1: a, b, c, e)

   This fungus is present in the United States. Aspen (*Populus tremuloides* Michx.) is affected by *C. fimbriata* across much of the Rocky Mountains, but because this is not a major commercial species, economic impact is limited. Also, tree mortality is not a common result. The pathogen infects stone fruits in the Central Valley of California. However, because the strains in South America may be different in pathogenicity than those in the United States, there is a potential for increased economic damage. This potential is increased because of the potential of other hosts that are not currently known or recognized, including herbaceous and woody species. Taro (*Colocasia esculenta* (L.) Schott) and *Syngonium podophyllum* Schott are two herbaceous hosts of *C. fimbriata* in Hawaii. The fungus has not been found there on woody plants. The introduction of new strains to Hawaii could expose a wide range of woody plants to infection.

6. Environmental damage potential: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: f)

   Because of the lack of information on potential hosts and degree of pathogenicity, the environmental damage is unknown. The amount of recognized damage in South America is limited. Exposure to new hosts in more temperate climates 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, such as aspen and stone fruits in California. Research into the differences in the strains and their hosts must be completed before firm conclusions regarding the actual impact can be stated. Until that is done, a high rating appears appropriate.

7. Social and Political Considerations: *Low* (RU) (Applicable rating criteria, from Chap. 1: none)

   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 perceived damage would greatly increase. This would increase the social and political damage potential to at least a moderate rating.

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

Selected bibliography

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Reviewers' comments—"As a general comment, I am having trouble with several of the chapters, especially this one and the preceding one on *Cytospora* and *Coniothyrium* that include together diseases with greatly differing symptoms and basic biologies. Writing a coherent summary is therefore made very difficult. In the cases at hand, *Botryosphaeria* and *Valsa* cankers would have made a much more logical pairing with regard to their symptomatology and biology." (Hodges)

"Well done. I am a bit worried about a pathogen that we do have and thus can easily infect our trees such as our aspen and potentially bring in new aggressive strains. You have rated this group high on all aspects. This is good." (Jacobi)

"For example, *Ceratocystis fimbriata* is apparently comprised of several interfertile strains; some that attack herbaceous hosts (e.g. sweet potato) and some that attack woody hosts (e.g. *Populus*). The economic and environmental effects of this pathogen on potential herbaceous hosts are not considered in the Consequences of Establishment. *Ceratocystis fimbriata's* ability to attack herbaceous hosts is also ignored in the Probability of Pest Establishment." (Johnson/Osterbauer)

“Genetic variability can be critical in pests like *Ceratocystis fimbriata* with its interfertile pathogenic strains.” (Johnson/Osterbauer)

“Coniothyrium and Cytospora Cankers; Botryosphaeria and Ceratocystis Cankers. It is unclear from the assessment what part of the tree these diseases infect. If infection were limited to branches it would seem less likely that these would be present on logs.” (Zadig)

Response to comments—The IPRAs on *Botryosphaeria–Ceratocystis* and *Cytospora–Coniothyrium* were reorganized to better reflect similarities in biology rather than in pest categories. *Ceratocystis fimbriata* became a separate IPRA because of this reorganization. This provided improved consistency between the IPRAs in the analysis and should reduce some of the confusion that was previously present. Additional recognition of herbaceous hosts and their potential for damage was added to the IPRA, although it did not alter the already high ratings. It is believed that the genetic variability within the species was discussed adequately for regulatory purposes and did not require further elaboration since definitive data are lacking. The IPRA was revised to give increased recognition of new hosts in the United States with the introduction of new strains.

Coniothyrium Canker

Assessor—Gregg DeNitto

Scientific names of pests—*Coniothyrium zuluense* Wingfield, Crous, and Coutinho (Coelomycetes)

Scientific names of hosts—*Eucalyptus grandis*

Distribution—*Coniothyrium zuluense* in Argentina; *Coniothyrium* sp. in Brazil, Colombia, and Uruguay

Summary of natural history and basic biology of the pest—A stem disease of *E. grandis* has been reported in South America caused by *Coniothyrium zuluense.* A similar fungus was isolated from *Eucalyptus* in Argentina and has been identified only recently through DNA techniques as being *C. zuluense* (M. Wingfield, University of Pretoria, Republic of South Africa, 1999, personal communication). Isolates from Uruguay are also being examined. A similar disease caused by *Coniothyrium* sp. has been observed in Brazil (states of São Paulo and Minas Gerais) on *E. grandis,* but its identity to species has not been confirmed (F. Ferreira, Federal University of Viçosa, Brazil, 1999, personal communication). An unidentified species of *Coniothyrium* causes branch cankers on *E. globulus* and *E. tereticornis* in Colombia (Orozco 1985). *Coniothyrium zuluense* causes a serious canker of the main stem of *E. grandis* in South Africa (Wingfield and others 1996).

Infections of *C. zuluense* are initiated on young green intact stems and can coalesce into larger necrotic patches. These patches can crack and exude large amounts of red–brown kino. Girdling of the stem can occur. Pycnidia readily develop on infected tissue. It is unknown how the fungus spreads, but it is thought that conidia are dispersed by rain and wind (Coutinho and others 1997). Infection occurs directly through the epidermis after the conidia germinate. Coniothyrium canker is more severe in the subtropical climate of South Africa than in temperate areas. Areas with high rainfall appear to be more conducive to the development of disease (Coutinho and others 1997). The origin of this disease is uncertain. It is not known to be from Australia and has not been identified in other hosts (Coutinho and others 1997). Examination of isolates from South Africa found a genetically diverse population, suggesting a well-established and possibly endemic fungus that has moved from a native host to *Eucalyptus* (Zyl and others 1997).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: d, e, h)

   Coniothyrium zuluense was recently identified from Argentina. Collections of a similar species (possibly *C. zuluense*) have been found in Brazil, Colombia, and Uruguay. This suggests it may be a recent introduction or a recent exposure to *Eucalyptus*. It is possible that levels of damage similar to that experienced in South Africa will occur in the more tropical areas of South America. The considerable amount of *E. grandis* and its hybrids in Brazil and Argentina are especially susceptible. If *C. zuluense* becomes more widely distributed on *Eucalyptus* in South America, the rating would increase to high.

2. Entry potential: *High* (RC) (Applicable rating criteria, from Chap. 1: b, c, d)

   Most canker fungi readily survive on dead trees as long as the wood does not dry for an extended period. The time required for transport to the United States (weeks at most) would not limit this survival.

3. Colonization potential: *High* (RU) (Applicable rating criteria, from Chap. 1: a, d, f)

   The recent identification of *C. zuluense* in limited locations in South America suggests it is a new arrival. Spore-producing pycnidia will be present on logs when they arrive in the United States. The occurrence of a warm, humid climate, such as in subtropical Florida and Hawaii, would increase the probability of spore production and spread. It is unknown what other hosts exist for *C. zuluense,* so the opportunities for colonization may be limited, especially if *Eucalyptus* are infrequent.

4. Spread potential: *High* (RU) (Applicable rating criteria, from Chap. 1: a, b, c, e, f)

   The potential for spread of *C. zuluense* depends on the point of introduction and the occurrence of unknown hosts. If the occurrence of the fungus in South America is a recent introduction, then obviously, it is through human assistance. If the fungus is introduced into a subtropical climate, the spread potential may be significant, through wind dispersal of the spores. Areas with cooler climates and lower rainfall may not experience any spread. If *Eucalyptus* are the only hosts in the United States, then spread will be limited, if at all.

B. Consequences of introduction

5. Economic damage potential: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: a, c, f)

The most significant potential economic damage is likely on the floriculture trade if additional hosts, including *E. pulverulenta*, are identified. However, the need for warm, wet conditions for infection may limit the opportunities for significant disease progression in California. If the floriculture trade increased in Hawaii, conditions may be more conducive to infection. If this disease became established in commercial *Eucalyptus* plantations established for pulpchip production, some economic loss might be experienced. Trees that become cankered may not be desirable for pulp chips because of the kino present. The potential for unknown hosts native in the United States could increase the potential for economic damage, especially in the wetter areas of the southeast.

6. Environmental damage potential: *Moderate* (RU) (Applicable rating criteria, from Chap. 1: d)

   The level of environmental damage is dependent on the host range of *C. zuluense*. If a few species of *Eucalyptus* remain the only hosts, then the damage will be nearly nonexistent. If another species is a host, then it is possible that significant damage could occur. Environmental damage may be limited to subtropical areas, which are primarily Florida and Hawaii. This could expose unknown hosts that are endemic in Hawaii to infection.

7. Social and Political Considerations: *Low* (RU) (Applicable rating criteria, from Chap. 1: none)

   Overall, social and political damage will be low. If an unknown host develops, then the political impacts might increase, at least locally in Florida or Hawaii. Individual owners of *Eucalyptus* plantations or groves that might be affected could raise some political issues.

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

Selected bibliography

Coutinho, T.A.; Wingfield, M.J.; Crous, P.W.; van Zyl, L.M. 1997. Coniothyrium canker: a serious new disease in South Africa. In: Proceedings, IUFRO conference on silviculture and improvement of eucalypts; 1997 August 24–29; Salvador, Brazil. Colombo, Brazil: Empresa Brasileira de Pesquisa Agropecuária: 3: 78–83.

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Zyl, L.M. van; Wingfield, M.J.; Coutinho, T.A. 1997. Diversity among isolates of *Coniothyrium zuluense*: a newly recorded *Eucalyptus* stem canker pathogen in South Africa. In: Proceedings, IUFRO conference on silviculture and improvement of eucalypts; 1997 August 24–29; Salvador, Brazil. Colombo, Brazil: Empresa Brasileira de Pesquisa Agropecuária: 3: 135–141.

Reviewer's comments—"The last sentence of p. 1 on page 115 is on kind of shaky ground since *C. zuluense* can infect through intact bark. I doubt if that is the case with *Valsa* and *Cytospora*." (Hodges)

"Sections A and B: Only *C. zuluense* is mentioned in any of the subsections." (Hodges)

"I just got a copy of a newsletter from South Africa (ICFR Newsletter, February 1999) (ICFR=Institute of Commercial Forestry Research) which has a very succinct writeup on the disease (p. 18) under the title "Disease Profile: Coniothyrium canker of eucalyptus (no author)." (Hodges)

"Coniothyrium and Cytospora Cankers; Botryosphaeria and Ceratocystis Cankers. It is unclear from the assessment what part of the tree these diseases infect. If infection were limited to branches it would seem less likely that these would be present on logs." (Zadig)

Response to comments—The IPRAs on *Botryosphaeria–Ceratocystis* and *Cytospora–Coniothyrium* were reorganized to better reflect similarities in biology rather than in pest categories. This resulted in the creation of a separate IPRA for Coniothyrium canker since it has different biological characteristics from the other three fungi. This should improve the understanding of the basic biologies and how this affects the pest ratings. It also resolves some of the questions on some statements in the IPRA. The new IPRA specifies the location of the disease associated with *C. zuluense*.

Pink Disease

Assessor—Gregg DeNitto

Scientific name of pest—*Erythricium salmonicolor* (Berk. & Br.) Burdsall (= *Corticium salmonicolor* Berk. & Br. =*Pellicularia salmonicolor* (Berk. & Br.) Daster. =*Botryobasidium salmonicolor* (Berk. & Br.) Venkatarayon); anamorph: *Necator decretus* Massee (Stereales, Corticiaceae)

Scientific names of hosts—More than 141 species in 104 genera. *Eucalyptus* species include *E. alba*, *E. grandis*, *E. kitsoniana*, and *E. tereticornis* (Ciesla and others 1996). Host species reported in the United States include *Cercis canadensis* L. (redbud), *Citrus*, *Ficus carica* L. (fig), *Malus pumila* Mill. (apple), and *Pyrus communis* L. (pear) (Farr 1973, Hepting 1971, Tims 1963). Other economic hosts include *Hevea brasiliensis* (Willd.) Meull.-Arg. (rubber), *Citrus*, *Theobroma cacao* L. (cocoa), and *Camellia sinensis* (L.) Kuntze (tea).

Distribution—Brazil, Peru, United States (Florida, Louisiana, Mississippi)

Summary of natural history and basic biology of the pest—Pink disease, caused by the fungus *Erythricium salmonicolor*, is widely distributed in the tropics and subtropics of both hemispheres. It is considered one of the most important diseases of *Eucalyptus*, although it has not been identified on *Eucalyptus* in Australia (Jacobs 1979). This disease has been reported on *Eucalyptus* in Brazil (Gibson 1975). It has also been identified in the southeastern United States from Florida to Texas on fig, apple, pear (Tims 1963), and redbud (Hepting 1971). In parts of India, *Eucalyptus* plantations in areas with high rainfall (>200 cm annually) have suffered nearly 100% mortality (Seth and others 1978). It causes a stem and branch canker that can girdle the main stem of young trees causing repeated dieback and possibly tree mortality. Older trees with larger diameter stems can develop nongirdling cankers.

Erythricium salmonicolor is able to penetrate intact bark through lenticels (Seth and others 1978) and then attack the cambium, or it can infect through wounds. Four disease stages of the fungus have been identified on most hosts (Seth and others 1978). The first form observed after infection is a thin, shiny mycelial growth on the surface of the bark, the cobwebby stage. The second form, the pustule stage, is sterile, pink pustules and crusts on the bark and in bark cracks. The third form, known as the necator stage, develops after canker formation and as the branch is dying. This form is the conidial stage (sporodochia) with orange–red fruiting structure development. Conidia are probably rain-splash disseminated. The importance of this stage varies with host, and its importance with *Eucalyptus* is not known. These spores can remain viable for up to 20 days under dry conditions, but high humidities are required for germination. A pink incrustation with basidiospore formation is the last stage to form in the fall. Development of the basidioma is dependent on heavy rainfall. Basidiospores are dispersed through rain splash and air currents. Basidiospore viability is reduced by low humidities, and spores probably lose viability after 24 h under field conditions. Of these four forms, only the first and last have been identified in the United States (Tims 1963). In addition to the two spore forms, it has been suggested that the fungus may also be disseminated in the air by the sterile stages when dead bark flakes off of the infected tissue (Seth and others 1978).

Evaluation of the culture filtrates of two isolates of *E. salmonicolor* collected from different areas of India showed differential responses on *Eucalyptus* shoots. The behavior of the two isolates suggested they were different strains of the fungus, with one of the strains being more aggressive (Sharma and others 1988).

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (RC) (Applicable rating criteria, from Chap. 1: c, d, e, g, h)

   Pink disease has been observed on *Eucalyptus* in Brazil, but there are no records on this host from other South American countries. The fungus occurs on other hosts in Columbia and Peru. Because of the widespread distribution of this fungus in the world and the large number of hosts, it is likely that *Eucalyptus* in other South American countries are, or will become, infected. A high incidence of pink disease only occurs in climates with very high levels of rainfall. This may limit the number of diseased stems harvested from areas with moderate rainfall. Cankers on larger stems may be visible during harvesting, but because much of this material may become chips, it is probable there will be little effort to select against cankered trees. This is especially true if trees are harvested with mechanical harvesters.

2. Entry potential: *High* (RC) (Applicable rating criteria, from Chap. 1: b, c, d)

   Transit of logs will not affect fungus survival. The likelihood of detection by inspectors is low. *Erythricium salmonicolor* does penetrate and grow through the sapwood in addition to the bark and cambium (Subramaniam and Ramaswamy 1987). Transport of chips in sealed containers will result in humid conditions that are conducive to fungal fruiting and spore production.

3. Colonization potential: *High* (MC) (Applicable rating criteria, from Chap. 1: c, d, f)

   Pink disease has a very wide host range, including several hosts known to be widespread in the United States. The more suitable environment for colonization to occur is in the southeast and Hawaii. Western areas are probably too dry for successful colonization to occur. In the southeast, the areas susceptible to colonization are coastal areas and Florida because of the high amounts of moisture and warmer temperatures.

4. Spread potential: *Moderate* (MC) (Applicable rating criteria, from Chap. 1: a, c, f, g)

   Spread of pink disease beyond the colonized area will be localized because of the requirement for high rainfall. Transport of any infected material in the form of logs or chips could distribute the fungus farther, but subsequent colonization will be dependent on environmental conditions. Host presence probably will not be a limiting factor because of the wide host range. Control techniques have been developed for some high value crops using fungicides, but it is not known if these would be effective at eradication.

B. Consequences of introduction

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

   The most significant economic damage potential of *E. salmonicolor* is on the floriculture trade. Loss of branches and limbs from infection will reduce the production of materials for this trade. Some economic loss could occur in the forestry trade from reduced production, but infected trees would still be available for chip production. Tree mortality is limited and usually occurs at early ages. The reported presence of this fungus in the conterminous United States and the lack of significant damage suggest that additional introductions will not increase the economic damage. However, if differences in pathogenicity exist, then introductions of new strains into the United States could result in some level of damage beyond what is currently being experienced. Introduction into Hawaii could result in significant economic damage to agricultural crops.

6. Environmental damage potential: *High* (RC) (Applicable rating criteria, from Chap. 1: c, d)

   The presence of pink disease in the southeastern United States suggests that further environmental damage will be minimal in the conterminous United States. Although *E. salmonicolor* has been identified on a wide number of hosts, the majority of damaging situations has been with introduced hosts. Further establishment and spread in the United States may damage exotic hosts, such as *Eucalyptus* and fruit trees, but impacts on natural systems are expected to be minimal. However, introduction into Hawaii with its unique ecosystems and plant life could expose plants with limited distributions to this damaging fungus.

7. Social and Political Considerations: *High* (RC) (Applicable rating criteria, from Chap. 1: a, d)

   Overall, social and political considerations will be low in the conterminous United States. Some political effects could develop if damage from introduction of this fungus occurred on ornamental *Eucalyptus*. Damage to the floriculture trade could have some short-term effects, but alternative materials would probably replace *Eucalyptus* foliage. If this fungus were introduced into Hawaii, there could be social and political repercussions if there were impacts to agricultural and ornamental plantings, as well as damage to native plants of limited distribution or those listed as endangered, threatened, or candidate species. Although of limited consequence to the United States as a whole, the social and political effects in Hawaii could be substantial.

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

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Reviewers' comments—"Well done. I am a bit worried about a pathogen that we do have and thus can easily infect our trees such as our aspen and potentially bring in new aggressive strains. You have rated this group high on all aspects. This is good." (Jacobi)

"The report states that *Erythricium salmonicolor* has not been identified in Australia. Available records show that *E. salmonicolor* occurs in New South Wales (Australia) as 'pink limb disease' on fruit trees, *albeit*, not on eucalypts. The pathogen is also recorded in New Zealand and southern Japan on citrus (Oniki and others, 1985; Transactions of the Mycological Society of Japan 26: 441-448)." (Mireku)

"Cryphonectria Canker and Pink Disease. If these pathogens primarily cause damage to very young trees, it seems likely that it could have an impact on nursery stock. If so, this impact should be addressed under the economic damage potential element." (Zadig)

Response to comments—The distribution presented for each pest is based on known locations on *Eucalyptus* relevant to this risk assessment. Locations outside of the United States and South America on other hosts are not included since they do not influence the assessment. The reference to Australia was on *Eucalyptus.* The intent was to suggest that *E. salmonicolor* is not a pathogen on *Eucalyptus* in its native state and may have crossed over from some other host in South America. Pink disease on *Eucalyptus* has been observed on younger trees in plantations. Common ages range from 2 to 5 years. However, no reports were found of this being a nursery disease problem.

Root and Stem Rots

Assessor—Harold Burdsall

Scientific names of pests—*Armillaria* spp., *Phellinus* spp., *Ganoderma* spp., *Gymnopilus spectabilis* (Fr.) A.H. Smith, *Inonotus* spp. (Basidiomycetes).

Scientific names of hosts—Many conifer and deciduous tree species (including *Eucalyptus* spp.), both temperate and tropical.

Distribution—Worldwide

Summary of natural history and basic biology of the pests—*Armillaria*, *Phellinus*, *Ganoderma*, *Gymnopilus,* and *Inonotus* species are being treated together here because they function similarly in the ecosystem, and mitigation procedures taken against one will be equally effective or ineffective against all. Species of heart-rot and root-rot fungi, represented by the fungus genera listed above, are distributed worldwide, and many of the species are not found in the United States. Nearly every country in the world, including those in South America, is home to a number of species that are exotic to the United States (Tables 11 and 12) (Buchanan and others 1995, Larsen and Cobb 1990, Volk and Burdsall 1995). Little information is available in the literature regarding the currently recognized species of these decay fungi that occur in South America. *Ganoderma australis, G. applanatus,* and *G.* cf. *lucidum* are, overall, the most frequently reported (Lopez 1983, 1988)**,** but whether the last two species are actually the same species as those in North America or merely similar morphologically has not been rigorously tested. *Gymnopilus spectabilus* was encountered frequently during the site visit as a root/butt-rot species in *E. globulus*, especially in Argentina, where it is commonly referred to as "the *Eucalyptus* fungus" (J. Wright, University of Buenos Aires, Argentina, 1998, personal communication). South America is also home to numerous species of *Phellinus* (Larsen and Cobb 1990, Lopez 1983, 1988) and several species of *Armillaria* and *Inonotus* (Lopez 1983, 1988). Many of these species are not known from North America and the species said to be conspecific with those in North America have not been submitted to intense biosystematic investigation to assure this.

In South America, *Armillaria procera*, *A. novo-zealandica*, and *A. luteobubalina* are well known for pathogenic capability (Kile and others 1991). All species examined to date have the ability to cause disease in some situations, frequently on a broad range of host species. They are also adept at surviving as saprophytes in dead wood for long periods of time (Kile 1980, Rishbeth 1972, Shaw 1975). During one site visit, an *Armillaria* infection center was observed in a young *Eucalyptus* plantation near Escuadrón, Chile. 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 that would accompany them.

The genus *Phellinus* is equally well represented in South America. The species differ substantially from one country to another, and new species are being described regularly. Many of these species are not found in North America.

Species of *Ganoderma* are also potential pests. They cause root- and butt-rot of either conifers or hardwoods, depending on the species. South America has species unknown in the United States (Martinez and others 1995). In many of these countries, *G. applanatum* (Pers.) Pat. and *G. lucidum* (W. Curt.:Fr.) Karst. are reported to occur. These species are also reported to occur in the United States. However, recent studies using molecular techniques have demonstrated that the species being called by those names are not conspecific, with many countries, including those of South America, all possessing taxa biologically different from those in the United States, even though they may carry the same name (Moncalvo and others 1995).

Armillaria and *Phellinus* species exist to one degree or another as rhizomorphs or mycelium (possibly chlamydospores), either in the soil itself or in woody debris and stumps. Recent data indicate that at least some species of *Armillaria* depend almost entirely on rhizomorphs as their principal means of dispersal (Smith and others 1992). *Ganoderma* species are not known to produce either chlamydospores or rhizomorphs. The mode of infection by the species in most of these genera is not known. Species of all of these genera and those of others that cause root- and heart-rot are thought to primarily use a root to root transmission in the formation of infection centers. However, basidiospores are the means by which long distance spread of the fungus is accomplished, and this could be very effective in an ecosystem that lacks the normal competitors.

Most root- and heart-rot fungi act similarly. In the case of the attack of a tree beyond an infection center, the mycelium or rhizomorphs in the soil or debris are in close proximity to the root system. In the case of rhizomorphs, they may be attached but causing no damage (Wargo 1984). When the tree is stressed, the root is penetrated and the mycelium grows through the root. It continues growth toward the root crown, killing roots until the complete root system is dead. Spread occurs by means of growth from one root system to another, causing "infection centers" that increase in size with time. Mushrooms and conks, the spore-producing part of the life cycle, are formed in the fall and discharge spores into the air, where they are carried by wind. Although the basidiospores are not important in the localized spread of the fungus or in the formation of infection centers, they probably are the means of long distance spread of the fungus into new areas. No anamorphic (conidiospore) state exists in the life cycle of *Armillaria* or *Ganoderma* species, but there are indications that some *Phellinus* species may form chlamydospores in the soil.

Table 11—*Armillaria* species, hosts, and distribution

Species name	Host	Distribution
Armillaria affinis (Singer) Volk & Burds.	Hardwoods	Central America, Caribbean
Armillaria griseomellea (Singer) Kile & Watl.	Unknown	South America
Armillaria melleo-rubens (Berk. & Curt.) Sacc.	Unknown	Central America
Armillaria montagnei (Singer) Herink	Unknown	South America, Europe
*Armillaria novae-zealandiae (*G. Stev.) Herink	Hardwoods, conifers	New Zealand, New Guinea, Australia, South America
Armillaria procera Speg.	Hardwoods	South America
Armillaria puiggarii Speg.	Hardwoods	South America
Armillaria sparrei (Singer) Herink	Hardwoods	South America
Armillaria tigrenis (Singer) Volk & Burds.	Hardwoods	South America
Armillaria viridiflava (Singer) Volk & Burds.	Hardwoods	South America
Armillaria yungensis (Singer) Herink	Hardwoods	South America

Table 12—*Phellinus* species, hosts, and distribution

Species name	Host	Distribution
Phellinus andinopatagonicus Wright & Desch.	*Nothofagus, Austrocedrus*	South America
Phellinus andinus Plank & Ryv.	Myrtaceae	Argentina
Phellinus apiahynus (Speg.) Rajch. & Wright	*Ocotea*	Argentina
Phellinus calcitratus (Berk. & Curt.) Ryv.	Hardwoods	South America,
		Caribbean Islands
Phellinus linteus (Berk. & Curt.) Teng	Hardwoods	Nicaragua, Mexico, tropical South America
Phellinus lividus (Kalchbr.) Ahmad	Hardwoods	South American tropics
Phellinus melanoderma (Pat.) O. Fidalgo	Hardwoods	Brazil
Phellinus noxius (Corner) Cunn.	Hardwoods	Circumglobal tropics
Phellinus pachyphloeus (Pat.) Pat.	Hardwoods, conifers	Circumglobal tropics
Phellinus resinaceus Kotl. & Pouz.	*Eucalyptus* spp.	New Guinea

Specific information relating to risk elements

A. Likelihood of introduction

1. Pest with host–commodity at origin potential: *High* (VC) (Applicable rating criteria, from Chap. 1: c, d, e, g, h)

   Because *Armillaria*, *Phellinus*, *Ganoderma*, and other root-rot species are common worldwide and occur as cambium, root-, and butt-rots, any log harvested could be infected with one of these fungi. Incipient infections could easily escape detection. Because these species are excellent saprophytes, they do not need the living tree to exist.

2. Entry potential: *High* (VC) (Applicable rating criteria, from Chap. 1: b, c, d)

   The root- and heart-rot fungi can survive well as saprophytes. Therefore, they would easily be able to survive during harvest and transport to the United States. Given the likelihood of significant moisture availablity (in holds of ships, docks, holding areas, etc.) the conditions could well be ideal for growth of these fungi in the transported logs. Additional entry potential exists because rhizomorphs and mycelium of these species could be under the bark on poorly debarked material.

3. Colonization potential: *Moderate* (RC) (Applicable rating criteria, from Chap. 1: c, d)

   Because most of the root- and heart-rot fungi do not produce conidiospores or other easily disseminated propagules and are not vectored by insects, the probability of dissemination of these fungi from imported logs to appropriate substrates in the United States is low. However, basidiomes and basidiospores may be produced if these materials are exposed to extended or repeated periods of moisture. Although unlikely, such a possibility does exist. However, the opportunities for colonization appear to be moderate at the highest.

4. Spread potential: *High* (MC) (Applicable rating criteria, from Chap. 1: a, b, c, d, e, f, g)

   Spread of these fungi depends heavily on the effectiveness of the basidiospores in infecting an appropriate substrate–host. Because logs can be stored or moved from the port to some other part of the United States, the potential availability of a susceptible host is increased. If the logs are not kept sufficiently dry in storage, basidiomes could be formed, basidiospores produced, and the spread potential greatly increased.

B. Consequences of introduction

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

   These fungi could result in tree mortality by causing root-rots on stressed trees. Because of the predominant root-to-root spread of these species and the usual restriction to infection centers, spread would be slow. The economic impact also would be slow to develop and probably never be major. However, if introduced species of these fungi are effective at long distance dispersal and establishment of populations by basidiospores the economic impact could be much greater.

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

   The environmental damage caused by root-rot species likely to be imported is low because of their assumed ability to spread at only slow rates (Smith and others 1992). The probable restriction to infection centers will result in only minor environmental damage. However, under certain conditions and in certain areas, infection centers could cause significant damage, especially in ornamental and specimen trees. This raises the potential to moderate. A factor that is difficult to evaluate but should certainly be considered is the competition with native species and the impact on other elements of the ecosystem.

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

   Increased mortality in native forests and horticultural plantings could have significant social and political impacts only if the fungus spreads rapidly, which is not expected for the species of root- and heart-rot fungi being discussed.

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

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Reviewers' comments—"I just noticed in the Checklist that *Laetiporus sulphureus* is reported on eucalypts in Brazil and Argentina. I knew about Brazil before, but forgot to put it on the list. Maybe it should be included in this chapter." (Hodges)

"The PRA process for individual pests is explained clearly on pp. 2-10. However, those directions are not necessarily followed in the IPRA. For example, according to the documented PRA process, the colonization potential for root and stem rots (pp. 128-134) should be 'high'. Despite this, it is listed as a 'medium' risk in its IPRA. The reason for this is not clearly explained." (Johnson/Oesterbauer)

"Under colonization potential, if the probability of dissemination to appropriate substrates is low, the selection of 'b' as applicable risk criteria appears contradictory, as it would not then be likely that the organism would encounter favorable climatic conditions. If the spread potential depends upon the effectiveness of basidiospore production, and this likelihood remains uncertain, the rating on both nodes appears to be high." (Zadig)

Response to comments—Risk criterion b under colonization potential, "organism has high probability of encountering favorable climatic conditions throughout the ranges of potential hosts(s)", was removed as a selection. As stated in the text and pointed out by the reviewer, most of the root- and heart-rot fungi do not produce conidiospores or other easily disseminated propagules and are not vectored by insects; thus, the probability of dissemination, and the likelihood of encountering favorable climatic conditions, is moderate at best.

Although reported on *Euculyptus* in Argentina and Brazil, *Laetiporus sulphureus* was not included in Table 9 because of its cosmopolitan occurrence, including the United States. Any mitigation measures effective against the pathogens discussed in this individual pest risk assessment would also be effective against *L. sulphureus*.

Chapter 4. Summary and Conclusions

Background

Several U.S. forest industries propose to import logs and chips of *Eucalyptus* from South America for processing in various localities in the United States. Current regulations require that unprocessed temperate logs from countries in South America be fumigated with methyl bromide to eliminate pests. Logs must be stored and handled to exclude access by pests after treatment (Title 7, CFR Part 319.40-6(a)). Chips of tropical origin are required to be 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)). 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 plantation-grown *Eucalyptus* throughout South America, that estimates the likelihood of their entry on logs or chips of *Eucalyptus* species into the United States, and that 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.

The genus *Eucalyptus* is one of the most widely propagated trees in the world because of its fast growth rate, environmental adaptability, and high quality for pulp production. The planting of fast-growing trees, such as *Eucalyptus*, has been encouraged by various South American governments. Brazil has the largest amount of *Eucalyptus* plantations with more than 2.7 million hectares. Other countries with significant plantings include Argentina, Chile, Peru, and Uruguay. The pests of *Eucalyptus* in South America include those that have been introduced from other parts of the world, as well as those that have crossed over from native hosts in South American countries. Most of the potential hosts in the United States are *Eucalyptus* or other Myrtaceae, especially in Hawaii. However, other suspected hosts may be present that have not yet been exposed to these pest agents.

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. All team members worked on previous pest risk assessments related to log imports. Representatives from APHIS, USDA Forest Service, Forest Service retirees, and the governments of Argentina, Brazil, Chile, and Uruguay assisted the team. In March 1998, three members of the team traveled to Brazil, accompanied by a former Forest Service employee knowledgeable of the country and its *Eucalyptus* plantings and pests and by an APHIS representative. Officials of the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) coordinated the site visit. The team visited numerous plantings of *Eucalyptus* in various parts of the country, including in temperate and tropical conditions. They also visited processing mills and ports. The team spoke with various government officials, industry representatives, and members of academia to discuss the risk assessment and conditions in Brazil. A second team of three members traveled to Argentina, Chile, and Uruguay in April 1998. An APHIS representative accompanied them. Members of SENASA (Servicio Nacional de Sanidad y Calidad) in Argentina; Ministerio de Ganaderia, Agricultura y Pesca in Uruguay; and SAG (Servicio Agricola y Ganadero) in Chile assisted the team in coordinating the visit. This team also visited a number of plantations, ports, and mills, as well as persons involved in *Eucalyptus* management and pest management in each of the countries.

The team began the risk assessment process by compiling a list of organisms reported to be associated with *Eucalyptus* species in South America. From this list, insects and pathogens that have the greatest risk potential as pests on logs or chips were identified using risk analysis procedures recommended by APHIS (Orr and others 1993). Two of the five criteria that were identified in the log import regulations for identifying potential pests of concern were expanded in this assessment (Table 7). Criterion 2 was expanded to include 2a, pests that are present in both South America 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 also used a new set of criteria in determining the level of risk associated with each risk element. These criteria were developed by a team under the leadership of APHIS who are assessing the risk of the importation of pests associated with solid wood packing material.

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

Major Pests of *Eucalyptus* Species on Imported Logs or Chips

Some of the organisms of concern on eucalypts (for example, the leaf cutting ants [*Atta* spp., *Acromyrmex* spp.], *Gonipterus* spp., *Cephisus siccifolius*, *Sarsina violascens*, the foliar pathogens, and *Puccinia psidii*) would only be associated with logs as hitchhikers, most likely confined to the bark surface. Although these hitchhiking organisms are generally not considered likely to be found on logs, several were identified in the risk assessment as a moderate risk potential. These include *Gonipterus* spp., the fungi that cause foliar diseases, and *Puccinia psidii*. They merit a moderate rating because of their possible association with bark and their colonization potential, not because of severe consequences once introduced. *Sarsina violescens*, a lepidopteran that feeds on a range of hosts and is widely distributed, was identified as a high risk potential. The hitchhiking lepidopteran is representative of organisms that could use eucalypts as a vehicle to gain access to host plants of a different genus in the United States. It has characteristics somewhat similar to gypsy moth, *Lymantria dispar,* with its large host range and ease of spread. This suggests a high risk potential.

Insects and pathogens that inhabit the inner bark and wood have a higher likelihood of being imported with logs than do organisms on the bark, particularly in the absence of mitigation measures. Seven of these groups of organisms were rated as a high risk potential. The scolytid bark and ambrosia beetles (*Scolytopsis brasiliensis*, *Xyleborus retusus*, *Xyleborus biconicus*, and *Xyleborus* spp.) have not been identified as significant pests of eucalypts in South America. However, because of the broad host range of the ambrosia beetle, past records of human-assisted movement, and the ability to move in logs, they are of concern to other potential hosts in the United States. The carpenterworm, *Chilecomadia valdiviana*, is a native organism in South America that has crossed over to *E. nitens* from *Nothofagus*. The amount of damage it has caused is limited, even in other non-*Eucalyptus* agricultural products that it infests. It is rated high because of the presence of unknown associated fungi, which appear to produce more damage in the wood than the insect itself. The round-headed wood borers (*Chydarteres striatus*, *Retrachyderes thoracicus*, *Trachyderes* spp., *Steirastoma breve*, *Stenodontes spinibarbis*) are occasional inhabitants of *Eucalyptus*. Normally, they are secondary inhabitants of felled or weakened trees. The limited association of these insects with eucalypts in South America lessens the risk of introduction, although if they are infesting logs, they could enter the United States. They have been intercepted at United States ports. *Phoracantha semipunctata* is another high-risk organism that is known to be present in part of the United States. *Phoracantha semipunctata* was noted as one of the more significant insect pests of *Eucalyptus* during site visits. However, it was mostly a concern in trees under stress, especially associated with drought. This insect has been transported to numerous locations in the world, including South America and the United States. Its ability for ready transport, wide host range, high rate of spread, and significant damage where introduced merited a high rating. The Botryosphaeria canker fungi (*Botryosphaeria dothidea*, *B. obtusa*, *B. ribis*) were rated as a high risk potential because of their wide host range and their genetic variability. Another canker pathogen, *Ceratocystis fimbriata*, has demonstrated its ability to infect a wide range of hosts and cause considerable economic damage to some of these hosts. It is currently widespread in the United States. However, 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. A population genetically different from that found in the United States has been identified in South America. The consequence of the introduction of new strains or pathotypes of *C. fimbriata* into the United States is not known. *Erythricium salmonicolor* is a concern because of its broad host range and the high level of damage it causes under certain environmental conditions. Its introduction into Hawaii could result in major losses to the agricultural industry, as well as potential adverse effects to native ecosystems.

Several groups of insects and pathogens that inhabit the bark or wood of *Eucalyptus* were rated as having a moderate risk potential. The ambrosia beetle, *Megaplatypus parasulcatus*, is infrequently an inhabitant of eucalypts, preferring poplars as its hosts. It requires live host tissue to survive and oceanic transport would probably result in mortality of the insects as identified in crating material in Chile. These factors reduced the probability of establishment to moderate. If introduced into the United States, it could cause damage primarily to poplars in subtropical areas. Subterranean termites (*Coptotermes* spp., *Heterotermes* spp.) were rated moderate

Table 13—Summary of risk potentials for South American pests of concern for unprocessed *Eucalyptus logs* (on bark, in or under bark, or in wood) and 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								
Leaf cutting ants (*Atta* spp., *Acromyrmex* spp.)	L	L	H	M	M	H	M	L
Eucalypt weevils (*Gonipterus* spp.)	H	H	H	M	M	L	M	M
Flea of the tifa leaf (*Cephisus siccifolius*)	L	L	M	M	M	L	L	L
Purple moth (*Sarsina violescens*)	H	H	H	H	M	M	M	H
Pathogens								
Foliar diseases (*Aulographina eucalypti, Cryptosporiopsis eucalypti, Cylindrocladium* spp., *Phaeophleospora* spp., *Mycosphaerella* spp.)	M	H	H	M	M	M	L	M
Eucalyptus rust (*Puccinia psidii*)	M	H	M	M	M	H	M	M
In or under bark								
Insects								
Scolytid bark and ambrosia beetles (*Scolytopsis brasiliensis, Xyleborus retusus, Xyleborus biconicus, Xyleborus* spp.)	H	H	H	H	H	M	M	H
Pathogens								
Cryphonectria canker (*Cryphonectria cubensis*)	H	H	M	M	M	L	M	M
Botryosphaeria cankers *(Botryosphaeria dothidea, B. obtusa, B. ribis*)	H	H	H	H	M	L	L	H
Cytospora cankers (*Cytospora eucalypticola*, *Cytospora eucalyptina*)	M	H	M	M	L	L	L	M
Ceratocystis canker (*Ceratocystis fimbriata)*	H	H	H	H	H	M	L	H
Coniothyrium canker (*Coniothyrium zuluense*)	M	H	H	H	M	M	L	M
Pink disease (*Erythricium salmonicolor*)	H	H	H	M	M	H	H	H
In wood								
Insects								
Carpenterworm (*Chilecomadia valdiviana*)	M	H	H	H	H	M	M	H *(E. nitens*) M (2 other species)
Platypodid ambrosia beetle (*Megaplatypus parasulcatus*)	M	L	H	H	H	M	M	M
Round-headed wood borers (*Chydarteres striatus, Retrachyderes thoracicus, Trachyderes* spp., *Steirastoma breve*, *Stenodontes spinibarbis*)	H	H	H	H	H	L	M	H
Subterranean termites (*Coptotermes* spp., *Heterotermes* spp.)	M	H	H	H	M	M	M	M
Eucalypt longhorned borer (*Phoracantha semipunctata*)	H	H	H	H	H	H	H	H
Yellow phoracantha borer (*Phoracantha recurva*)	L	H	H	H	H	H	H	M
Pathogens								
Root and stem rots (*Armillaria* spp., *Phellinus* spp., *Ganoderma* spp., *Gymnopilus spectabilis*)	H	H	M	H	M	M	M	M

[a]H = high rating; M = moderate rating; L = low rating

because their addition to the United States fauna may not increase the economic damage already done by subterranean termites already present. Also, termite colonies would be very evident in eucalypt logs and could be excluded from entry by inspection. Although *Phoracantha recurva* represents a threat similar to that of *P. semipunctata* to eucalypts in the United States, it was rated as moderate rather than high because of its extremely limited distribution in Chile and its absence from production areas of *Eucalyptus* in that country. Cryphonectria canker, caused by *C. cubensis*, has been reported in Florida and Hawaii on eucalypts. The climate associated with these states is what is conducive to infection, so further new introductions would probably be limited, possibly to some Gulf Coast states. The limit for additional spread beyond its current occurrence reduced its risk potential to moderate. Because the Cytospora canker fungi (*Cytospora eucalypticola*, *C. eucalyptina*) appear to be of limited occurrence in South America and occur only on *Eucalyptus*, they received a moderate rating. Coniothyrium canker, caused by *C. zuluense*, is apparently a recent introduction to South America. Currently, its limited damage and distribution reduces the risk potential to moderate. Over time, if this fungus spreads, the potential may increase to high; although the area of damage in the United States would probably be principally in the warm, moist climates. The root and stem rots received a moderate risk potential rating. Limited occurrences of this group of organisms on *Eucalyptus* were reported, but their location in the wood and survival capability increase the opportunity for transport. The limiting factor in their establishment in the United States may be their restricted dissemination ability once they arrive.

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. Also certain life stages of defoliating insects may be attached to the bark. Within the first several weeks after felling, beetles and borers, such as *M. parasulcatus*, 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. 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 countries. These differences, such as debarking, can influence the risk potential for certain pests, especially hitchhikers and those that invade the inner bark. 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. Clearly, debarking and reducing logs to chips will seriously impact the survival and hence the risk of importing 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 IPRAs for insects, all would be rated at moderate or low risk of surviving chipping and transport. 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 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. Chips on the surface of undisturbed chip piles will be unaffected by heating. Although chipping, piling, storage, and transporting *Eucalyptus* may alter the risk of pest importation, other risks such as insect hitchhikers on transport vehicles would remain unchanged.

In addition to harvesting practices, some differences were noted among countries 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 countries. This is compounded by the fact that certain species of *Eucalyptus* are preferentially planted in certain countries. For example, most of the export from Argentina is expected to be *E. grandis*, *E. saligna*, and *E. dunnii,* while *E. grandis* and *E. globulus* are exported from Uruguay. *Eucalyptus globulus* is the only one of the above species commonly grown in Chile. The remaining species in Chile are not principal species in the other countries we visited.

Several factors suggest that eucalypt logs destined for export from South America may be relatively free of most damaging organisms. Commercial *Eucalyptus* plantations are well managed with the intent of maximizing production. This has resulted in the selection of species, provenances, and clones that are more resistant to insect and pathogen attack and in close monitoring to detect and control damaging pests. *Eucalyptus* is not native to South America; therefore many of its native pests are not present. Those that are present have been introduced. Of more concern, however, may be the pest organisms native to South America that have crossed over to *Eucalyptus*. This characteristic suggests an ability to have a wider host range and adaptability for new hosts. In fact, many of the organisms analyzed in the IPRAs are native to South American hosts and have crossed over to *Eucalyptus.* Some of these organisms are found in many areas of the world and have a broad host range, such as the Formicidae, subterranean termites, *Botryosphaeria* spp., *Cryphonectria cubensis*, *Erythricium salmonicolor*, and root and stem rots. Other native organisms have a more limited host range in South America but still are found on *Eucalyptus.* Some of these organisms have hosts only in the Myrtaceae family and include *Sarsina violascens* and *Puccinia psidii*. Organisms such as *Chilecomadia valdiviana, Megaplatypus parasulcatus, Cephisus siccifolius*, and ambrosia beetles are native to South America and are found occasionally in *Eucalyptus* but have other native and nonnative principal hosts. This indicates the ability of many of the insects and pathogens assessed to move to hosts other than *Eucalyptus* and, in some cases, in families other than Myrtaceae. Most of these other hosts are broadleafs, which suggests an increased risk to broadleaf species in the United States, especially in the East and Midwest. Introduction of these native South American insects and pathogens into the United States with the array of potential new host species could result in significant economic and ecological consequences.

Conclusions

There are numerous potential pest organisms found on *Eucalyptus* in South America 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 while others are affiliated with logs in a peripheral fashion but nonetheless pose serious threats to forest or agricultural hosts in the United States. Thus, the potential mechanisms of log infestation by nonindigenous pests are complex. Several of the rated organisms are more tropical in nature. Their ability to colonize hosts in much of the United States, therefore, may be more limited. However, consequences to Hawaii if introduced could be considerable because of the state's more tropical nature and the extent of endemic species, especially Myrtaceae, that are present there. Previous log import risk assessments have not included Hawaii as a potential port of entry. Because of the elevated risk to this state, we decided to include it in this assessment.

The situation of plantation-grown *Eucalyptus* in South America bears similarities to previous log import risk assessments, notably *Pinus radiata* and Douglas-fir from New Zealand and *P. radiata* from Chile. In all of these situations, the proposed export crop is relatively free of insects and pathogens because of the exotic nature of the host. The risk may be less in this assessment than the previous assessments since *Eucalyptus* is also not native to the United States. Also, *Eucalyptus* occurs in limited locations, notably California, Hawaii, and Florida. Any introductions of pest organisms, if limited to *Eucalyptus*, would have limited consequences. However, crossovers to native hosts could result in more significant adverse effects.

For those organisms of concern that are associated with South American *Eucalyptus*, 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 South America

Brazil: March 15–April 2, 1998

March 15

Five members of the Wood Import Pest Risk Assessment and Mitigation Evaluation Team departed on various flights from across the United States to Miami. We continued with an international flight to São Paulo, Brazil. The team members were Borys Tkacz, USDA Forest Service (team leader); Dennis Haugen, USDA Forest Service (trip coordinator); John Kliejunas, USDA Forest Service; David Reeves, APHIS; and Charles Hodges, retired from USDA Forest Service (interpreter).

March 16

The team was picked up at the São Paulo airport and driven to the campus "Luiz de Queiroz" at the University of São Paulo in Piracicaba. We met with Dr. Evoneo Berti Filho (entomologist) and Dr. Tasso Krügner (plant pathologist). Borys presented background information on the risk assessment process and our objectives. The draft lists of potential insects and pathogens of concern were discussed in detail.

About 300 species of insects are reported on eucalypts in Brazil, but only a few were introduced into Brazil (*Phoracantha, Gonipterus, Ctenarytaina*). All of the Lepidoptera species on the list are native to Brazil and their native host range is generally limited to the Myrtaceace family (which includes *Eucalyptus*). Dr. Berti Filho stated that the defoliating lepidopterans have egg stages that last 10 to 15 days; thus, transportation of eggs on export logs from the plantation to a U.S. port is very unlikely. *Sarsina violascens* is a significant pest in the state of Sao Paulo, and large population fluctuations have been observed. These sharp population decreases are thought to be due to parasites. These leafcutting ants are the major pest in the establishment of eucalypt plantations in Brazil. However, *Atta sexdens* probably could not establish in the United States because of the climate.

Dr. Krügner stated that most fungi on *Eucalyptus* in Brazil are part of pest complexes, with predisposing environmental factors involved in disease expression. *Cryphonectria cubensis* was a problem when *E. saligna* was the major species planted, but other resistant species and clones have largely replaced *E. saligna*. He stated that Puccinia rust is a problem only the first 2 years on plantation trees and is limited to foliage and small twigs.

We were given four forest insect manuals. The manuals deal with defoliating lepidopterans of eucalypts (Vol. 1), forest insects of southern Brazil (Vol. 2), termites (Vol. 3), and Scolytidae of tropical conifers (Vol. 4). We also viewed a leaf cutting ant colony, Cryphonectria canker, Puccinia rust, and several leaf pathogens of *Eucalyptus*. The team spent the night at the prefeitura on campus.

March 17

The team departed for the São Paulo airport and the flight to Curitiba, the capital of the state of Paraná. We were met by Sergio Ahrens (international coordinator, EMBRAPA). EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária) is analogous to the USDA Agriculture Research Service (ARS), and the Curitiba offices include the National Center for Forest Research.

In the afternoon, we met with Francisco Bellote (deputy chief of research and development) and explained the purpose of our visit. Erich Schaitza (research wood technologist) gave us an overview of eucalypt plantations in southern Brazil (the three southern states, Paraná, Santa Catarina, and Rio Grande do Sul). Of approximately 1,770,000 ha of forests in the three southern states, 270,000 ha are *Eucalyptus* plantations, mostly *E. grandi*s but also *E. dunnii*, *E. saligna*, and the urograndis hybrid. Erich also presented an overview of the *Eucalyptus* plantation situation in other areas of the country. Erich provided us with the proceedings from the IUFRO Conference on Silviculture and Improvement of Eucalypts (EMBRAPA 1997), which contained several papers related to insects and pathogens of eucalypts in Brazil.

Celso Garcia Auer (plant pathologist) reviewed the draft list of potential pathogens of concern with us and provided the team with a list of pathogens on *Eucalyptu*s that he had prepared. It was pointed out by Celso that Puccina rust, Cryphonectria canker, and the numerous leaf pathogens are problems only on young trees and are usually absent from plantations more than 2 years old. Heart-rot fungi have been studied little anywhere in Brazil.

March 18

In the morning, we met with the entomologists at EMBRAPA (Edson Tadeu Iede, Susete do Rocio Chiarello Penteado, and Dalva Luiz de Queiroz Santana). We discussed the species on the insect list in detail. Leafcutting ants are considered the most important insect pest of eucalypt plantations in southern Brazil. The weevil, *Gonipterus scutellatus*, has caused some outbreaks in Rio Grande do Sul (1956), Paraná (1978), and São Paulo (1990s). Adults have been found overwintering on pines (but not egg laying or feeding on pines). A very good egg parasite, *Patasson nitens* (=*Anaphoidea nitens*) (Hymenoptera: Mymaridae), has been introduced into Brazil. *Sarsina violascens* has a wide distribution—from Rio Grande do Sul to Para in northern Brazil. It is most important in the states of Minas Gerais and São Paulo. The ambrosia beetle, *Megaplayptus parasulcatus* (*Platypus sulcatus*), is native to Brazil and is very polyphagous. It attacks stressed trees, but it usually does not kill the tree. However, it does cause a defect in the wood. Its northern range is São Paulo, where it attacks *E. urophylla*, and it extends through southern Brazil where *E. robusta* is a host.

A number of cerambycids are found on eucalypts. *Phoracantha semipunctata* is an introduced pest from Australia. In the 1950s, it was found in Rio Grande do Sul, and it was found later in São Paulo in the 1990s. No record of establishment has been recorded for the states of Paraná or Santa Catarina. Native cerambycids have been found attacking eucalypts but are not likely to be associated with eucalypt logs. *Oncideres* species (*O. amputator, O. dejeani, O. vermiculata*) are twig girdlers; the adult beetle cuts the branch and then oviposits in the fallen branch. *Trachyderes* species (*T. striatus, T. succinctus*, *T. thoracicus*) are also twig girdlers, and their host range includes citrus, cassia, acacia, mimosa, scabrella, and eucalypts. Another longhorned beetle species, *Steirastoma breve*, rarely attacks eucalypts, and its life cycle is not well known. A generation takes 16 months in southern Brazil, but it can have four generations per year in tropical Amazon.

Edson gave us a tour of the entomology labs and a briefing on the biological control program for *Sirex noctilio,* an exotic woodwasp in the pine plantations of southern Brazil.

In the afternoon, we met with Dr. José Henrique Pedrosa-Macedo (forest entomologist, Federal University of Paraná). His specialty is Scolytidae. He has seldom found bark beetles and ambrosia beetles with eucalypt logs. Overall, there is a general lack of Scolytidae in the Southern Hemisphere—only 300 species collected over 60 years. The species present in Brazil have little potential to adapt to the climate in the United States. The ambrosia beetle, *Platypus sulcatus*, has been renamed *Megaplatypus parasulcatus*. It must have a living tree for a host. If the tree is cut, it will exit within a week and its brood will not survive. Brazil does not have quarantines on log imports. From his view, the greatest risk of Scolytidae introductions into Brazil are associated with the pallet material from the United States to South America. Dr. Pedrosa–Macedo reviewed the draft of the insects of concern table (Table 8) with the team and provided considerable information on those listed. He pointed out that although *Armillaria* is common on pines and *Araucaria*, he has observed the fungus only once on *Eucalyptus*. He stated that of approximately 4 million ha of *Eucalyptus* plantations in Brazil, 70% are *E. grandis*.

In the evening, the team flew from Curitiba to Belo Horizonte in the state of Minas Gerais. After a delay in São Paulo due to stormy weather, our flight arrived at the Belo Horizonte airport. The team spent the night in the town of Vespasiano.

March 19

In the morning, we drove to Viçosa in two rental cars. The Federal University of Viçosa is one of the major agricultural universities in Brazil. Profa. Rosangela D'Arc Lima de Oliveira (head of Plant Pathology Department) welcomed us to Viçosa. Borys presented an overview of the risk assessment process.

We met with Prof. Acelino Alfenas and Prof. Francisco Ferreira (forest pathologists) and discussed the list of potential pathogens of concern on eucalypts. Because both have published extensively on *Eucalyptus* diseases and have current, active research programs, the team received extremely useful and first-hand information regarding eucalypt pathogens present in Brazil. The team also learned about their relative importance and strategies used to manage them. During discussions of the pathogens of concern (Table 9), the professors pointed out that although species of *Cylindrocladium* and most other leaf pathogens are common up to the second year in plantations, they become hard to find after that. They have never observed *Armillaria* on *Eucalyptus*. We viewed ongoing lab studies on a recently described leaf spot of *Eucalyptus* caused by *Rhizoctonia*. Acelino and Francisco were students of team member Chuck Hodges when Chuck was at the university in the early 1970s on an FAO assignment.

March 20

Prof. Jose Zanuncio (forest entomologist) presented his research on Lepidoptera of eucalypts and the biological control project with hemipteran predators. All of the lepidopterans feeding on eucalypts are native to Brazil, and their hosts are the native Myrtaceae species. Generally these lepidopterans have short outbreaks (only a few generations), then their populations collapse because of physiological factors between the insect and host or because of biological control. Frequently, they have observed outbreaks in only a small part of a plantation (with same clone and soil factors), but they have not found the reason. They are studying population trends of the species by light trap collections in plantations. Inconsistent fluctuations have been common for most species—high in one year, then very low the following year. The geometrids, *Glena* spp., are a major concern in eucalypt plantations. They lay eggs under the bark (single eggs, very small) and can complete a life cycle in about 40 days. *Sarsina violascens* is found throughout Brazil and also has a short life cycle. However, biological control usually prevents outbreaks. *Timocratica palpalis* feeds on inner bark of living eucalypts and constructs a gallery in the wood for protection.

Genesio Ribeiro (consulting forester with the university) joined us, and we discussed the list of potential insects of concern associated with eucalypts. The subterranean termite, *Coptotermes*, is only found in the first meter of butt logs of

E. urophylla and *E. grandis* in Minas Gerais. They are starting to find more scales and other Homoptera on eucalypts, but none have reached pest status yet. Most species have not been identified, and no research has been started. Dr. Zanuncio pointed out that removing the bark and foliage would eliminate many pests as a concern. Some foliar fungi could survive on dried foliar specimens exported for ornamental use. Apparently, there are no restrictions on importation into the United States of dried foliage.

Prof. Robert Barreto, director of the new Plant Disease Clinic, gave us a tour of the new laboratories. We also had a short meeting with Prof. Carlos Sediyama (vice president of the university) and Profa. Maria Cristina Pimentel Campos (international affairs). We all agreed that the stop in Viçosa has benefited both parties, and we thanked the university for their cooperation and assistance. Prof. Ferreira presented information to the team, illustrated with slides, on the numerous leaf fungi and other pathogens of *Eucalyptus*. The day was concluded with a seminar to a packed auditorium of students and faculty. John gave an overview of the U.S. Forest Service and the mission of forest health protection. Dennis presented the case history of gypsy moth (an exotic pest) and Forest Service programs that help manage it. Borys talked about the general process of a pest risk assessment and the specific intent for this assessment.

March 21 and 22

We drove to Ouro Prêto, a historic gold mining town in the Serra do Espinhaço range on Saturday. The entire city is a World Cultural Heritage Site. We spent the remainder of the day walking the cobblestone streets and visiting the numerous churches and museums. On Sunday, we continued on to Belo Horizonte.

March 23

We were picked up by CAF Santa Barbara Ltda., the forestry subsidiary of Belgo Mineira Company, and driven to Bom Despacho, one of their regional environmental education centers. Roosevelt Almado (pest manager) and Augusto Rodriguez (forester) were our hosts. This region has 27,000 ha of eucalypt plantations. Eucalypt plantations were established to supply fuelwood to the ore refineries. Now, they are shifting their plantation management to produce saw timber, in addition to fuelwood. The current sawmill in the region has an output of 32,000 m^3 per year. A new sawmill is being constructed in the state of Bahia. The saw timber is for the Brazilian market. However, CAF is exporting pulpwood logs from Bahia to Europe (Finland, Sweden, Portugal, Spain, and Morocco). The logs are generally debarked mechanically the day the tree is cut. Approximately 60 days pass from the time of cutting until the logs leave the port for export.

The team was presented with a packet of information prepared by CAF, including tables of insect occurrence on *Eucalyptus* and other data on pests. Leafcutting ants are the major pest of plantations. CAF has an ant monitoring program and will enter a plantation to spot treat the ant nests every 15 months. They use a sulfluramide bait on big nests and dig up new nests. This program costs about US$600,000 per year. The former program, which treated 100% of the plantations every 6 months, spent US$3 million per year. Outbreaks of lepidopterans are sprayed by airplane, mist-blower (manual or tractor-mounted), or tractor with applicator (liquid or powder insecticide). The main insecticides are Bt or Deltamethrin (Decis-25 CE). Most common treatment is Bt with a tractor mist-blower usually covering 50 to 100 ha. Outbreaks have been limited. *Sarsina violascens* is only found in two of the CAF regions, and less than 1,000 ha have been attacked over the years. A geometrid, *Sabulodes caberata caberata*, has only occurred on 14,000 ha of plantations over the years, about 11% of the total area. Another geometrid, *Thyrinteina arnobia* mostly occurs in the Bom Despacho region. Its largest outbreak in one year was 1,500 ha (out of 126,000 ha of plantations).

We were given a tour of the Unidade de Industrialização de Madeira sawmill by Marcelo de Souza, the mill manager. The mill operates 44 h per week. *Eucalyptus grandis* and *E. cloeziana* are the two species. Logs with bark are trucked to the mill and stored in decks. The average storage time is 5 to 6 days in the dry season and up to 20 days in the wet season. The sawmill processes about 1,500 m^3 of log each month, all for the Brazilian market (about 70% for furniture and 30% for crates and pallets). The sawmill has a new facility for kiln drying. We did notice a few galleries and exit holes of a wood-boring beetle in *E. cloeziana* logs that had been on a deck for 30 days. They were not familiar with this borer, but it is most likely *Phoracantha semipunctata*. A blue stain fungus was observed fruiting on the cut end of several *E. grandis* logs. Blue stain is caused by either a species of *Ophiostoma* or *Ceratocystis*. Blue stain on eucalypt logs has not been reported previously. The team returned to Belo Horizonte that evening.

March 24

We flew to Salvador, the capital of Bahia and were met by Genesio Ribeiro (consulting forester from the Federal University of Viçosa) and the van driver from COPENER Florestal Ltda. We were driven to a COPENER office in Alagoinhas. We met with Jacyr Mesquita Alves (director of research and forest development). He briefed us on COPENER operations and provided team members with a packet of written materials on the company's operations, including information on insects and pathogens in their plantations. The most damaging pest is the leafcutting ant. Ants do not prefer *E. camaldulensis*, *E. citriodora*, or *E. maculata*, but these species have lower productivity than *E. grandis*, *E. urophylla*, and *uro-grandis* hybrids.

COPENER started eucalypt plantations in 1981 to produce fuelwood. Since 1985, the emphasis has been changed to pulpwood. Current production is 550,000 m^3 per year for domestic market and 330,000 m^3 per year for export to Europe, mainly Portugal. Logs for the local fuelwood market are not debarked. Logs destined for foreign countries (80% go to Portugal) are debarked in the field as soon after cutting as possible. Aracaju Port (in Sergipe) is used for the export logs. A new port facility is being planned at Aratu Port (in Bahia), just north of Salvador. Most existing ports in Brazil are government-owned and expensive; thus, private companies are building their own ports. Their breeding program, done with other private companies through a cooperative, is centered on *E. grandis*, *E. urophylla*, and uro-grandis hybrids. Clones are selected for growth rate, percentage cellulose, drought tolerance, and disease resistance. Growth rates of 60 to 65 m^3 per hectare per year have been achieved.

Genesio talked about the Forest Protection Program at COPENER, which includes fire, environmental preservation, and pest management. Insect and disease concerns are integrated into an overall program for forest protection, which includes fire and environment. Plantations are monitored for insect and pathogen problems once a month for the first 2 years. After 2 years, pests, including the leaf-cutting ants, are no longer present. Defoliating insects, which may be a problem during the dry season, have been controlled through the application of Bt. The largest outbreak occurred in 1988 by *Thyrinteina arnobia*, which defoliated 1,500 ha. They aerially applied a pyrethroid to control this outbreak, but now they use Bt (Dipel 400 g per hectare) for lepidopteran defoliators. In 1994, a complex of *Thyrinteina*, *Sarsina*, *Eacles*, and *Eupseudosoma* defoliated 300 ha. This defoliation was spotty in the plantations, and *E. cloeziana* was the most susceptible eucalypt species.

No direct control for pathogens is done, or needed. Disease problems are localized and sporadic and are nonexistent during periods of low rainfall. Diseases are being controlled through an aggressive genetic program that selects resistant clones. Because susceptibility to *C. cubensis* is the first trait looked for when selecting clones, the canker pathogen has not been a problem since the early 1980s.

The team spent the night in the town of Alagoinhas (and assisted Chuck with the celebration of his birthday).

March 25

Genesio took us to an 8-year-old uro-grandis plantation that was being harvested. The logs were being mechanically debarked in the field. The machine can debark logs up to 40 cm in diameter. Logs are usually debarked within one day of cutting. Logs are removed from the plantation within 7 days after felling, so the stump sprouts that develop will not be damaged by the machinery. We saw termite galleries in eucalypt logs stacked on the decks. The termites are present in the standing tree but only in the first meter. When the tree is cut, the galleries are very evident. The nests are usually only found in dead trees, so termites are not common in vigorous plantations.

The team then visited the Aracaju Port. Logs for export are trucked to the port and off-loaded in bundles containing 5 m^3 of logs (about 4 metric tons). Bundles are stacked in the port before being loaded on ships. The importer from Portugal allows 5% bark. We noticed that most of the logs were cleanly debarked. A few logs with stem deformities were not completely debarked, and an occasional log was not debarked at all. Galleries and exit holes of a wood-boring beetle were visible on a few debarked logs. A few logs had cut ends with cavities from decay that were large enough for termite nests to be present. Brazil inspectors have never refused to issue a certificate; Portugal has never refused a shipment from Brazil. The team arrived back at Salvador at 10:00 p.m. that night.

March 26

With an early morning flight from Salvador, we arrived in Brasilia, Distrito Federal, at 9:00 a.m. We were met at the airport by a driver from EMBRAPA and were taken to the EMBRAPA/CENARGEN (do Centro Nacional de Pesquisa de Genéticas e Biotecnologia) Center (Plant Quarantine Laboratories for Brazil). We met with Maria de Fatima Batista (virologist and head of the Plant Health Group), Arailde Fontes Urban (mycologist), and Denise Mavia Magalhaes Ferreira (entomologist). Borys presented background information on the risk assessment process and on our objectives. Though this group does not specifically work on forest or plantation pests, they were able to provide us with a list of quarantine pests from the Southern Cone countries. The pests are given an A-1 rating (do not have and do not want) or an A-2 rating (have in limited areas). The A-1 list had 19 species listed as forest pests but only one for eucalypts (*Xyleutes magnifica*, Lepidoptera). The draft list of potential insects of concern was discussed. Maria commented that hitchhiking insects may be of concern, in route to and at the port, and that foliar feeding Lepidoptera would not be a problem.

In the afternoon, we met with Dr. Jose C. Dianese, plant pathologist with the Federal University of Brasilia. He has done research on bacterial wilt, Puccinia rust, and other diseases of *Eucalyptus* and is now concentrating on the taxonomy of fungi associated with native vegetation of the cerrado. Jose, a graduate of University of California-Davis, provided the team with extensive information on the draft version of the pathogens of concern (Table 9) and with personal insights on the *Eucalyptus* diseases in tropical Brazil, including bacterial wilt, Puccinia rust, and pink disease. Bacterial wilt, caused by *Ralstonia* (*Pseudomonas*) *solanacearum*, can cause local problems on recently cleared land in the Jari area, causing up to 35% loss of cuttings in some areas. The bacterium is an indigenous organism associated with the rhizosphere of numerous native plants. Three biovars of the organism are present in Brazil; the banana wilt biovar is not. The tropical rust *Puccinia psidii* is a very minor problem and only on juvenile growth. Jose pointed out that there are biotypes of *P. psidii* and that the rust is much more virulent on the introduced *Eucalyptus* host than on the native guava (*Psidium*) host. Jose stated, as had others the team had visited, that most diseases of *Eucalyptus* in Brazil are controlled by genetics (if one provenance is susceptible, select another one). A discussion of the "seca de ponteiros", or dieback, problem followed. The problem occurred primarily in the valley of the Rio Doce, east and northeast of Belo Horizonte. Symptoms include a general dieback of the tree, followed by attack of one or more secondary fungi in the crown. Although soil and environmental factors have been suggested as the cause, the exact etiology of the dieback has not been determined. The problem can be avoided by growing provenances suited to the site.

March 27

Our next appointment was with the Ministry of Agriculture. We were greeted by Joao Carlos de Souza Carvalho, the plant protection coordinator, and two members of his staff, Paccelli Jose Maracci Zahler (chief of Plant Quarantine and Transit Division) and Odilson Ribeiro e Silva (chief of Prevention and Pest Control Division). Discussions centered on regulations for movement of wood products within Brazil and port inspections for wood exports. The Division of Plant Quarantine and Transit has representatives in all states, at all ports of entry, and at all border crossings. Phytosanitary certificates are issued based on information from field inspections and from inspections at the port. This Division has agreements with EMBRAPA and with the universities to identify any unknown insects found. As part of any inspection, this Division has a work plan containing a checklist of all requirements of the importing country.

We had hoped to meet with IBAMA (the Federal Natural Resource Agency) in the afternoon, but the major forest fires occurring in the Amazon Basin (state of Roraima) had occupied the staff. Therefore, we were not able to meet with the appropriate people.

March 28

Borys departed the team and took a series of flights back to Phoenix. The remainder of the team had the day to see sites of interest in Brasilia, including the Houses of Congress, Kubitschek Memorial, Catedral Metropolitana, Temple da Boa Vontade, Sanctuario Dom Bosco, presidential Palacio da Alvorada, and the native cerrado vegetation surrounding the city.

March 29

Sunday was spent flying from Brasilia to Monte Dourado in the Amazon Basin. After a 2.5-h flight to Belem, capital of Para, and a 4-h layover, our flight departed for Monte Dourado through lightning and thunderstorms. We arrived in Monte Dourado at 9:30 p.m.

March 30

Jari Celulose S.A. arranged a guide for us, Euclides Luiz Reckziegel, a forestry research technician. Euclides has been with Jari for more than 30 years and was very knowledgeable about the forestry operations. He took us to one of eight genetic reserves of tropical rainforest that Jari has set aside. The reserve is 2,000 ha and has more than 430 tree species, of which 56 species are commercial. The eight reserves (35,000 ha total) contain 8,500 marked trees. Ten percent of these are observed monthly, and phenological characteristics are recorded. We saw a Brazil nut tree (pollinated by a large brown moth called mamagaba) and a quinine tree (bark is used to make a tea for treatment of malaria).

Jari mostly uses *E. urophylla* and the uro-grandis hybrids. The best growth is from clonal material with the best performer producing 118 m^3 per ha per year at age 6. Eucalypt plantations produce an average of 33 metric tons per hectare per year. We viewed Jari's nursery, which produces 7 million rooted cuttings per year. Plantations are established during the wet season (April and May are the wettest months), and 97% to 98% seedling survival is expected. Blocks are planted with a single clone, and these blocks are limited to a maximum of 80 ha. We inspected several log decks for pests, and found them to be quite clean. Normally, the logs are in the field decks for 1 to 2 weeks (4 weeks maximum) before being transported, via the road system or the 70 km of railway, to the mill.

Jari also has a bauxite mine. After mining, the land reclamation is done by the Forestry Section and eucalypt plantations are established. Topsoil is piled separately and is added back to the top before planting.

We saw one of the last melina (*Gmelina arborea*) plantations. This species was initially the primary plantation species for Jari. In 1980, 68% of the plantations were melina, and 3% were eucalypts. After trial plantations on the various soils, only about 20% of the land for plantations was suitable for melina, which was not enough for viable pulp production. Melina was also susceptible to a canker disease, caused by *Ceratocystis fimbriata*. More emphasis was put into pine production and later into eucalypt production (currently about 85% of the plantations are eucalypts).

March 31

Euclides took us to eucalypt plantations on the better soils. We viewed more log decks and found the logs to be quite clean with only a few termites and a blue stain fungus (similar to the fungus seen at CAF). Euclides also took us to a huge Brazil nut tree (*Bertholietia exceisa*) that was approximately 30 m tall and more than 14.5 m in circumference. Jari is evaluating trees for nut production and is selecting trees that are consistent producers. A mature tree can produce 400 L of nuts per year.

At Jari's Education Center in Monte Dourado, we saw the collections of wood from trees native to Jari land (430 species), fruits, herbarium sheets, and insects.

In the afternoon, Roberto Pacheco (research manager) gave us a tour of the pulp mill at Munguba. Jari has 1,682,000 ha of land, but only 70,000 ha are in plantations for pulp production (85% eucalypts and 15% pine). The pulp mill is currently producing 290,000 metric tons per year, but it has the capacity to produce 400,000 metric tons per year. Thus, Jari will continue to use its eucalypt logs for pulping and not be an exporter of eucalypt logs for the foreseeable future. Jari is currently harvesting plantations at age 5.5 years. They want to extend that to 6.0 years in 1999 and to 6.5 years in 2000. Logs are debarked and chipped at the mill site. They maintain a chip pile to supply the mill, and the maximum storage time is 8 days. A metric ton of pulp is produced from 4.4 metric tons of eucalypt log with bark. The pulp is packaged in 250-kg boxes for export. The main destination of the pulp is Europe, but some is also sent to Japan and the United States. The processed pulp is then reconstituted to produce writing paper and tissues. The port can take ships up to 30,000 metric tons. Jari is unique in its low transport distances. The average haul for logs from the plantations to the mill is 45 km, and the mill is adjacent to the port.

Jari and the story of this pulp mill have been featured in National Geographic (May 1980: "Jari: A Billion Dollar Gamble"). The pulp mill was constructed in Japan on two barges, then pulled by tugboats across 25,000 km of oceans for 87 days to its permanent site on the Jari River in 1978. Jari was the vision of Daniel Keith Ludwig, an American industrialist. He bought the land in 1967 at the age of 70. Jari built the town of Monte Dourado and its infrastructure to support the workers (current population 8,000). In addition to its forestry operations, Jari has projects in water buffalo management, hydroelectric generation, bauxite and kaolin mining, and rice production. Jari is now owned by the Caemi Group, a Brazilian consortium.

April 1

Our Nordeste flight left Monte Dourado and arrived in Belém. The team spent the remainder of the day at the Museu Emílo Goeldi. The museum, which consists of a park with many native and exotic trees, permanent cultural exhibits, zoo, and aquarium, is a research institution for the study of the flora, fauna, peoples, and physical environment of the Amazon. The visit provided the team with an excellent summary of what we had observed during our visit to the Amazon.

April 2

Our international flight departed from Belém to Miami (with a stop in Manaus). In Miami, team members caught their domestic flights and arrived home that evening.

Argentina, Uruguay, and Chile: April 13–30, 1998

April 14

Three members of the Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET) (Andris Eglitis, Harold Burdsall, and William Wallner), accompanied by APHIS/International Services Deputy Assistant Director for Preclearance Carolyn Cohen, arrived in Buenos Aires, Argentina. In the afternoon, the team met with several officials from the Direction of Forestry within the Ministry of Agriculture (Dirección de Forestación, Secretaria de Agricultura, Ganadería, Pesca y Alimentación [SAGPyA]). The director of the Direction of Forestry, Jose Luis Darraidou, introduced other participants in the meeting including Eduardo Cosenzo (director of Plant Health), Cynthia Ruiz (staff member from Plant Quarantine), Diego Quiroga (staff member from National Direction of Plant Protection and Argentina's representative to COSAVE, Comite de Sanidad Vegetal del Cono Sur), and Elvira Bedrai (staff member from Silviculture). Director Darraidou explained the structure and role of the Ministry of Agriculture (SAGPyA). SAGPyA manages all aspects of forestry that relate to protection and production. National parks, reserves, and the wildlife resources are all managed through the Ministry of Natural and Renewable Resources (Secretaria de Recursos Naturales y Renovables). Within the Ministry of Agriculture, the National Service of Agricultural Health and Quality (Servicio Nacional de Sanidad y Calidad Agroalimentaria [SENASA]) contains programs in forestry, silviculture, and agriculture. It also includes the plant health agency, Dirección de Sanidad Vegetal. SENASA is in charge of phytosanitary inspections in forest plantations and takes the lead in all pest programs involving Argentina's forest resource. At this time, SENASA does not have a specific program for pests of *Eucalyptus* because there have not been any major problems associated with the host.

COSAVE is the Southern Cone Plant Health Committee that has Argentina, Brazil, Chile, Uruguay, and Paraguay as members. The committee was officially formed in 1989 to address pest problems at the regional level. The member countries of COSAVE all have their own protocols on subjects such as regulating crating and dunnage, but work together and share reports of pest interception records. COSAVE also has seven permanent working groups dealing with plant quarantine, forest and plant health, biological control, vegetative propagation, analytical methods, pesticides, and phytosanitary certification. The permanent work group dealing with forest and plant health has developed regional A1 and A2 quarantine pest lists for forest species, has identified potential pathways of introduction of these pests, and has formed a project of technical cooperation for monitoring and control of the woodwasp *Sirex noctilio*. This committee provides technical advice to MERCOSUR.

MERCOSUR (Mercado Comun del Sur; the Common Market of the South) is an organization intended to promote free trade. Currently, the member countries are Brazil, Uruguay, Paraguay, and Argentina, with Chile, Bolivia, and Peru soon to join. MERCOSUR contains several working groups and advisory committees that address diverse aspects of trade such as transit, economics, and harmonization of legislation.

Mr. Darraidou described the forest resource in Argentina. At the beginning of the 20th century, about one-third of the country was covered by native forests (100 million ha). In the north, much of this forest resource consisted of dry mesquite (*Prosopis* spp.) and related species such as quebracho blanco (*Aspidiosperma quebracho-blanco*) and quebracho colorado (*Schinopsis quebracho-colorado*). Elsewhere, the native forest included diverse species known by their Argentine common names as walnut, cedar, laurel, *Araucaria,* and others. Many of the native forests were heavily exploited in the first few decades of the 20th century to provide railroad ties and other products for a growing nation. Now, about 35 million ha of native forest remain, and only half of that total is manageable as a sustainable resource.

The practice of forestry is fairly recent in Argentina. Intensive plantation-based forestry began in the 1940s, and there are currently almost 800,000 ha of plantations in the country. About 86% of this resource is composed of comparable amounts of pines (primarily *Pinus elliottii* and *P. taeda*) and eucalypts.

The *Eucalyptus* resource, according to Mr. Darraidou, now covers 120,000 ha in Argentina. Most of the plantations are found in the northeastern provinces of Corrientes and Entre Ríos, with others in Buenos Aires province. The primary species are *Eucalyptus grandis* and *E. globulus.* Lesser but still important species of *Eucalyptus* in Argentina include *E. saligna, E. viminalis,* and *E. camaldulensis.* There are various levels of processing for *Eucalyptus*, and about 35% of the production is exported in the form of logs and chips.

Argentina's export trade of *Eucalyptus* began in 1988. Key markets include Japan (which receives logs and chips of *E. grandis* from the provinces of Entre Ríos and Corrientes), and Spain, Morocco and Finland. The port of Concepción del Uruguay in the province of Corrientes is one of the key ports for export. We inquired if there had been any pest interceptions or complaints from importers regarding the phytosanitary condition of *Eucalyptus* products from Argentina and were told that there were none.

Other key areas of intensive forestry include the pine (*Pinus elliottii* and *P. taeda)* plantations of Misiones province, the Delta of the Paraná River where poplars and willows are planted, and the Patagonia region with ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*).

Thus far, the limitations to forestry are purely those associated with site quality rather than with biotic factors. Intensive forestry in Argentina has considerable room for expansion, as the total area suitable for plantation forestry has been identified at an additional 20 million ha.

Currently, local needs for wood are generally being met by local production, although some wood flooring is imported from Chile.

We asked a number of questions regarding the COSAVE quarantine list of organisms and the means available to deal with potential pests in Argentina. Mr. Darraidou explained that quarantine organisms are studied by the universities and by INTA (Instituto Nacional de Tecnología Agropecuária), the national research organization under the Ministry of Agriculture (SAGPyA). There are also diagnostic laboratories at both the national and provincial levels. Some of the key quarantine pests for *Eucalyptus* in Argentina include *Cryphonectria* (=*Diaporthe*) *cubensis, Ctenarytaina* sp., and *Armillaria* spp. Argentina is also concerned about the introduction of the gypsy moth, *Lymantria dispar*. Current problems associated with forestry include the woodwasp *Sirex noctilio* in pines and the ambrosia beetle *Megaplatypus parasulcatus* in poplars. Specific organisms of concern in *Eucalyptus* include ants (*Atta* spp., *Acromyrmex* spp.) and weevils (*Gonipterus* spp.) in recently established plantations and the cerambycid wood borer *Phoracantha semipunctata* in stressed trees. There are active programs of biological control for both the woodwasp in pines and the weevil on *Eucalyptus.*

April 15

In the morning, the team traveled to Concordia in the province of Entre Ríos. This province, together with Corrientes and Misiones to the northeast, forms the Mesopotamic Region of Argentina, so named for the two large rivers that border the region to the east and west. The Uruguay River separates this region from Brazil and Uruguay to the east, and the Paraná River forms the western border with other provinces of Argentina and the northern border with Paraguay. The Mesopotamic Region is very important for plantation forestry with *Eucalyptus* predominating in Entre Ríos, pines being more important in Misiones, and an equal mixture of the two genera in Corrientes.

We were met in Concordia by Martin Sanchez from the local research station (Instituto Nacional de Tecnología Agropecuária–INTA) and Ricardo Tommasi from the Entre Ríos provincial office of SENASA. Mr. Sanchez had arranged for the team to meet with experiment station entomologist Norma Vaccaro and plant pathologist Sergio Garrán. Both of these specialists work primarily with pests of citrus and deal with forest pests on an occasional basis as the needs arise. We discussed our preliminary pest list with both specialists. Norma Vaccaro added a native defoliating insect, *Pyrrhopyge pelota* (Lepidoptera: Hesperiidae), which is the only known defoliator of *Eucalyptus grandis* in Entre Ríos Province. Feeding damage by this insect is sporadic and usually of little consequence. *Pyrrhopyge pelota* also defoliates some fruit trees including *Psidium guajava.*

Phoracantha semipunctata is considered the most important insect associated with *Eucalyptus*. The wood borer infests only trees that are dying or debilitated. Stand-level problems only arise under extreme conditions such as those brought about by droughts. Wood infested by *Phoracantha* is easily recognized since the larvae make meandering galleries in the cambium before entering the sapwood. Sawmills and export sort yards both require that borer-infested wood be separated out from sound wood.

Since our preliminary list of insects of concern (Table 8) included several other wood borers (*Trachyderes* spp.), we inquired about their status in Argentina. We were told that these other species occur in *Acacia* and citrus but are not found in *Eucalyptus*.

Another important problem associated with *Eucalyptus* in this area concerns ants of the genus *Acromyrmex*, particularly *A. lundi*. These insects feed aggressively on foliage in young plantations and resprouts and require control for plantations to be successful. Typically, damage is most severe in the first 6 months of tree growth. Similarly, young eucalypts are also infested by weevils of the genus *Gonipterus*. The female weevils deposit eggs on the foliage, and developing larvae consume the leaves. These insects, although abundant in plantations, do not have an association with the bark or wood of their hosts. (These weevils also feed on the foliage of pines in the first 3 years after a plantation is established.)

During the Brazilian visit, termites were found in the base of standing *Eucalyptus* trees. We were told that this does not occur in Argentina. Another association we questioned involves the ambrosia beetle *Megaplatypus parasulcatus*, which has *Eucalyptus* as a primary host in New Zealand and Australia. In Argentina, *M. parasulcatus* occurs on poplars, particularly in the Delta of the Paraná River and the only association with *Eucalyptus* has occurred when freshly cut lumber from Entre Ríos has been transported to that region. Given its severity in poplar, there is a regional program of biological control for *M. parasulcatus* administered by SENASA. Another ambrosia beetle, *Xyleborus* sp., is found in Argentina but is not associated with *Eucalyptus.*

Diseases also do not appear to be important on *Eucalyptus* in this province. Neither *Phytophthora* nor *Armillaria* have been found in Entre Ríos. Only *Coniothyrium* has been found and is being studied by M.J. Wingfield, University of Pretoria, Republic of South Africa.

Some manufacturing of *Eucalyptus* occurs in Entre Ríos, although production is relatively minor in terms of the world market. A local mill called Fiplasto makes high-density hardboard from a mixture of *E. camaldulensis*, *E. tereticornis*, *E. viminalis*, and *E. grandis*. Other products from this area include peeled and sliced veneers. A Chilean manufacturing company called Masisa is also in the area, producing lumber, medium-density fiberboard, and particleboard from pine and *Eucalyptus*. Other Chilean companies presently with holdings in the area include Alto Paraná, Shell Oil, and Arauco. Dry kiln capacity is fairly limited but does exist. There are 30 kilns in Argentina, all associated with sawmills.

In the afternoon, we visited the experiment station's *Eucalyptus* plantations. Since 1982, INTA-Concordia has been conducting extensive field trials of seed sources and performance for several species of *Eucalyptus* including *E. grandis*, *E. dunnii*, and *E. saligna*. Martin Marco, the principal investigator, has worked with 150 different clones from Australia. Considerable variation in tree growth and frost resistance has been found during these trials. To maintain genetic diversity within the preferred provenance, seeds for outplanting are collected directly from Australia and from seed orchards in South Africa. Some work is also being done with hybrids (for example, *E. robusta* × *E. botryoides*) but on a smaller scale. The proper selection of seed sources and treatments such as fertilization are enabling growers to harvest *Eucalyptus* within 10 to 14 years after planting.

We discussed the import–export regulations in Argentina. Imports and exports must be accompanied by a phytosanitary certificate. Wood products entering the country must be free of bark. There are special regulations for tissue culture and Christmas trees, although a pest risk assessment has been done for Christmas trees from Canada and the United States, and those can be brought into the country. There are no special regulations for research materials; these must follow the standard protocols for entry. The question was raised to our team about regional differences that might exist in the pest status of *Eucalyptus* from one country to another and how we would deal with this issue. We speculated that our report would recognize those differences and might recommend distinct mitigation measures depending on numerous factors such as the level of interaction of the countries, the nature of the pests, and other factors.

April 16

The team traveled with Martin Sanchez to visit the port of Concepción del Uruguay. En route to the port, we learned a number of things about the province and its forest resources.

Paraná is the provincial capital and largest city in Entre Ríos, with 200,000 inhabitants. Concordia has a population of 140,000, while most other towns in the province are considerably smaller. The countryside along the Uruguay River between Concordia and Concepción del Uruguay is savanna-like with scattered palm trees and coarse grasses. *Eucalyptus* plantations of all sizes are scattered throughout the area. Many of these plantations are owned by people primarily involved in some business other than forestry.

Over the years, the Argentine government has sponsored various programs that offered financial incentives to landowners for forestation. Between the 1960s and 1975, the government offered tax breaks for investing in plantations. This system was replaced in 1975 by a payment subsidy where 75% of the total cost of site preparation, planting, and thinning were subsidized. Under the current system that began in 1990, the landowner is reimbursed about half of the cost of establishing a plantation provided that certain conditions are met. To qualify for reimbursement, the land must be suitable for forestry and the trees to be planted must be selected from a list of species determined to be appropriate for that site. Once the plantation has been established, there are additional subsidies for pruning and thinning later in the rotation. These subsidies apply for the entire country and for all species of trees. Foreign investors are also able to receive these subsidies, generally for the first 10 years.

The Province of Entre Ríos has about 3 million ha of good-quality forestable land, 2 million of which could produce 20 to 30 m^3 of volume per hectare per year. About 200,000 ha could produce more than 30 m^3 of volume per hectare per year. Land suitable for forestry is more readily available and cheaper than in Chile or Brazil. Current costs for forestable land in Entre Ríos range from US$400 per hectare to US$800 per hectare, depending on the site quality. Forest land is even cheaper in Corrientes province, but owners receive lower stumpage prices because they are further from transportation facilities and lack the industrial infrastructure of Entre Ríos.

There are more than 100 sawmills in Entre Ríos and less than 20 in Corrientes. The sawmills in Entre Ríos buy logs from Corrientes, sometimes from more than 200 km away.

The growth rates of *Eucalyptus* in Entre Ríos rival those of Chile, Uruguay, and the Republic of South Africa. On a 10-year rotation, the growth averages 35 m^3 per hectare per year and in some cases reaches 55 m^3 per hectare per year. The key product derived from *Eucalyptus* grown in Entre Ríos is lumber, although other parts of Argentina produce rustic furniture and poles.

The clearcut is a common form of harvest for *Eucalyptus.* The stems sprouting from the stumps are then managed as a second rotation. We learned that there are occasionally problems with decays from the original stump entering the resprouting stems.

We were met at the port of Concepción del Uruguay by Mr. Enrique Papetti of the local office of SENASA. He showed us the facilities and explained that this is a key port for the transport of wood. The harbor is very shallow and only allows ships to be filled to 60% capacity. The loads are topped off downriver in the port of Ibicuy with wood of the same species. Typically 13,000 to 19,000 tons can be loaded in this port, and the final load will be around 25,000 tons after Ibicuy. The government has plans to dredge the harbor and increase the depth from 5.8 to 6.7 m. This key port lies 300 km from Río de la Plata and another 50 km from the ocean.

We had an opportunity to view a load of pulp logs of *Eucalyptus grandis* ready to be transported from the sort yard of Savinor, S. A., owned by Mr. Saverio Gualtieri. We saw that large bundles of logs were sitting on a dirt surface and contained soil, grasses, leaves, and small branches. We were told that the soil is not washed from these logs before they are shipped. Most of the logs were free of bark, but some had extensive bark remaining. We noted some superficial decay and extensive checking in the logs. We inquired if Mr. Papetti ever rejected logs for any reason and he informed us that he had done so on occasion for decay. He said that in his inspections of logs he had not come across evidence of ambrosia beetles. These logs were destined for Spain and Finland. We learned that each company has its own sort yard and that it is not uncommon for wood to be in storage for 1 to 3 months until sufficient quantities have been accumulated to fill a ship (15,000 bundles).

There is considerable variation in the effort required to debark different species of *Eucalyptus. Eucalyptus grandis* is the easiest species to debark, and the bark is often peeled before the tree is felled. However, if bark is not removed from the tree within 3 days of felling, debarking becomes extremely difficult. For this reason, the debarking of *E. grandis* either before or immediately after felling is an essential standard practice for this species. Other species such as *E. camaldulensis* and *E. tereticornis* are harder to debark than *E. grandis*.

We visited Paul Forestal, the largest tree nursery in the area. The nursery can produce 8 million seedlings per year grown in two rotations of 4 million each. *Pinus elliottii, Eucalyptus grandis,* and *E. dunnii* are produced for sale to private individuals and companies who order these seedlings for establishing plantations. Eucalypts are produced from seeds imported from Australia and South Africa and are ready for sale 3 months after seeding. Pines are grown for 5 months before being sold. The nursery uses ectomycorrhizal fungi applied through the watering system for both pine and eucalypt seedlings. We inquired about pest problems associated with the nursery and were told that damping off sometimes occurs. The nursery has its own diagnostic capabilities for pest problems and does not rely on specialists from SENASA.

Paul Forestal also has extensive plantations on their property of 650 ha. We examined an 11-year-old *Eucalyptus* plantation next to the nursery. The plantation had suffered frost damage when 2 years old, and had been cut at that time, leaving the stumps to resprout and grow for the past 9 years. The original stumps had begun to show signs of decay, and we speculated that the decay might be present in the bases of the new shoots as well. Some carpenter ant (*Camponotus* sp.?) nests were also evident at the bases of live trees, but the ants were apparently not infesting the wood. We also found some fruiting bodies of a root fungus, possibly *Gymnopilus* sp., at the base of a live eucalypt in the plantation.

In the evening, we flew to the town of Paso de los Libres in the southern portion of the province of Corrientes.

April 17

In the morning, we met with provincial SENASA representative Luis Ezama and with personnel from the Direction of Forest Resources Carlos Jacobo (director) and Wilda Ramirez (coordinator of services for Plant Health) for the province of Corrientes. Our plan for the day was to travel the highway from Paso de los Libres to the city of Corrientes. We planned to visit a number of plantations and learn about processing facilities for *Eucalyptus* along the way.

We visited a plantation of *E. grandis* established in 1977 using seeds from INTA. The plantation was located adjacent to a site where a large multiproduct mill is being proposed to be built. The mill will produce lumber from the larger logs and will chip smaller logs for pulp. The wood supply for the mill will come from the adjacent landholdings of Mr. Gualtieri (owner of the mill) and from other growers in the area. Two harvest entries are planned for this plantation; the first to remove material for poles, and secondly a clearcut of the remaining stems in 5 years. The first resprout from the stumps will also be managed to a harvestable age and then new seedlings of genetically improved stock will be planted between the old stumps. We inquired about problems associated with various plantations such as these. (Bill Wallner found a leafroller here. Although it was not identified, we were told that these insects only occur in small trees in the first year of the plantation). Decay in wood is not normally associated with old stumps and is apparently only a problem when a plantation is subjected to a fire. We once again found evidence of fruiting bodies of a fungus similar to *Gymnopilus*, a root pathogen. There were problems with ants during the establishment of the plantation, but once the trees reached 1.2 m in height, the problem subsided. In some areas, the cost of controlling ants is around US$300 per hectare. At one time, heptachlor was used for control but it has been replaced by permethrin and chlorpyriphos, which are less effective, especially on moist sites. There have been significant problems with soil compaction in some areas, and a subsoiler has been used to reduce the problem.

A second plantation in the area was 9 years old and originated from sprouts after the harvest of the initial plantation. Typically, there are numerous sprouts per stump, and all but two are usually thinned out to concentrate growth onto fewer stems. In this plantation, we noted numerous termite nests made of hardened mud and usually located near an old stump. The termites appeared to be contained entirely within their mud nests and not associated with the live trees in the plantation. We were unable to determine the species of these termites. Our hosts told us that stumps from some of the South African seed sources break down after 3 years. We noted high numbers of biting ants living in some of these decomposing stumps. Some problems occur with compaction, especially in the heavier soils, and replanting is occasionally necessary. Ant hills and termite mounds are used to judge site quality for planting; when termite mounds are abundant, the soil is generally heavy and wet and not suitable for forestry. We examined another plantation established as a clonal study from INTA-Bahia. There appears to be a strong emphasis to maximize growth rates, and such clonal studies as these are quite common. This plantation was alongside another trial of a hardwood from Australia, *Grevilea robusta*, which grows almost as well as *Eucalyptus* and is being tested as a possible wood for furniture.

We also had the opportunity to view a plantation that had been affected by a wildfire. We learned that *Eucalyptus* is very sensitive to fire but will resprout vigorously after being damaged. The trees damaged by fire were infested by *Phoracantha semipunctata* within about 8 days. The infested wood is easily separated from sound wood.

We drove along a 1-million-ha marsh on the way to Corrientes. We passed by a phytosanitary control checkpoint that spot-checks cars, and they waved us through. Some of the land is planted in blocks of *Eucalyptus* to provide shade for cattle. The area around Corrientes has an extensive cattle industry and is also famous for a variety of fish.

Mr. Jacobo described some of the native forests in the province. These cover from 300,000 to 500,000 ha and include such species as *Tabebuia, Jacaranda*, *Canafistula*, cedars, *Prosopis, Enterolobium,* and *Tipuana tipa*. Much of the area forested by native species is in the form of riparian stringers. In Corrientes, much of the land suitable for forestry is not forested, unlike the province of Misiones to the north, where native forest is removed to plant pines. This year in Corrientes, there are 48,000 ha projected for planting, including 39,000 ha in pine and 8,000 in *Eucalyptus.*

In the evening, we arrived in the city of Corrientes and met with a number of officials from the provincial offices of the Ministry of Agriculture. In addition to the people we traveled with during the day, our meeting was attended by Dardo F. Decoppet from the Subsecretary of Coordination, Programming and Sector Development, Julio Cesar Vera, from Fire Prevention and in charge of the control program for *Sirex noctilio*, Susana Sten from the Seeds section, and Segundo Morales Barturen from the Direction of Forestry. We described our pest risk assessment process for the group and then discussed the forest resource and its management in the province. One of the issues concerning foresters in Corrientes is the management of the second rotation of *Eucalyptus*. Foresters are trying to encourage reforestation on better sites with carefully selected planting stock, rather than managing the resprouts from the original plantation. Currently, there are very few phytosanitary problems associated with

Eucalyptus plantations. Defoliating ants (*Atta* spp. and *Acromyrmex* spp.) and the wood borer *Phoracantha semipunctata* are the primary concerns, and no diseases have been detected. We discussed the possible importance of soil-borne organisms such as *Armillaria* and *Gymnopilus* in future rotations on the same sites. These are not significant yet since many sites are being forested for the first time. A new program of vigilance and monitoring is being installed because the level of forestation is increasing. We participated in a fairly lengthy discussion of the philosophy of vigilance programs and approaches that should be taken to optimize the efforts expended. In this province, as in Entre Ríos, the INTA research station works closely with the plant health agency to identify their management concerns that require research efforts by INTA personnel. As in Entre Ríos, the INTA scientists work on agricultural problems as well as forestry. Mr. Vera discussed the program for controlling *Sirex noctilio*, the woodwasp introduced into Buenos Aires in 1986 and detected in Corrientes in 1993. There has been success with the biological control program using the parasitic nematode *Deladenus siricidicola*.

Another current concern for the Plant Health agency is the boll weevil, which was recently introduced into Formosa Province and is the subject of an intensive program of trapping and monitoring.

The team spent the evening in the city of Corrientes.

April 18

In the morning, the team returned to Buenos Aires and was met at the airport by Mr. Norberto Echeverría of SENASA's Direction of Plant Health. Mr. Echeverría was the person responsible for coordinating our site visit in Argentina. We were taken by Mr. Echeverría to the University of Buenos Aires where we met with Dr. Jorge E. Wright and Dr. Jorge R. Deschamps. Dr. Wright is a mycologist at the University of Buenos Aires and his colleague Dr. Deschamps is an ecologist at the University of Belgrano. The two work closely together and have co-authored a book called "Patología Forestal del Cono-Sur de America" (Forest Pathology of the Southern Cone of America).

We spent several hours with the specialists discussing some of the things we had seen in the field and their impressions about the status of the pathology of *Eucalyptus* in Argentina. Drs. Wright and Deschamps pointed out that there is a shortage of specialists in the country and as such, pathologists and entomologists need to be generalists in their work. There is no pest database, and reports of certain pest–host associations are sometimes difficult to verify. Following our initial letter, they canvassed the entomologists and pathologists, and their general conclusion was that *Eucalyptus* plantations are mostly free of pests. Furthermore, since young trees are involved, the likelihood of importing noxious pests seems low. The feeling seemed to be that the only *Eucalyptus* species likely to be exported from Argentina would be *E. grandis*, *E. saligna*, and *E. dunnii*. This was based on the fact that those species have the best growth rates, and hence, the least likelihood of the pest problems that are associated with poorer growth rates. *Eucalyptus globulus*, for example, has been planted along the coast and rivers for windbreaks and ornamental uses and has performed rather poorly in Argentina, with some occurrence of *Rosellinia* sp. on wind-thrown trees. This species of *Eucalyptus* would probably not be exported from Argentina.

They identified the large orange mushroom we had seen in plantations as *Gymnopilus spectabilis* s.sp. *pampianum.* This organism is already present in the United States and is not considered a problem. In Argentina, it can sometimes cause significant damage in young trees but is generally not considered to be important.

We inquired about stump rot in plantations and its potential significance as a source of decay in new coppice shoots. Dr. Deschamps said that this had not been seen enough to warrant study. He did add, however, that not treating stumps to prevent infection could potentially cause some problems in the future. Stumps are currently not being treated in Argentina or Brazil. Dr. Deschamps did not know if *Eucalyptus* stumps are treated in other countries.

We also discussed the state of knowledge of *Armillaria* in Argentina. The genus has been found in association with *Nothofagus* in Patagonia but has not been verified on *Eucalyptus* thus far. There are no specialists in the Agaricales in South America although Cardozo May from São Paulo did some work in the 1960s, citing *Armillaria mellea* on *Eucalyptus* in Brazil. (Dr. Rolf Singer, however, has reported that *A. mellea* does not occur in South America).

Other organisms we inquired about specifically included *Ceratocystis* (a problem in elms but not on *Eucalyptus* in Argentina) and *Diaporthe* (*Cryphonectria*) *cubensis* (strictly tropical and not believed to occur in Argentina except possibly in the extreme northern province of Jujuy, which has some *Eucalyptus* grown for charcoal production). We inquired about other literature citations for organisms associated with *Eucalyptus* (for example, *Phytophthora nicotiniana*) and were told by Dr. Wright that the literature contains many improper citations.

Dr. Wright has been collecting information for another book and provided the team with a list of organisms associated with *Eucalyptus* from his search of the literature. His parting message for us was that the presently benign phytosanitary condition of *Eucalyptus* could change over time as the number of plantations increases and native organisms have more opportunities to adapt to a new host.

The team spent the afternoon and evening in Buenos Aires and prepared to travel to Uruguay on Sunday.

April 19

The team flew to Montevideo, Uruguay, and was met at the airport by Mr. Juan F. Porcile from the Ministry of Livestock, Agriculture and Fisheries (Ministerio de Ganadería, Agricultura y Pesca). Mr. Porcile took us to our hotel in downtown Montevideo and briefed us on the agenda we would follow while in Uruguay.

April 20

We were met in the morning by Juan F. Porcile (entomologist) and Nora Telechea (pathologist) who work in the Pests and Diseases Department of the Forestry Division within the Ministry of Livestock, Agriculture and Fisheries. Mr. Porcile had organized our two days in Uruguay.

We traveled to the port of Montevideo and met Nelson Ledesma from the private industry, Tile, S. A. Mr. Ledesma is Director of Harvesting for this company that owns some forest land and exports wood to several countries. Tile, S. A. owns about 25,000 ha, mostly in Uruguay, but has some holdings in Entre Ríos Province in Argentina as well. For the past 10 years, the company has exported pulp logs of *Eucalyptus grandis* and *globulus* to Norway, Sweden, Finland, Morroco, South Africa, Spain, and Portugal. Tile, S. A. is the first Uruguayan company to have exported *Eucalyptus*. At this time, no company is exporting chips, although some may do so in the future.

In the sort yard at the port, we met Joaquin Abel, another employee of Tile, S. A., who showed us some logs destined for Finland and Norway and explained some of the procedures carried out at the port. *Eucalyptus* logs are debarked on site immediately after the trees are harvested and thus always arrive at the port free of bark. At the port, logs are visually inspected prior to shipment and a phytosanitary certificate will accompany the shipment if requested by the importer. (There appears to be considerable variation in the requirements placed on log shipments by different countries. Spain and Portugal require phytosanitary certificates, while the Scandinavian countries have no inspection requirements). If required, the exporter could provide phytosanitary certificates at the harvest site or packing and loading areas. Fumigation with methyl bromide can be carried out at the port facility using a tarpaulin but is rarely done because it is an expensive procedure and is generally not requested. Logs are typically stored in the port from 1 to 2 months, depending on shipping schedules. This company presently transports some export wood 500 km, mostly by truck but occasionally by train. Wood exports are expected to increase greatly within the next 2 to 3 years.

At the time of our visit, there were about 30,000 m^3 of wood in the sort yard, and we were able to do a visual inspection. Some of the *E. globulus* logs had a star-shaped pattern of checking in the heartwood but seemed to be relatively free of visible organisms. We did, however, find a lymantriid egg mass (species unknown) on the end of one log. In addition, we noted an unusual reddish stain associated with the heartwood of *E. globulus*. This stain was sometimes accompanied by a sappy reddish residue oozing from numerous holes along the annual rings. This condition is believed to have an abiotic cause, perhaps resulting from the tree's response to cold temperatures. *Dacromyces*, a saprophyte, was found on the end of a log. We observed that there was soil on some of the logs and were told that it is not cleaned off before the logs are loaded for shipment. Although most logs were bark-free, there were occasional stems in the log decks with some bark present. We also observed some leaves and occasional twigs mixed in among the decked logs.

The team asked about the inspection history in the port—if pests had ever been found or if shipments had ever been rejected by the importer for phytosanitary reasons. We were told that there had been no insects or decay found on any logs. Logs infested by *Phoracantha semipunctata* are not accepted for export. Another important insect, *Megaplatypus parasulcatus*, occurs primarily in poplars and has very limited association with *Eucalyptus*. We also inquired about ambrosia beetles of the genus *Xyleborus* and were told that they do not occur in Uruguay. We were told that *Armillaria* is not found with *Eucalyptus* in Uruguay, but that *Fusarium* and *Pythium* do occur on seedlings in plantations. *Gymnopilus spectabilis* is associated with old ornamental *Eucalyptus* as a weak pathogen, but it has not been a problem in young commercial plantations.

In total, there are four companies working with wood exports in Montevideo. In a typical year, about 300,000 m^3 of wood are exported. In 1997, Tile, S. A. exported about 30% of the wood exported by Argentina and Uruguay for the year. About 50% of the wood they export is from their own land; they purchase the rest from other growers throughout the country. These other growers must meet certain quality standards to sell their logs to Tile, S. A. Most forests are more than 400 km from the port in Montevideo. The wood from Entre Ríos, Argentina, comes through the port of Concepción del Uruguay. Two other ports used for export are Fray Ventos and Nicochea. All logs in the port were being exported for pulp. Typically, a shipment for export is partially filled with logs in Concepción del Uruguay (a shallow port) and then topped off downriver at deeper ports. We learned that no sawlogs are exported from Uruguay. Occasionally, some sawn wood is exported, mainly to Italy for construction of pallets. We were also told that a test shipment of kiln-dried lumber was sent to Miami in the previous week.

There are about 50,000 ha (120,000 acres) planted each year in Uruguay (80% *Eucalyptus* and 20% pines). *Eucalyptus grandis* was first planted in 1978, and most of the current plantations are first generation. Most of the *E. globulus*, however, is in regeneration. *Eucalyptus globulus* has about a 50% higher value than *E. grandis* but is used only for paper, whereas *E. grandis* is used for both paper and sawn wood.

Because the pulp market has been fairly unstable in recent years, there has been an emphasis on diversification and development of new forest products for the future. Poles treated with chromated copper arsenate (CCA) are being shipped to Argentina. There is also a medium-density fiberboard (MDF) plant in Argentina. In the northern part of Uruguay, they are doing finger jointing and developing other new products as well to utilize *E. grandis*. Currently, green *Eucalyptus* lumber is shipped untreated to Italy and Japan. Pine lumber destined for Japan is treated to prevent infection by bluestain.

In 1987, Uruguay passed a forestry law (ley forestal) designed to promote forestation in the country. The law subsidizes the establishment of plantations, provided that three conditions are met: (1) suitable sites are selected for planting, (2) proper species are planted, and (3) the area to be planted is at least 10 contiguous hectares in size. If the forestation proposal is approved, the government pays half of the planting cost. Several companies including some from the United States and Canada have purchased land in Uruguay to establish forest plantations. Unlike Argentina, there has not been competition in Uruguay between applicants for state support; all parties requesting subsidies have received support thus far. The forestry law requires that all pest problems be reported. To keep abreast of the phytosanitary situation, the existing plantations are stratified by soil and climatic regimes and are surveyed periodically to determine their pest status. This survey system has been in place for 4 years and is administered by the Direction of Forestry. Mr. Juan F. Porcile (entomologist) carries out the survey and is assisted by Nora Telechea (plant pathologist). There is close cooperation between the Plant Protection Service and the Direction of Forestry to prevent the introduction of pests presently not in the country.

Future rotations of *Eucalyptus* will probably come from new plantings rather than from coppice cuttings. This will enable foresters to take advantage of advances that may occur in the selection of seed sources. The National Institute for Agricultural Technology (Instituto Nacional de Investigaciones Agropecuária (INIA)) has a program of genetic tree improvement. Seeds are currently imported from the Republic of South Africa (*E. grandis*) and Chile (*E. globulus*). *Eucalyptus grandis* is the primary *Eucalyptus* species being planted in Uruguay. INIA is also studying the suitability of *E. dunnii* and various species of pines. Changes are not anticipated in rotation ages or the selection of species, but the total area planted is very likely to increase, based on the current rate of 40,000 to 50,000 ha planted per year. About 90% of these plantings are for wood production. There are 3.2 million ha considered suitable for forestry and less than 10% of those are currently planted.

There are also about 600,000 ha of native forests in Uruguay, consisting of 200 species of Rhamnaceae, Myrtaceae, and Leguminosae. These forests are generally protected from harvest with small exceptions for some local production.

We later met with Mr. Peter Lyford–Pike, Director of Tile S. A.; two officials from the Ministry of Livestock, Agriculture and Fisheries (Ministerio de Ganadería Agricultura y Pesca - MGAP), Mr. Felipe Canale, Director of the Plant Protection Service (Servicio de Protección Agrícola) and Mr. Atilio Ligrone, Director of Forestry within the General Direction of Renewable Natural Resources (Dirección General de Recursos Naturales Renovables); and a pathologist from the Plant Protection Service, Mr. Luis Diaz. The team discussed various aspects of the relationship between the forest industry, the government, and pest regulatory issues in general. The government takes the responsibility of pest eradication when this becomes an issue on forested lands. Mr. Lyford–Pike pointed out that the industry participates in an Association of Forestry Growers, which has a committee that deals with the government–industry relationship and with the universities so as not to duplicate efforts in dealing with pest issues. Regarding quarantine regulations, we learned that import permits are issued by the Plant Protection Service, taking into account the origin of the commodity. Through participation in COSAVE, there is the harmonization of procedures between participant countries, while each country also maintains its own quarantine pest list.

We inquired about specific organisms occurring on *Eucalyptus* in Uruguay. *Atta sexdens* is associated with foliage of young eucalypts, as is the weevil *Gonipterus gibberus*. The weevil is believed to have been introduced into the country via infested seedlings. It is currently being controlled by a parasitic wasp, *Anaphes nitens*, through a biological control program. The wood borer *Phoracantha semipunctata* occurs throughout the country but is only considered a problem during drought conditions. The parasitic wasp *Avetianella longoi* has been introduced from South Africa as a biological control agent and appears to be successfully established. Other longhorned wood borers including *Chydarteres striatus*, *Trachyderes* sp., and *Retrachyderes thoracicus* are mostly found in fruit trees and only in those eucalypts previously killed or infested by *P. semipunctata*. *Xyleborus* has not been found in Uruguay. Some leaf rollers have been found but only along the edges of plantations, and they are not considered important. A defoliating weevil, *Pantomorus* sp., came from grassy fields that were converted to plantations of eucalypts. *Megaplatypus parasulcatus* is native in Uruguay, but it is rare in *Eucalyptus* and is more common in other hosts, including pines on occasion. A new species of *Ctenarytaina* (*spatulata*) has recently been found on juvenile foliage of *Eucalyptus*. No mortality has been caused yet by the psyllid. Of the diseases, there have been no records of *Armillaria*, *Cryphonectria*, *Uruphlyctia*, or *Ceratocystis* on *Eucalyptus* in Uruguay. *Stereum* (=*Dendrophorium) albobadia* is found in association with hibiscus and *Ligustrum* but never on *Eucalyptus*. *Harknessia hawaiiensis* causes leaf spot on *Eucalyptus*.

April 21

Juan F. Porcile and Nora Telechea took the team on a field trip to observe some *Eucalyptus* plantations and some of the associated organisms. We traveled eastward to Minas, northeast of Montevideo, then to the coast and returned in the late afternoon to Montevideo.

Our hosts showed us the form they use for surveying plantations for the incidence of damaging organisms. A typical plantation survey consists of 50 trees per transect, with the total number of transects depending on the size of the plantation (desired sampling intensity is 0.1% to 0.2%). Each plantation is inspected periodically.

We learned that the earliest plantings of *Eucalyptus* in Uruguay were carried out by Thomas Tompkinson in 1853 for fuelwood for the city of Montevideo.

Some studies are being carried out at the university on soil productivity. The effects of *Eucalyptus* and pines on nutrient depletion are currently unknown. At this time, the only fertilization that takes place for *Eucalyptus* is done at the time of planting.

Forestable land in this area costs about US$700 to US$1,000 per hectare, and half of the planting cost is subsidized by the government under the Forestry Law of 1987.

We stopped at a 6- to 7-year-old plantation of *E. grandis* that had been established to protect the soil on a site previously used for growing sugar beets. Trees in the plantation appeared to be growing well and pest-free even though the site was heavily compacted. The trees will be harvested for fuel when they are 10 years old.

A second plantation contained 4-year-old *E. globulus* planted at 2- by 4-m spacing. This plantation is typical of a common agroforestry practice in Uruguay where grazing and forestry are combined. These trees were being defoliated by the weevil *Gonipterus gibberus*. We saw small, orange adults laying eggs (6 to 10 eggs per mass) and feeding on the leaves. Some larvae were present also. We were told that the weevils are capable of completely defoliating the trees but that the trees resprout. During drought periods, the affected trees may be killed by *Phoracantha semipunctata* (we observed one dead tree in this plantation with evidence of subcortical wood borer galleries).

We visited a third plantation of *E. tereticornis* that was established in the 1930s. This plantation had been harvested nine times from the original stumps, and numerous logs were still on the ground from the most recent harvest 1 month earlier. The wood is used for fuel and for telephone poles. Some of these logs contained fresh boring dust from one or two genera of secondary wood borers (*Retrachyderes* sp. and *Chydarteres* sp.). Both genera normally attack weakened fruit trees. The females require bark to be present on their hosts for egg laying and thus would not be associated with freshly peeled logs. We also found a parasitic wasp, *Leobracon* sp., on one of the logs. There were also some ants (*Acromyrmex* sp.) on foliage that was sprouting from the freshly cut stumps.

We noted that even though the stumps were very old, there was little evidence of decay in them. Mr. Porcile speculated that this was probably due to the high cold tolerance of this eucalypt species.

The countryside along our route featured rolling hills with some plantations of Australian pine (*Casuarina* sp.). We also noted plantations of *Pinus elliottii* planted from seeds from Georgia. Native forest had been removed in some areas to provide for cattle grazing.

We visited another plantation of 5-year-old *E. globulus*. The foliage contained some evidence of feeding by *Gonipterus* weevils. Feeding damage was light because the biological control agent had been released in this plantation. We learned that these weevils are specific to eucalypts. Eggs are laid on the foliage, and the mature larvae pupate in the soil. In this plantation, we also noted trees with twisted boles (a result of j-rooting in the nursery) and some evidence of the same resinosis that we had seen earlier on logs in the port of Montevideo (thought to have an abiotic cause).

We observed that the draws are usually not planted with eucalypts. These are kept clear as natural pathways for “ecological flows” and to avoid problems with frost.

We returned to Montevideo along the coast and saw some plantations along the way that were established at tight spacing to stabilize sand dunes. *Pinus pinaster* is an important species that has been planted along the coast using seeds from France, Spain, and Portugal. We also saw coastal plantations of *E. grandis* and *E. globulus* on very sandy soils.

We returned to Montevideo in the afternoon and flew to Santiago, Chile, in the evening.

April 22

The team met with Marcos Beeche, a forester in the Plant Defense Project (Proyecto Defensa Agrícola) of the Department of Plant Protection within the Agriculture and Livestock Service of the Ministry of Agriculture (Departamento Protección Agrícola, Servicio Agricola y Ganadero (SAG)). SAG performs the same functions in Chile that APHIS does in the United States. Mr. Beeche had arranged our itinerary for the week in Chile. He introduced the team to other officials from SAG including Orlando Morales, director of the Plant Protection Department, Miguel Angel Poisson, a forester in the Subdepartment of Diagnosis and Survey

(Subdepartamento Diagnostico y Vigilancia), and Alvaro Sapag, an attorney and director of the Judicial Department for SAG. We traveled from the central office of SAG to their diagnostic laboratory facility in Lo Aguirre, west of Santiago, for a day of meetings. The meeting in Lo Aguirre was also attended by officials from other government agencies including Corporación Nacional Forestal (CONAF, the Chilean Forest Service within the Ministry of Agriculture) and Instituto Forestal, the agency that conducts forestry research in Chile. Also present were representatives from some private forest industries and from the Corporación Chilena de Madera (CORMA), a private organization that assists Chile's forestry companies in dealing with national forest production issues. Numerous local employees of SAG were also present at the meeting. The following people attended the introductory meeting:

Servicio Agrícola y Ganadero: Alvaro Sapag Rajevic, attorney; Daniel Claro.

SAG Plant Protection Department: Orlando Morales Valencia, director; Marcos Beeche Cisternas, forester; Miguel Angel Poisson S., forester; Ariel Sandoval, entomologist.

SAG Lo Aguirre Laboratory: Luis Brucher Alvarez, operations director; Margarita Villanueva, head of pathology; Ana Maria Paraguez, nematologist and laboratory chief; Angela Tortora, pathologist; Sergio Rothman, entomologist and joint inspector with APHIS for the Metropolitan Region (Santiago); Patricia Jimenez, entomologist.

Instituto Forestal: Sandra Perret Duran, subdirector of silvicultural technologies; Patricio Parra, forester.

Corporación Nacional Forestal (CONAF): Jose Antonio Prado Donoso, executive director; Cristian Pérez Soto, chief of Forest Health Protection Program; Maria Aida Alvarez de Araya; Alex Arancibia.

Corporación Chilena de Madera (CORMA): Juan Eduardo Correa Bulnes, executive vice-president; Maria Teresa Arana S., chief of studies.

Monte Águila, S. A.: Deric Quaile, general director.

Orlando Morales began the meeting with a review of the itinerary that had been proposed and then discussed the day's agenda, which was dedicated to the discussion of phytosanitary aspects and forest production in Chile. In his overview, Mr. Morales pointed out that we would learn about the plant quarantine system in Chile, the survey, inspection programs, and the actual phytosanitary status of *Eucalyptus* in Chile.

Marcos Beeche discussed the Chilean plant quarantine system that protects the country's resources from invasive pests. The quarantine system includes surveys, legal actions, phytosanitary certification, diagnostic systems, and control actions against specific organisms once they are introduced. The principal actions include establishing import rules and regulations based on risk assessments, issuing phytosanitary certificates for exports, and establishing and maintaining internal and external barriers where inspectors examine plants and products in transit. SAG is organized to operate at three levels: national, regional, and sectoral. The sectors carry out work on the ground. The Chilean Plant Quarantine System employs 1,500 people, 692 of them professionals, 405 technicians, and 293 administrators. There are checkpoints of phytosanitary control throughout the country at each marine, air, and terrestrial entry point into Chile, totaling 72 in all. Chileans believe that their country is an island because of significant geographical barriers such as the Atacama Desert to the north, the wide range of the Andes Mountains to the east, and the Pacific Ocean to the west. These natural barriers have in large part enabled the country to remain relatively free of invasive pests to date. This isolation is further supported by the fact that the plants and insects in Chile have more in common with New Zealand than with the rest of South America.

Considerable emphasis is also placed on surveys within the country to detect organisms that may have gained entry. When necessary, outbreaks are delimited and an action plan of eradication is developed.

No wood is imported into Chile, except in the form of crating. Specific regulations regarding imported crating are addressed in Resolution #1826, a law passed in 1994. This law requires that the crating wood be free of bark, without insect holes, and free of insects. Inspectors at each entry checkpoint have manuals that guide the inspection process and identify the organisms on the quarantine list. Crating with evidence of problems is held and a record of interception is made. Samples are taken for identification and the crating is either fumigated or destroyed. The exporter is notified of the interception. Certain specialized inspection procedures are applied to those shipments that originate from areas of particular concern. We were shown a videotape that highlighted the inspection process.

We learned that control measures have only been taken on one species of forest insect so far in Chile. The European pine shoot moth (*Rhyacionia buoliana*) was discovered in the mid-1980s in Monterey pine plantations. It was treated initially with insecticides and later with biological control techniques. More recently, the weevil *Gonipterus scutellatus* has been introduced into Chile and will be treated later this year.

Miguel Angel Poisson discussed the five programs that comprise the Vigilance–Surveillance function of SAG. These programs include (1) forest survey, (2) pest risk assessment, (3) gypsy moth, (4) *Sirex noctilio* woodwasp, and (5) Scolytid bark beetles.

The objectives of the forest survey program are to monitor areas with pest incidents and to detect new forest pests. Systematic surveys are carried out both in plantations and natural forests. Some parameters of evaluation include symptoms, pest identification, tree section, and damage intensity. These surveys are done throughout forested areas with special emphasis on high-risk areas.

The gypsy moth detection program classifies the ports according to the likelihood of entry and monitors these ports with delta traps baited with disparlure. At present, trapping is being done at six ports including Lirquen, Puerto Williams, San Vicente, Valparaiso, and two others. Trapping density is two traps per square kilometer, the same as in New Zealand. The traps are monitored at 15-day intervals during the flight period of gypsy moth. In 1997, US$27,000 were spent on the trapping materials. Three months ago, the Chileans signed an Asian gypsy moth agreement with Russia much like the agreement between the United States, Canada, and Australia regarding ship certification. All ships that have been in Russian Far East ports within the last two years and Russian railway containers are thoroughly inspected for egg masses and other life stages. Other moths of concern in this detection program include the nun moth (*Lymantria monacha*) and the rosy gypsy moth (*L. mathura*). Through another agreement, New Zealand notifies Chile when it rejects a Russian ship. The forests are also surveyed for gypsy moth.

The objective of the scolytid trapping system is to detect bark beetles on the quarantine list. The monitoring is carried out during beetle flight periods at all airports and seaports, dunnage storage centers, and in high-risk stands of *P. radiata*. Funnel traps of various sizes (10, 15, and 20 cm) are baited with a mixture of alpha-pinene and ethanol deployed as a general bait. More specific lures include lanierone for *Ips pini* and frontalin for *Dendroctonus frontalis*. About 200 traps, costing US$50 per trap, are deployed between Regions IV and XII (Valparaiso to Puerto Montt).

The most likely pathways of introduction of the woodwasp *Sirex noctilio* are believed to be crating and dunnage. To detect early introductions in Chile, the *Sirex* monitoring program utilizes 5 to 10 trap trees in high-risk stands of *P. radiata*. The trap trees are stressed with an herbicide to make them susceptible to the opportunistic woodwasp that attacks weakened trees. The bait trees are harvested after the flight period of the woodwasp and examined for attacks. Special bait tree plantations have been established near areas where dunnage is stored. High-risk stands are also surveyed to see if natural attacks have occurred. Sea and air ports are classified according to the risk of introduction and trap tree density is adjusted accordingly. International barriers have been established in Regions IX and X because the insect is presently found in Bariloche, Argentina. Trapping densities in this area are one plot per 2,500 ha of forested land, a radius of 50 km. The plot density in dunnage storage areas is one plot per 5,000 ha of forest.

The pest risk assessment program has dealt with numerous insects in the recent past including the weevil *Gonipterus scutellatus*. In cooperation with other agencies, hot spots of infestation have been identified. Since 1994, the program has been tracking all interceptions at all checkpoints of wood products. During that time period, the Coleoptera represent about 85% of the insects intercepted, with comparable levels coming from Europe, North America, and South America. The United States shows the highest risk of introduction at 22% of the total interceptions, with Germany, Italy, Argentina, and Brazil each at a risk of about 9%. These interception records are comparable with those of New Zealand. (The interception records from New Zealand, compiled over the past 25 years, suggest that the families most often represented among the live insects collected are the Bostrichidae, Cerambycidae, Curculionidae, Siricidae, Scolytidae, and Platypodidae). With regard to the woodwasp interceptions in Chile, more *Sirex noctilio* came from South America in the past but now more come from Europe due to the relatively effective biological controls implemented in South America. Within the PRA program, a systematic procedure exists to identify risk of introduction of certain organisms and to develop a set of mitigation measures.

Mr. Morales discussed the participation of Chile in COSAVE. Member countries in COSAVE include Argentina, Brazil, Chile, Uruguay, and Paraguay. There are eight working groups with two professionals from each participating country. The Forest Health Working Group is centered in Chile and has recently produced a number of products. The group has developed two pest lists, a regional list and a specific country list. The protocols for inspecting crating also came from this working group. Chile is probably the only country currently inspecting crating, but the other countries will soon be doing this. The forestry working group also develops programs for specific insects such as *S. noctilio*. In some cases, bilateral agreements are drawn up, such as the one between Chile and Argentina where money from the private sector is being brought in to address control of *S. noctilio* near Bariloche.

Patricio Parra described a cooperative genetic improvement study established from Region IV to Region XI by Instituto Forestal and private forest companies. Several species with different seed sources were tested in a variety of locations. The species performing best in Chile included *Eucalyptus camaldulensis*, *E. nitens*, *E. delegatensis*, *E. viminalis*, and *E. globulus*. In connection with this study, the Instituto Forestal conducted a phytosanitary survey of *Eucalyptus* throughout the country. The specific objectives of the survey were to detect the principal damage agents associated with *Eucalyptus* and describe their symptoms, to determine the magnitude of damage caused by these agents by measuring growth reduction, to identify research priorities to reduce pest-induced losses, and to publish the results of the survey. In addition, a detailed manual was prepared describing all of the symptoms associated with various damage agents. The manual is used to pinpoint the occurrence of pest organisms and the association with different provenances or seed sources. As the relationship between susceptibility and certain biotypes is determined, the Instituto Forestal will be able to recommend certain types with reduced growth rates but greater resistance to pests. Although it was originally developed for evaluating trees in genetic improvement studies, the manual has broader application and can be used in industrial plantations as well.

Miguel Angel Poisson provided an overview of the current pest situation for *Eucalyptus* in Chile. In general, the phytosanitary condition of *Eucalyptus* plantations appears to be very good with very few problems. Of the insects associated with *Eucalyptus* in Chile, only four species are considered capable of causing problems at some level. These include two species of *Phoracantha* wood borers (*P. semipunctata* and *P. recurva*), the cossid wood borer *Chilecomadia valdiviana,* and the recently introduced weevil *Gonipterus scutellatus*. Two of these are very limited in terms of geographical distribution (*P. recurva* and *G. scutellatus*) and another is limited in terms of host (*C. valdiviana*), affecting only one species of *Eucalyptus* (*E. nitens*). *Gonipterus scutellatus* was just discovered in Chile on February 14, probably having entered the country on a truck from Argentina. Intensive surveys have shown that the infestation presently covers about 1,700 ha. An eradication program will be undertaken this summer. The fungi most commonly found on *Eucalyptus* in plantations include *Sonderhenia eucalypticola*, *Harknessia eucalypti*, and *Mycosphaerella cryptica*. All three are foliar pathogen and have several hosts within the genus. In the nursery setting, there are some fungi that cause damping off and require chemical control.

Cristian Pérez of CONAF gave a detailed presentation on the longhorned borer, *Phoracantha semipunctata*, in Chile. Since the 1980s, CONAF has been involved in the evaluation of damage and in determining management options for the wood borer. As a collaborator with SAG and others on the National Forest Health Committee, CONAF has been involved in technology transfer to ensure that managers are aware of the latest information.

The wood borer was first detected in Chile in 1957, but damage was not noted in trees until 1973 near San Felipe in northern Chile. Other small infestations were noted in 1974 and 1975 in *E. globulus* and *E. camaldulensis* in Region IV, Region V, and the Metropolitan Region (Region VI). By 1977, CONAF reported that the wood borer was distributed through almost 80% of the eucalypt plantations in the country. Various surveys were done to delimit the distribution, including one in 1986 that examined the relationship between insect occurrence and soil types. The insect now occurs between Regions III and X, with greatest concentrations in the drier north. In addition, *P. semipunctata*, a native of Australia, is also found in Bolivia, Peru, Argentina, Uruguay, Brazil, Republic of South Africa, Israel, Turkey, Cyprus, Tunisia, Italy, Portugal, Spain, New Zealand, and the United States.

The insect has a 1-year life cycle with the adult stage present in the spring and summer between November and May. Eggs are laid in mid-summer and fall (January–May), and larvae are present between December and October. The early larval stage feeds in the cambium and girdles the tree. The wood borer infests seven species of *Eucalyptus* in Chile (*E. globulus*, *E. gomphocephala*, *E. resinifera*, *E. torquata*, *E. camaldulensis*, *E. viminalis*, and *E. oleosa*), with *E. globulus* being one of the most susceptible. Since the wood borer is an opportunist that takes advantage of weakened trees, there is a very strong relationship between its presence and the incidence of drought. As such, the eucalyptus borer is far more common in the northern, drier part of the country (Regions III to VI) than in the south with its abundant rainfall.

Some of the control measures that have been applied for the eucalyptus borer include silviculture and the use of bait trees. Thinnings and prunings are carried out to maintain high tree vigor. Whenever trees are killed, they are cut and destroyed before new adults can disperse from the host material. In some areas, trees are mechanically girdled to make them attractive to the borer, and once infested, the trees are cut and debarked while the larvae are still developing beneath the bark. Chemical controls have not been applied effectively against any stage of *P. semipunctata*.

We also had an opportunity to discuss a second species of *Phoracantha*, *P. recurva*, which was recently introduced into Chile (March 1997). *Phoracantha recurva* is presently found in the Metropolitan Park in Santiago, with the infestation covering about 112 ha. About 89 ha of the park contain pure forests of *Eucalyptus* while 23 ha are mixed-species forest. An aggressive eradication program has been undertaken, and about 95% of the affected area has already been treated. The city has removed and chipped the infested eucalypts. The remaining uninfested trees are being monitored to see if the insect populations are being successfully controlled. Bait trees will also be used as another form of monitoring.

Deric Quaile from the private forestry company Monte Aguila discussed the industry perspective and provided some insights into why Chile is a desirable location for investments in *Eucalyptus* forestry. Monte Águila, S. A. is a Shell Oil company and a CORMA member, which has been associated with *Eucalyptus* for 20 years. Along with Forestal Mininco and Forestal Arauco, Monte Águila is one of the three largest forestry companies in Chile. Sixty percent of the *Eucalyptus* in Chile is grown by large companies. There are several reasons why companies have invested in Chile for agroforestry. These include a proximity to Pacific Rim markets, desirable characteristics of tree species, fertile soils, high rainfall during the growing season, political stability, and a high level of professionalism, which leads to an efficient timber industry.

Although *Eucalyptus* was first planted in Chile in 1881 for mining timbers, large-scale production did not begin until almost a century later. Currently there are about 349,000 ha in Chile planted with *Eucalyptus* (195,000 with *E. globulus* and 139,000 with *E. nitens*). Of these plantations, 260,000 ha contain trees less than 5 years old. More than two-thirds of the *Eucalyptus* plantations are in Regions VIII and IX (southern Chile). Pulp is the primary product, with 50% of the output for local consumption and 50% for export. The export trade of *Eucalyptus* is currently more than 1.2 million m^3 per year, 80% of which is in form of pulpwood chips to the Asian market. By the year 2005, the export market is expected to double in volume and will probably include additional products such as sawlogs, sawtimber, mouldings, veneer, pulpwood, and wood for energy. Both of the key species of *Eucalyptus* belong to the globulinae group that has a very high pulp yield (3.0 to 3.8 m^3 of pulp per dry ton of chips). Wood production has increased from 18 to 25 m^3 per hectare per year in 1988 to 30 to 45 m^3 per hectare per year in 1998. Much of this increase is due to greater knowledge of appropriate seed sources and other improvements in genetics.

Following the day of presentations, the team was given a tour of the laboratory and diagnostic facilities at SAG's Lo Aguirre site. This laboratory is the diagnostic center for processing all of the samples collected at the phytosanitary checkpoints throughout the country.

The evening was spent in Santiago.

April 23

The team traveled by air to the city of Concepción and was met at the airport by Ricardo Medina, a local functionary of SAG for Region VIII. We were taken to the Escuadrón experiment station, a research facility for one of the largest private forestry companies in Chile, Forestal Mininco (a company of CMPC (Compañia Manufacturera de Papeles y Cartones)). We were received by Luis de Ferari, head of the Department of Phytosanitary Protection for the company within the silviculture department. Mr. de Ferari introduced us to other company employees including Claudio Goycoolea, head of laboratories for Phytosanitary Protection, Jose Alvarez, head of the Department of Site Productivity, and Carlos Gantz from the Genetics Department. Mr. de Ferari presented an overview of the organizational structure of Forestal Mininco and some of its programs. As of 1997, Forestal Mininco owned more than 500,000 ha of forest land in Chile, 12% of which was dedicated to *Eucalyptus* (*E. globulus* and *E. nitens*) (58,400 ha). In addition, the company owns 20,000 ha of *Eucalyptus* and pine in Argentina. The company has four divisions, silviculture, production, industry, and marketing. The company first became involved in phytosanitary protection in 1985 when the European pine shoot moth (*Rhyacionia buoliana*) was discovered in Monterey pine plantations. The discovery served as valuable evidence of the vulnerability of the forest resource and has highlighted the need for technical and professional readiness for newly arising pest problems. In 1997, Forestal Mininco dedicated a budget of US$1.7 million to the phytosanitary protection program. At this time, the company employs 22 people in the Phytosanitary Protection Program. The most important forest pests for the company are in Monterey pine (*Rhyacionia buoliana* and *Dothistroma pini*), and thus far, *Eucalyptus* has been relatively free of important pests. At this time, the most important organisms associated with *Eucalyptus* are the cossid moth *Chilecomadia valdiviana*, the eucalypt borer *Phoracantha semipunctata*, and various foliar fungi including *Mycosphaerella* spp. Now that *Gonipterus scutellatus* has been introduced into northern Chile, the company is putting considerable effort into surveying its plantations for presence of the weevil.

The forests are all intensively managed for maximum yield. The total company production is around 3.5 million m^3, with 60% as boards and 40% as logs for pulp. Each year Forestal Mininco produces 20 million pine seedlings and 5 million *Eucalyptus* seedlings and plants 4,000 ha per year in *Eucalyptus* (3:1 ratio of *E. nitens* to *E. globulus*). *Eucalyptus globulus* is planted on coastal sites, and *E. nitens*, a cold-tolerant species, is best for the interior, the central valley, and the volcanic soils of the pre-cordillera foothills. Appropriate sites are carefully chosen, and in some cases, pre- and post-planting weed control is necessary. Fertilizers are sometimes applied at the time of planting. The objective is a growth rate of 28 m^3 per hectare per year and a rotation age of 14 years. For pulp plantations, 1,250 trees are planted per hectare, and establishment costs are around US$710 per hectare.

Carlos Gantz presented some information on the genetics program for Forestal Mininco. The genetic improvement program for *Eucalyptus* began about 8 years ago. The objectives of the recurring selection are to increase productivity and improve bole and branch form. Other goals are to increase the frost resistance of *E. globulus*, increase the wood density of *E. nitens*, and obtain new races by hybridizing the two species. The experiment station at Escuadron maintains a seed orchard and clone bank. There is also work being done with vegetative propagation. The genetics staff consists of five people at the Escuadron station, but they have many contacts elsewhere including the University of Florida, University of North Carolina, University of Chile-Santiago, University of Concepción, and INIA Chillán. Currently, the genetics trials cover more than 262 ha including progeny trials, biodiversity plantings, and provenance studies. The future will also include advanced tissue culture using elite materials and sprouts from source trees. The goal of the genetics program is for 40% genetic gain for *E. nitens* and 60% gain for *E. globulus* by 2005.

In the afternoon, we traveled to the University of Concepción to meet with Professor Luis Cerda, forest entomologist. Mr. Cerda has been studying the cossid moth *Chilecomadia valdiviana* since its discovery in *Eucalyptus nitens* 6 years ago. (A number of surveys have been done, and no other eucalypts were found to be affected although the literature lists *E. gunnii* and *E. camaldulensis* as occasional hosts). The team was briefed on the biology of *C. valdiviana*, which is an insect native to Chile that feeds on a variety of hardwoods and fruit trees. The insects attack live trees, laying eggs at the branch axils. The initial larval stages feed gregariously in the bark for 1 to 2 months, moving later into the sapwood and then deep into the heartwood where they eventually construct individual galleries. The larval tunnels in the heartwood can be numerous and fairly extensive. (The longest gallery has been measured at 27 cm.) Numerous stain and decay fungi are associated with the larvae, and the fungi appear to grow throughout the wood well beyond the feeding zone of the larvae. Although the fungi have not been specifically identified, there may be as many as 12 species of fungi associated with the infested wood. Even though the insect does not kill trees, the boles of infested trees are commonly subject to wind breakage. Detection of attacks is often difficult. Sawdust will sometimes be present on the ground beneath the exit hole of the moth. Since reinfestation of the same trees is common, there will be a buildup of the boring dust at the base of the tree over time. When trees are heavily infested, they will exude a sappy material that covers the bole and provides a medium for growth of sooty fungi, giving the bole a blackish appearance. Adult emergence comes in two distinct periods, about 6 months apart. The insects are weak fliers. Within a stand, the amount of trees attacked has not exceeded 5%. The distribution of infestation centers appears to be random, with no connection to road networks or harvesting practices. (Early detection was near native forests, but subsequently, infestations have been found in areas far removed from native forests). *Chilecomadia valdiviana* has a 1- to 2-year life cycle, depending on the flight period. Adults can be found between the months of August and February, with the majority between August and October. Females lay about 200 eggs in groups of 30 to 70 eggs (August–March). The larval stage can be found throughout the year. Pupation occurs between May and January.

At this time, a key research priority is the determination of chemical attractants for the insect. Various foliar chemicals have been tested so far, and some antennal response has been demonstrated. If an attractant can be identified, it may have some application in pest management, perhaps as a bait. Insects are being raised in the laboratory to test for pheromones and to conduct other chemical bioassays. Other management questions have been examined, such as sanitation treatments to reduce infestation, but with no success so far. Damage symptoms are the same in other hosts, but the wood of *Eucalyptus* appears to break down faster due to the high level of moisture in the wood. We inquired about the quarantine implications of shipping infested wood and were told that logs with *C. valdiviana* are easily recognized and can be readily separated from those not infested. Debarking, if done early in the infestation, could kill larvae in the phloem. Once inside the wood, the larvae would be able to complete their development even though the tree is dead, but the emerging adults will be smaller. Prof. Gastón Gonzalez from the University of Concepción is working on identification of the associated decay fungi. We expressed our concerns about the polyphagous nature of the insect and a lively discussion ensued. We were reminded that polyphagy in an herbivore should not be taken to mean that all species might be susceptible.

Later in the day, we traveled to the community of Arauco and met with Miguel Poblete, head forest health specialist for the large company Forestal Arauco. Mr. Poblete explained the structure of his company, which has three parts: a pulp company called Celco, consisting of three plants, two for pines and one for *Eucalyptus*; a forestry company in Arauco called Bosques Arauco; and a forestry company in Valdivia called Forestal Valdivia. The company Bosques Arauco owns about 500,000 ha of plantations, of which 15,000 are *E. globulus* and 2,600 are *E. nitens*. The trees in virtually all of these plantations are less than 10 years old. The company has a goal of 25,000 ha of *Eucalyptus* and will plant about 2,000 to 2,500 ha per year toward that end. Since these plantings are all for pulp, the rotation age will be 11 to 12 years. Mr. Poblete described the forest health monitoring program for the company, which involves systematic surveys by trained personnel called guardabosques, or forest caretakers. Each of these forest caretakers covers about 5,000 ha as part of their responsibility.

We visited a plantation of *E. globulus* with trees 4 to 5 years old and 15.2 m tall, which is typical of the local growing sites. Growth rates here are 40 m^3 per hectare per year, and this is one of the highest sites available. Mr. Poblete pointed out that the most important biological agent here has been the foliar pathogen *Mycosphaerella cryptica*, but yield does not appear to be affected. Given the high moisture regime in this area, the wood borer *Phoracantha semipunctata* is not an important factor. In the recent past, the Asian market has been the key destination for Chilean pulp, but sales have been low for more than a year. Morocco is being considered as a future market.

At another plantation, we met Francisco Pérez, in charge of the genetics program for Bosques Arauco, researchers Arnoldo Villaroel and Patricio Parra from Instituto Forestal, and Luis Manso from Bosques Arauco. We were shown a trial plantation at Los Hermanos where 35 provenances and various families are being tested for growth performance. Most of the provenances are from Australia and are being tested to increment the genetic base of *Eucalyptus* by incorporating material from natural areas. The test was established in 1989 in this location near Arauco, with two other replicate installations, one in Valdivia and one in Talca. The trials are managed intensively to test tree performance with fertilization, herbicide application for weed control, and thinning regimes. The best trees will be selected for the second generation. After 9 years, it is possible to see distinct differences in the performance of the provenances. The tallest tree grows about 3 m per year in height. The Apollo provenance from Victoria, Tasmania, seems best suited for these sites. In addition to growth rates, the provenances will also be tested for pulp quality. The phytosanitary condition of these trees appeared to be very good. We were told that the only problems appear to be a leaf fungus and occasional wind breakage. Some of the progeny trials are addressing the relationship between growth rates and resistance to *Mycosphaerella*, with the intention of combining the traits.

We learned that this is the region where the four largest companies have forest land—Forestal Mininco, Forestal Bio-Bio, Forestal Arauco, and Monte Águila, S. A.

We returned to Concepción for the evening.

April 24

In the morning, the team traveled from Concepción to Los Angeles. Along the way, we discussed various aspects of the *Eucalyptus* resource with Marcos Beeche. We learned that the different eucalypt species are kept separate due to their different pulping characteristics. As such, the likelihood of *E. nitens* being mixed with *E. globulus* at any point is very low. The team asked about debarking and learned that there is not a universal standard practice. Some countries such as Japan prefer pulp logs to have bark because the bark helps the logs retain maximum moisture, which makes them easier to chip than when they are dry. Chile would prefer to export dry chips rather than moist logs but does not always have that option. Logs are also not debarked for local pulp uses in Chile. Debarking, when done, is always mechanical. We saw some areas where former pine plantations are being replanted to *Eucalyptus*. The main motivation for this change of species is the belief that short fiber pulp will be more valuable in the future than the longer conifer fiber.

The team visited the forest nursery at Colicheo, belonging to Forestal Mininco. We were met by the nursery manager Claudio Herrera and by Luis de Ferari, Marcelo Donoso, and Miguel Castillo, all from Forestal Mininco. Mr. Herrera explained the nursery operations to us and described the production schedule. This nursery is one of four belonging to Forestal Mininco and is used to grow *Pinus radiata*, *Eucalyptus nitens*, and *E. globulus*. The nursery presently has 4.5 million containerized seedlings and 900,000 bare-root seedlings of *E. nitens* and 1.3 million containerized seedlings of *E. globulus*. The future trend is toward producing more hybrids between the two species of eucalypts and more genetic propagation. Problems are fairly limited, with some damping off and *Botrytis*. *Eucalyptus nitens* appears to have fewer problems than *E. globulus*. In the future, this nursery will be closed and Forestal Mininco will consolidate its seedling production into two nurseries.

In Los Angeles, we visited the private company Controladora de Plagas Forestales, S. A. (CPF) and met with the director of the company, Osvaldo Ramirez Grez. Mr. Ramirez described the mission and objectives of this company, which was formed in 1992 to address pest management issues for the country's private industrial forestry companies. Originally, 13 of the largest forestry companies from Regions VII to X formed CPF to combat the European pine shoot moth, *Rhyacionia buoliana*. Now there are 25 companies that have ownership in CPF, representing a land base of 800,000 ha of pine plantations. This group of companies decides the priorities for CPF. The mission of CPF is to keep pest damage below economic thresholds and to provide any sales and services that the parent companies might need in the way of pest-related matters. The objectives presently include to mass produce *Orgilus obscurator* (the parasitic wasp used in the biological control program for the European pine shoot moth), to provide various services, to develop survey protocols, and to order supplies as needed. The company has a board of directors, which receives input from a technical advisory committee (which is chaired by Luis de Ferari) regarding the technical feasibility of plans and designs to meet the mission of the company. Other work in the biological control arena includes looking for other natural enemies of the European pine shoot moth and the woodwasp *Sirex noctilio*. In addition, CPF is also involved in carrying out, coordinating, and contracting research, conducting training sessions as a center for technology transfer, carrying out extension work, standardizing approaches to common pests, producing information brochures, and representing the parent companies in other arenas including state and public forums. The future for CPF will probably involve participation in developing problems such as the recently introduced weevil *Gonipterus scutellatus.* The company has a staff of 19 people including 5 administrators and 14 laboratory employees. Recently, CPF signed an agreement with SAG and with EMBRAPA (Brazil) to maintain a stock of the parasitic nematode *Deladenus siricidicola,* which is the biological control agent for *Sirex noctilio.*

Following the meeting, we visited a sort yard to inspect logs of *Eucalyptus viminalis* and *E. delegatensis.* The trees had been harvested from a test plantation and were destined for the local pulp market. Although the logs had not been debarked and were sitting on a dry soil surface, we found them to be very clean. Some logs contained soil and a few showed signs of the reddish heartwood stain we had seen in Uruguay.

We were not able to find evidence of stain or decay fungi, ambrosia beetles, or wood borers. The team was told that these logs would be sorted by diameter and debarked at the chipping site near the pulp plant.

Next we traveled to Fundo Porvenir to examine a plantation of *E. nitens* that was infested by *Chilecomadia valdiviana*. The plantation was established in 1989, and the infestation was discovered in 1995. The local forest caretaker showed us the larval tunnels in infested logs. Other symptoms of attack were also readily evident, including the sawdust at the base of the infested tree and the exudate on the bole. The blackish sooty mold growing on the moistened bark surface helped to identify an infested tree from a considerable distance. We learned that trees greater than 5 cm in diameter are likely to be attacked and that the associated decay fungi appear within 2 to 4 months after the infestation. The fungi grow well ahead of the larval tunnels (as much as 4 m beyond the gallery) and render the wood useless even for fuel by the following year. The insect is not believed to be a vector for the decay fungi. Rather, airborne spores enter through the larval galleries, which are kept clear of frass by the feeding insects. Although we saw numerous infested trees within the plantation, there did not appear to be a discernible pattern to the attacks. Some trees in the stand had been marked and subsequently wounded mechanically to see if the insects prefer weakened trees. Only one of the wounded trees was attacked, leading to the conclusion that stress in the tree may not necessarily be involved in host selection. We inquired about the infestation pattern in other hosts and how it compares to the symptoms we had seen in *E. nitens*. We were told that the *Nothofagus* hosts have more extensive galleries than *E. nitens*, but that damage by fungi is far greater in *E. nitens* than in the beeches because of much higher moisture content in the eucalypt host. Neither *Nothofagus* nor *Salix chilensis*, (another important host for *C. valdiviana*) show the sap flow and sooty mold symptom that is so pronounced on *E. nitens*. In another location, 400 infested trees had been removed in a sanitation harvest in April, and later in October, another 100 needed to be removed because they had been overlooked in the first entry. The reason is that initial attacks often occur high in the tree and may not be as readily evident as in a tree that has been reinfested. The insect attack is at least 2 months old before the blackish mold appears on the bark surface.

We stopped briefly at another plantation (Fundo Verdún) that had been established in 1994 and 1996. The young trees were planted at a 3- by 3-m spacing, which will be the planting convention for the future (1,300 trees per hectare). The plantation had been treated with glyphosate to control weeds and had been fertilized with calcium and phosphorous. Subsoiling had been done prior to planting because the field had previously been planted in wheat.

We returned in the evening to Concepción.

April 25

In the morning, one of our traveling companions, Miguel Angel Poisson, was replaced by another SAG functionary, Ariel Sandoval. The team traveled with Mr. Sandoval and Marcos Beeche to the port of San Vicente near Talcahuano. We were met by Alejandro Sesnic, chief inspector at this port for SAG. This is a key port for the export of *Eucalyptus* chips and pine lumber to numerous countries. We noted that all export products were on a concrete surface and that the adjacent hillside was devoid of trees. At the time of our visit, there was a large pile of *Eucalyptus* chips in the port. The pile was wet and cool on the surface but very hot inside (70°C). This heat probably limits the development of most organisms except certain fungi such as *Trichoderma* spp. Japan is currently the only country that imports *Eucalyptus* chips from Chile. We were told that Japan does not require that the chips be treated prior to shipping. The team was also told that if chips needed treatment, it would not be economical to export them. The short-fiber *Eucalyptus* pulp is used for high-quality computer paper, whereas the long-fiber pine pulp is best for newsprint and tissue paper. It takes a full month to accumulate a sufficient quantity of chips to fill a ship. A ship can be loaded in 3 days (9 shifts) to a typical capacity of 45,000 tons. As chips spend more time in the pile, the lignin begins to break down, and thus less energy is required at the pulping plant to break it down.

We inquired about the capabilities for fumigating chips. The port of San Vicente does not export any products requiring fumigation. As such, if fumigation were needed, it would need to be done aboard the ship or beneath a tarp because there are no chambers available. Mr. Sesnic pointed out that phytosanitary certificates will be written at the port if requested by the importer.

In the afternoon, we traveled to the city of Temuco. Along the way, we discussed various phytosanitary issues with Marcos Beeche. He mentioned that *Megaplatypus parasulcatus* has been intercepted in Chile many times in crating made of poplar. In particular, interceptions have been common at the border in Mendoza, Argentina. Thus far, the insects have always been dead. (Crating is not ideal host material for the insects because it dries out and the symbiotic fungus cannot develop for the insects to feed on.) *Megaplatypus parasulcatus* is of particular concern because it has many hosts including pear trees and sycamores. (In some areas, *M. parasulcatus* attacks and kills the branches of *Platanus occidentalis* street trees.)

Other species of *Platypus* have also been intercepted in Chile in crating from Brazil and Ecuador.

April 26

Visited native *Araucaria* forests near Argentine border.

April 27

The team met in the local offices of SAG with District Head Cesar Hidalgo; Hector Espinosa, regional director of Agricultural Protection; and Veronica Torres, plant health specialist for SAG in region IX. Marcos Beeche explained our mission to the director, and the team gave an overview of their impressions so far. Mr. Espinosa pointed out that there are four international points of entry into Region IX, including three border points with Argentina (Liucura-Malleco, Icalma, and Puesco) and the international airport Manquehue. Ms. Torres explained the surveillance system that is in place at these international checkpoints. Bark beetle pheromone traps are used for detection of *Dendroctonus* and *Ips*. Trapping is also done in native and exotic forests and in sawmills. Samples collected in these traps or intercepted during routine inspections are sent to the regional diagnostic laboratory that is staffed by Jaime Luna (entomologist) and Orlando Lara (plant pathologist). The laboratory maintains an extensive diagnostic collection of specimens to support the surveillance and inspection programs within the Region.

Region IX does not receive many containers but inspects all that do arrive here. Crating is inspected for presence of bark, evidence of boring, and the organisms themselves. Phytosanitary personnel from SAG visit the companies within the Region who receive products likely to be crated or likely to involve dunnage and train them as to the protocols for dealing with wood material. They are asked to ensure that no crating or dunnage is allowed outside the premises of the receiving company.

We inquired about the early detection program for *Sirex noctilio* and learned that although the program is in place throughout the entire country, bait trees are just along international borders with Argentina and in the airports. The program has been in place for 5 years and concentrates on those points of high risk for entry.

We also inquired about special survey protocols for eucalypt plantations. All are surveyed in the normal fashion, but those in high-risk areas are surveyed more intensively. The principal mission of surveys of both *Eucalyptus* plantations and elsewhere is the early detection of quarantine pests.

The team discussed many of the specific insects on our preliminary list with SAG entomologist Jaime Luna. He said there are no ants of the genera *Acromyrmex* or *Atta* in Chile. *Chilecomadia valdiviana* is only found on *E. nitens* and only occurs in isolated locations. His feeling was that the cossid moth was associated with weakened trees. He also noted its occurrence in *Salix* and *Nothofagus* hosts. Two of the cerambycids on the list were dismissed as having no significance as pests on *Eucalyptus: Acanthinodera* (decomposer) and *Callideriphus* (not found on *Eucalytpus*). We also discussed four genera of termites that appear on our preliminary list: *Cryptotermes* (strictly a drywood termite, of restricted distribution and limited to wood in use), *Kalotermes* (only on Juan Fernandez Islands), *Neotermes chilensis* (a wood decomposer), and *Porotermes* (a wood decomposer with no record on *Eucalyptus*). *Phoracantha semipunctata* occurs in Region IX but is far less significant here than further north. *Phorancantha recurva* does not occur here nor does the defoliator we encountered in Argentina, *Pyrrophyge pelota*. Other insects on our list that do not occur on *Eucalyptus* include *Xyleborus* spp. and *Rhyephenes* spp. Mr. Luna added a weevil, *Naupactus xanthographus* to the preliminary list as a marginal associate of *Eucalyptus*. The weevil generally prefers fruit trees but will occasionally feed on leaves and deposit eggs on the roots of *E. viminalis*. We asked Mr. Lara about the presence of *Gymnopilus* in Chile, which he has not seen. He has also not encountered *Ceratocystis* and does not see much *Mycosphaerella*. Other organisms he had not seen on *Eucalyptus* included *Ophiostoma* and *Cryphonectria*. The conclusion of the two specialists was that there is generally very little *Eucalyptus* material sent to their laboratory for diagnosis unless the trees have been stressed.

Following our meeting with SAG in Temuco, we traveled to Valdivia to meet with entomologists and pathlogists from the Universidad Austral de Chile. We were welcomed by entomologists Angelica Aguilar and Dolly Lanfranco and by pathologist Hernán Peredo. Also present in the meeting were Sergio Rothman and Angela Tortora from the Central Lab of SAG in Santiago and Pablo Gonzalez from the SAG office in Puerto Montt. We discussed the preliminary pest list and confirmed much of the information we had received elsewhere regarding associations of various organisms with *Eucalyptus*. There was considerable discussion of the fact that our risk assessment covers four countries that are very different in terms of the organisms associated with *Eucalyptus* and perhaps more importantly, different in terms of their ability to evaluate the phytosanitary condition of the forest resource. Chile takes great pride in its plant quarantine and surveillance systems and expressed the concern that a broadly applied generic regulation of imported *Eucalyptus* would not be sensitive to their ability to regulate the phytosanitary condition of their particular resource. We also had a particularly lively discussion on the philosophy of risk assessments and the conflict between free trade and protection of resources.

We asked the university scientists which organisms they thought were the most important associates of *Eucalyptus*. Although two insects were mentioned (*Phoracantha semipunctata* and *Chilecomadia valdiviana*), both were named with the caveat that they are of limited importance, either in terms of host associations or distribution. Mr. Peredo stated that there are no diseases of *Eucalyptus* in Chile, only fungal associates.

Mr. Gonzalez from the SAG office in Puerto Montt described the operations at the port of Calbuco. The port is an important one for the export of wood products. Only chips are being shipped at this time, but the port has the capability to ship logs as well. The surface is paved and thus free of soil. There are presently no installations in this port or in any other port for fumigation, except for that of crating. (Only the United States is requiring fumigation). At present, Japan is the primary recipient of chips (mostly native hardwood and 12% *Eucalyptus*). When required, phytosanitary certificates are written at the port. The team inquired about the debarking procedure for *Eucalyptus* and learned that it is variable and dependent on how the wood will be used. Pulp logs are generally debarked, but debarking well ahead of the pulping process makes the logs harder to chip. Sawlogs are generally not debarked. We were told that if debarking were required as a mitigation measure, then it would be done, and there should be no problem in meeting the standard of 2% to 5% bark remaining on debarked logs.

Following the meeting at Universidad Austral, we returned to Santiago.

April 28

The team traveled north from Santiago to the towns of Los Andes and San Felipe, where the weevil *Gonipterus scutellatus* was discovered 2 months earlier. At present, the weevil is distributed across an area of 1,770 km^2 within the drainage of the Aconcagua River, leading SAG officials to believe that it has been in Chile for at least 2 years. Eucalypts in this area are sparse and fairly widely scattered, but the infestation is just 130 km from the production forests of Region V. *Eucalyptus globulus* is presently the only host in Chile for *G. scutellatus* although hosts in other countries also include *E. viminalis*, *E. camaldulensis*, and *E. regnans*. A large ridge to the south of the present infestation and the lack of contiguous host material are currently keeping the insect contained and out of the Santiago Valley. A two-pronged control program will be undertaken. Beginning in September, SAG will carry out a chemical control with three sprays of a microencapsulated formulation of a pyrethrin insecticide applied from a helicopter to the early larval stages. The second phase of control will involve mass rearing and release of a natural egg parasite, *Patasson nitens*, to be collected from South Africa. (The weevil was introduced into Uruguay, Brazil, and Argentina with its native parasite, but came to Chile without the parasite.) The chemical application is expected to cost US$30,000 for three applications, and the biological control should be US$75,000.

This is the second introduction in recent years from Argentina. The elm leaf beetle, *Xanthogalerucella luteola*, was introduced into Chile in 1992.

We met with the three SAG personnel in charge of surveying this area to determine the distribution of the weevil (Juan Ravenales, Gema Olivera, and Erica Ereche). We were taken to a plantation that had extensive feeding on the foliage. The feeding does not kill the host but reduces the rate of growth. All the feeding damage in this area was new since the previous July, indicating that the insect is multiplying and spreading rapidly. We learned that three applications of the insecticide will be necessary because of the staggered life stages of the insect and the rapid growth of the host plant. Karate is apparently a feeding repellent as well as a larvicide and adulticide.

We discussed the question of taxonomic synonymy between *Gonipterus scutellatus* and *G. gibberus*, which we had learned about in Uruguay. SAG entomologists felt that there were noticeable differences between the two species (*G. scutellatus* with two stripes on the larvae and adults brown; *G. gibberus* with no stripes on the larvae and adults orange).

We returned to Santiago to visit the crating inspection program at Pudahuel International Airport. The team was met by two wood and dunnage inspectors for SAG, Luis Alarcon and Miriam Vega. We also met local APHIS inspector Ximena Preto and entomologists Juan Carlos Moroni and Ruben Zuñiga. Miriam Vega explained the crating inspection process at the airport. Most of the crates (60%–70%) arriving at the airport are visually inspected for presence of bark, insect signs, and damage in the wood. If any of these signs are found, the inspectors invoke the “Act of Retention” and all of the shipping information from the manifest is entered into the computer. The inspector or customs agent notifies a contractor who will fumigate the crating with methyl bromide or phosphamine. The cost of the fumigation is borne by the importer. The importer is given the opportunity to remove the contents of the crating before the fumigation is done. After the treatment has been done, a sample of the crating is brought to the diagnostic laboratory to determine if pests are present and if the treatment was successful. About 200 to 300 crates require fumigation at Pudahuel in a typical year, which is about 70% of the crates inspected. If live insects are intercepted in the initial inspection, the crating and its contents are sprayed before fumigation. Typically, not many live insects are found. We learned that in Valparaiso and other large ports, the percentage of crating that is inspected is far lower (10%) and suspicious crating is burned instead of fumigated. Crates not inspected at the port of entry will be inspected on arrival at their destination.

The evening was spent in Santiago.

April 29

In the morning, we met with Jim Mackley, regional director for APHIS International Services (U.S. Embassy), and his staff to discuss our impressions of the site visit to Chile.

In the afternoon, we were asked to meet with SAG officials for a closeout meeting. That meeting was also attended by people from numerous other agencies, private forestry companies, and specialists from Universidad Austral de Chile.

Present at the closeout were Orlando Morales, Marcos Beeche, Miguel Angel Poisson, Ariel Sandoval, and Pablo Gonzalez from SAG; Patricio Parra and Sandra Perret from Instituto Forestal; Jose Antonio Prado and Cristian Pérez from CONAF; Angelica Aguilar from Universidad Austral; Maria Teresa Arana from CORMA; and Luis de Ferari from Forestal Mininco.

We thanked SAG and the rest of our hosts for their cooperation and for spending the time with us to enable us to evaluate the risks associated with the importation of *Eucalyptus* into the United States. We then described the process we will need to follow to complete the actual pest risk assessment report, including the development of Individual Pest Risk Assessments (IPRAs) that form the backbone of the risk assessment. Mr. Morales pointed out that IPRAs should only be drawn up for pests on the quarantine list or those interfering with the establishment of plantations. We reiterated the respective positions of the U.S. Forest Service and APHIS with regard to risk assessment and risk management, emphasizing that the role of WIPRAMET was to analyze the organisms associated with different ecological niches on *Eucalyptus* (on the bark, beneath the bark, in the wood) and that APHIS would determine risk management based on those individual assessments. We also described the model for analysis, the seven elements of the probability of establishment and the consequences of establishment. We assured our hosts that they would have an opportunity to comment on the risk assessment and that the pathways to our conclusions would be readily transparent.

Other subjects of interest were the timelines for our document and the development of regulations by APHIS. There was also concern expressed that the four countries included in our assessment be treated individually and not with a "broad brush."

In a final overview, we summarized our general impressions, which were that there appear to be very few phytosanitary problems associated with the *Eucalyptus* resource, the system of vigilance and survey in Chile is very good, and that a solid infrastructure exists to deal with developing problems. On the other hand, we pointed out that where biological information is lacking (for example, the decay fungi associated with *Chilecomadia valdiviana*), we needed to take a conservative approach in our assessments.

In the evening, the team returned to the United States.

Appendix B—Scientific Authorities for Species of *Eucalyptus*

alba Reinw. ex Blume
amygdalina Labill.
angulosa Schauer
astringens Maiden (Maiden)
bicostata Maiden
botryoides Smith
brassiana S.T. Blake
brockwayi C. Gardner
camaldulensis Dehnh.
campaspe S. Moore
camphora R. Baker
cinerea F. Muell. ex Benth.
citriodora Hook.
cladocalyx F. Muell.
cloeziana F. Muell.
cypellocarpa L. Johnson
deglupta Blume
delegatensis R. Baker
diversicolor F. Muell.
dunnii Maiden
eugenioides Sieber ex Sprengel
exserta F. Muell.
fastigata Deane & Maiden
ficifolia F. Muell.
flocktoniae (Maiden) Maiden
globulus Labill.
gomphocephala DC.
grandis Hill ex Maiden
gunnii Hook.
kitsoniana Maiden
lesouefii Maiden
linearis Dehnh.
longifolia Link
macarthurii Deane & Maiden
maculata Hook.
maidenii F. Muell.
marginata Donn ex Smith
microcorys F. Muell.
moluccana Roxb.
nesophilia Blakely
nicholii Maiden & Blakely
nitens (Deane & Maiden) Maiden
nova-anglicae Deane & Maiden
obliqua L'Her.
oleosa F. Muell. ex Miq.
paniculata Smith
pellita F. Muell.
phaeotricha Blakely & McKie
pilularis Smith
propinqua Deane & Maiden
pulverulenta Sims
punctata DC.
pyrocarpa L. Johnson & Blaxell
radiata Sieber ex DC.
regnans F. Muell.
resinifera Smith
robusta Smith
rostrata Cav.
saligna Smith
sideroxylon Cunn. ex Woolls
stoatei C. Gardner
tereticornis Smith
tessellaris F. Muell.
torquata Luehm.
torelliana F. Muell.
trabutii A. Vilm. ex Trab.
urophylla S. T. Blake
viminalis Labill.

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

Introduction

A draft of the South America pest risk assessment was provided to 63 reviewers in various countries, including Argentina, Australia, Brazil, Canada, Chile, Colombia, Great Britain, Morocco, New Zealand, the Union of South Africa, the United States, Uruguay, and Venezuela. 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 *Eucalyptus*.

Responses were received from 24 reviewers or organizations (see Acknowledgments for their names and addresses): 15 from the United States, two from Australia, two from Uruguay, and one each from Argentina, Brazil, Chile, Colombia, and Great Britain. The review from Chile was provided through a working group of representatives from The Agriculture and Livestock Service (SAG), the National Forestry Corporation (CONAF), the Chilean Wood Corporation (CORMA), the Forestry Institute (INFOR), and the private companies Forest Pest Control (CPF-SA) and Forestal MININCO.

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

General Comments From Reviewers

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

"Overall, except as noted above, I believe the team has done a thorough and commendable job of assessing the pest risk associated with importation of *Eucalyptus* logs and chips from South America." (Billings)

"The team has made a commendable effort in addressing the enormous variety of potential pests found over a very large and diverse geographical area on a large number of *Eucalyptus* species." (Cameron)

"…the summary information on pests is valuable and well presented and I would congratulate you on it." (Eyre)

"Congratulations on a job well done. I am particularly impressed with the rigorous method of risk assessment you have used in the IPRA's. I am going to talk to our Quarantine authority about using your approach for a similar PRA we did for Australia." (Floyd)

"…I congratulate the Team on an excellent presentation. It is thorough and clearly written." (Hansen)

"You folks have such a daunting task with limited data to go on. I congratulate you." (Jacobi)

"For the most part, we were impressed with the document. The WIPRAMET team did a good job of choosing pests that reflect the various 'habitats' of potential exotic invaders on imported logs and chips." (Johnson/Osterbauer)

"This is an excellent report that clearly reflects the expertise and experience of the group to address the real and potential risks of the importation of *Eucalyptus* into the United States from South America. It is very well balanced between the two potential groups of pests—insects and diseases." "In summary, this is an excellent examination of the problems, potential and real of the importation of raw wood from *Eucalyptus* plantations now growing at a wide variety of locations in South America. Certainly, our own natural resources deserve the best efforts by our scientists—as evidenced by this report." (Lattin)

"Firstly, may I congratulate the Wood Import Pest Risk Assessment and Mitigation Team (WIPRAMET) on an excellent piece of work. The report is well written, concise and comprehensive, covering representatives of important insect pests and diseases of eucalypts that may pose quarantine threats to the USA. The trip report is very informative, providing a useful contribution to the pest risk assessment process. I strongly support the assessment and conclusions proposed by the assessment team (WIPRAMET)." (Mireku)

"The document is very good! And I think that the document will be very important for us in South America, because it is a synopsis of all forestry protection problems, and represents an overview of all experts in Brazil, Argentina, Chile and Uruguay. Wonderful document!" "All of those who research and work with Forest protection in South America will use the report as a guide.” (Pedrosa–Macedo)

“The report will be very useful as it includes in one document the general information and the risk elements that make up the determination of pest risk criteria applied for the determination the pest risk in the United States; so it will help to coordinate actions in the future.” (Telechea/Porcile) (translated from Spanish)

“As with other risk assessments, the trip reports are very helpful.” “I commend the team for the work that they’ve done. This is a very well done initial effort.” (Zadig)

Major Issues of Reviewers

Other comments from reviewers not pertaining to specific pests were organized into 11 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 this Wood Import Pest Risk Assessment and Mitigation Evaluation Team.

Issue 1: Geographical Scope of Assessment

Reviewers’ comments—Concern was expressed by Chilean reviewers and others that, because of numerous differences among countries, separate risk assessments should be done for each South American country. Others felt that the risk assessment should be expanded to include additional countries.

“Why wasn’t this pest risk assessment extended to include Central American countries and Mexico? At least one U.S. company has recently established large plantations of *Eucalyptus* in Mexico with plans to bring chips and logs into Texas for processing.” (Billings)

“Although it would greatly complicate this PRA, a regional approach might provide a more accurate assessment of risk. In South America there is substantial regional variation in the distribution of the pests, *Eucalyptus* species present, and plantation management practices. For example, *Chilecomadia valdiviana* is restricted to certain parts of Chile and the Andean region in Argentina and would not be a risk from anywhere else in South America.” (Cameron)

“The authors state that *Eucalyptus* plantations in South America are well-kept and prompt action is taken when pest problems occur. This is true in many of the commercial plantations, however, in many areas, *Eucalyptus* has been planted as part of government incentives programs by private landowners and has subsequently been unattended. This is another reason that regional or more specific assessments would more accurately assess potential pest risks.” (Cameron)

“Finally, we were happy to see some of our more vulnerable ecosystems (e.g. Hawaii) receive attention. The impact of potential exotic pests on Hawaii, Alaska, and the U.S. territories is often not considered in PRA.” (Johnson/Osterbauer)

“The inclusion of the Hawaiian Islands into consideration is excellent. Far too long we have excluded this State from consideration.” “The results of introduction of a wide variety of organisms have resulted in extinction and drastic reduction of the native biota.” (Lattin)

“In its overall structure, the reviewed document considers the development of the process of Pest Risk Analysis (PRA) for an entire subcontinent—South America—within which there are significant differences with respect to the species of *Eucalyptus* planted from one country to another, the species of insects and fungi associated with the *Eucalyptus* present in those different countries, the distribution and diversity of those species, climatological differences, differences in biogeographic aspects, difference with respect to the official and non-official phytosanitary institutions, differences with respect to the characteristics of wood-loading ports, etc.” (Peña Royo) (translated from Spanish)

“For the reasons just stated, we believe the Pest Risk Assessment should be carried out independently for each of the countries that have an interest in exporting chips and logs of *Eucalyptus* to the United States. This becomes especially significant when Step 3 of the Risk Management process is undertaken—that of proposing mitigation measures, which should reflect the stated differences of phytosanitary risk between countries.” (Peña Royo) (translated from Spanish)

“As an example, in Tables 8 and 9 there are 135 insects and 60 fungi shown to be associated with *Eucalyptus* in South America. Of these, Chile has 9 and 7 species of insects and fungi respectively, which represents 6.6% and 11.6 % of the total for the region analyzed (one species of insect lives exclusively in the archipelago of Juan Fernandez Islands), which reflects a significant difference with respect to the diversity of species associated with *Eucalyptus* in Chile compared to the rest of the region.” (Peña Royo) (translated from Spanish)

Response to comments—The scope of this pest risk assessment was based on a request by APHIS that the U.S. Forest Service Wood Import Pest Risk Assessment Team conduct a “pest risk assessment of *Eucalyptus* species from several South American countries” (A. Elder, APHIS, 1997, personal communication). This pest risk assessment primarily focused on the countries of Brazil, Chile, Argentina, and Uruguay since these countries have the largest *Eucalyptus* resources and are most likely to export logs or chips to the United States. Information on *Eucalyptus* resources and pests for the other countries in South America are provided where available. Country-specific differences in the condition, pests, and management of the *Eucalyptus* resources are discussed in the pest risk assessment. This pest risk assessment does not attempt to assign an overall risk level to the continent of South America nor to any specific country. Consideration of the factors that distinguish one country from another with regard to the risks associated with the particular organism of concern is the responsibility of APHIS. As stated in the Conclusions of this pest risk assessment, detailed examination and selection of phytosanitary measures to mitigate pest risk is the responsibility of APHIS and is beyond the scope of this assessment.

Issue 2: Biological Scope of Assessment

Reviewers' comments—Reviewers felt that the insects and pathogens of concern tables (Tables 8 and 9) and the pest categories were confusing or inadequate. Some pointed out that organisms were listed as occurring on *Eucalyptus* in their country without citations, were listed to genus only, were secondary organisms on *Eucalyptus* and should not be listed, or were organisms already present in the United States. Others suggested that all organisms occurring on *Eucalyptus* in South America be included in tabular format. One reviewer pointed out that several insects that were not listed occur in California.

"With respect to the list of Potential Insects Associated with the commodity of *Eucalyptus* cited for Argentina (Table 8), we have the following comments:

> *Callideriphus laetus*, *Eurymerus eburoides*, *Sarsina violascens, Steirastoma breve* and *Strepsicrates marcopetana*: From the bibliography consulted there are no references that mention these as being present in the country, nor have these pests been detected in areas where eucalypts are grown in Argentina.
>
> *Colaspoide vulgata*: Listed for Argentina, present in the province of Misiones, only affects foliage and seedlings (young nursery plants).
>
> *Retrachyderes thoracicus*: Borer of fruit trees. Observed in Argentina producing damage only in fig and peach trees." (Guillen) (translated from Spanish)

"With reference to the list of Potential Pathogens Associated with eucalypts (Table 9) we have the following comments for some of the pathogens cited as being present in Argentina:

> *Armillaria* spp., *Botryosphaeria* spp., *Ganoderma* sp., *Phellinus* spp.: It is requested that citations of pests include both the genus and species, since from the perspective of plant quarantine, the proper taxonomic position of the pathogen is of great importance for the development of the corresponding risk assessment.
>
> *Botryotinia fuckeliana*. Present in Argentina. *Eucalyptus* is a secondary host. *Cerospora epicoccoides*, *Coniella fragariae* (syn.: *Coniothyrium fragariae*), *Cytospora eucalipticola*, *Diplodia australiae*, *Gymnopilus spectabilis* (syn.: *Pholiota spectabilis*), *Mycosphaerella suttoniae* (syn.: *Phaeophleospora epicoccoides*), *Phaeophleospora eucalypti*, *Pseudocercospora eucalyptorum*, *Sphaerotheca pannosa*: From the bibliography consulted, no citations arose which mention these pathogens as being present in the country, nor have they been detected in areas where eucalypts are grown in Argentina." (Guillen) (translated from Spanish)

"In accordance with the comments just expressed, I would ask you to please send us the scientific foundation which supports the citations of the aforementioned pests in the Document and on which we have made comments." (Guillen) (translated from Spanish)

"This is the document that APHIS will turn to when someone asks for a permit to import green *Eucalyptus* lumber from South America. Therefore, the PRA should include pests found on green lumber and other wood products. The risk associated with the importation of these products will differ from the risk associated with chips and logs. The PRA should reflect that." (Johnson/Osterbauer)

"It would be extremely useful to include tables such as those that appear in Appendix A from the 'Pest Risk Assessment of the Importation of *Pinus radiata* and Douglas-fir Logs from New Zealand'. Such tables would be excellent, quick references for APHIS inspectors when a potential pest is intercepted on imported Eucalyptus. For example, *Rosellina*, *Pythium* and *Fusarium* are mention in Appendix A—Reports on Team's Site Visits to South America—as other pathogens found on *Eucalyptus* seedlings. These and similar pests should be listed in the PRA. We know that whenever a potential pest is intercepted on *Pinus radiata* logs from New Zealand, APHIS used the tables in Appendix A of the New Zealand PRA to make their regulatory decisions. If a pest is not listed, it may be considered unimportant." (Johnson/Osterbauer)

"As pointed out in my previous comment on the preliminary pest list, the list of potential pests of concern (Table 8, pp 29–37) only deals with insects and not arthropod pests. There are many serious arthropod pests which are not insects (e.g. mites) and therefore the list should include all arthropods and not just insects." (Mireku)

"I note that the list of potential insect pests and diseases of concern presented in Tables 8 and 9 (pp 29-45) may not encompass all pests associated with eucalypts in South America. However, as stated in the assessment, it is very difficult to collect biological data on all possible pests (particularly root- and stem rots). Selecting representative pests that inhabit a variety of niches on logs will certainly enable APHIS to identify effective mitigation options that will control both the known pests and unknowns. I support this principle, provided mitigation measures to manage the known pests are effective against the full spectrum of possible unknown pests." (Mireku)

"Table 7—Pest categories and descriptions. In recent years California has discovered a number of introduced species associated with Eucalyptus. Of the species listed in this table the following have been found in California infesting Eucalyptus: *Ctenarytaina eucalypti*, *Gonipterus scutellatus*, *Phoracantha semipunctata*, and *Trachymela sloanei* (California Plant Pest and Disease Report, January-June 1998)." (Zadig)

Response to comments—The objectives and scope of this pest risk assessment are identified in Chapter 1. The scope of the assessment includes the importation of unprocessed *Eucalyptus* logs and chips from South America and does not extend to manufactured wood products. Some of the pest organisms that are considered in the risk assessment are probably also associated with green lumber and other wood products. The biological information provided in the individual pest risk assessments may be helpful in determining risk levels for these types of material, but this was not the intent of this assessment. Although this assessment attempted to be thorough in determining the possible insects and pathogens that are present in the South American countries on *Eucalyptus*, it should not be considered complete. Tables 8 and 9 are lists of potential insects and pathogens of concern, not lists of quarantine pests, nor inclusive lists of organisms found on *Eucalyptus* in South America. Collecting the needed information on all possible pests present is not possible because many of the organisms have not been identified adequately and may have limited, if any, biological information available. The pest risk assessment process takes the approach of identifying a spectrum of organisms that occupy various habitats and represent potential avenues of entrance into the United States on the resource being considered. The intent is to provide an assessment of representative organisms that could enter the United States so that APHIS can develop appropriate mitigation measures. It is not the intent of this assessment to be inclusive of all insects and pathogens that are known to be present on *Eucalyptus.* Even less information is known about arthropods than insects. These were not included within the scope of this assessment, but it is assumed that mitigation measures that are effective against insects in the different niches would be effective against other arthropods.

Reviewer comments regarding specific insects and pathogens in Argentina were addressed directly in subsequent correspondence between the team and the reviewer. Literature citations referring to the presence of specific organisms on *Eucalyptus* in Argentina were provided. The four insect species mentioned as having recently been found in California are identified in pest category 2 in Table 8. This acknowledges that they are not native to the United States but are present and may be capable of further spread. Information on the states where non-native insects are present in the United States has been added to Table 8.

Issue 3: Definition of a Quarantine Pest

Reviewers' comments—Reviewers from Chile requested clarification of the classification of pests considered in the draft document and how these categories comply with international standards for quarantine pests.

"The reviewed draft document shows a classification of the pests considered into five categories [the categories are listed]. On this aspect, we have the following comments:

The revised text of the International Plant Protection Convention (IPPC) (Rome, 1999) defines a Quarantine Pest as 'Pest of potential economic importance for the area at risk when the pest is not present, or if present, is not extensive and is under official control' (See Enclosure 1). Taking into account the IPPC definition of Quarantine Pest, species that are present in the United States and are not under official control should not be considered as quarantine pests, according to the criteria established through the IPPC. It is appropriate to point out that only quarantine pests and regulated non-quarantine pests can be the subject of phytosanitary regulations that govern the importation of plant products." (Peña Royo) (translated from Spanish)

"As stated previously, those pests that do not qualify as quarantine pests should not be considered as pests to be controlled under the regulations established for the importation of chips and logs of *Eucalyptus*.

In this sense, not all of the pests listed in Categories 2 and 2a should be considered as quarantine for the United States unless they are officially being controlled in the United States. For the reasons previously stated, it should be clarified if the following pests which are present in the United States as well as in Chile are under *official control*: *Gonipterus scutellatus*, *Phoracantha semipunctata*, *Phoracantha recurva*, *Aulographina eucalypti* and *Mycosphaerella walkeri*." (Peña Royo) (translated from Spanish)

"If these pests are presently being subjected to official control in the United States, the measures of quarantine control applied to Chile should be *equivalent* to the phytosanitary measures already established within the United States to limit the further dissemination of these pests from states/counties where they occur into states/counties where they do not occur. Following from previous discussion, we believe that it is not possible to determine the Pest Risk Potential for species whose quarantine status within the United States has not been previously clarified; such as is the case for *Gonipterus scutellatus*, *Phoracantha semipunctata*, *Phoracantha recurva*, *Aulographina eucalypti* and *Mycosphaerella walkeri*, which have been classified with Pest Risk Potentials of *High*, *Moderate*, *Moderate* and *Moderate*, respectively." (Peña Royo) (translated from Spanish)

Response to comments—The criteria for categorizing potential insects and pathogens of concern were biological and do not strictly reflect plant protection policy. Determination of quarantine status for any organism is the responsibility of APHIS and is beyond the scope of this assessment.

Although *Phoracantha semipunctata*, *P. recurva*, and *Gonipterus scutellatus* are found in California, the latter two species are still not widely distributed. Even *P. semipunctata*, the most widely distributed of the three species, is not found throughout the range of *Eucalyptus* in the United States. The eucalyptus borer is still not reported to occur in Florida and may be of limited distribution in Arizona. Currently, there are active control and management programs in place in the state of California for all three of these exotic pests of *Eucalyptus*. APHIS is in the process of reviewing these programs to determine if they can be sanctioned as programs of Official Control as defined by IPPC.

Issue 4: Lack of Adequate Background Information

Reviewers' comments—Reviewers described sections of the draft document that provided insufficient information to the reader and offered suggestions for improvement.

"Clearly, APHIS is responsible for examining the information presented in this report and suggesting appropriate phytosanitary measures to mitigate risk associated with the importation of *Eucalyptus* logs and chips. However, additional information about life cycles and habits as they relate to mitigating procedures would be very appropriate. There is little information presented on how different methods of harvesting, handling, and processing of logs would affect the pests evaluated in this PRA. Descriptions of specific inspection procedures available for *Eucalyptus* plantations that would adequately detect potential pests also would be useful information to have in the pest risk assessment." (Cameron)

"I would have appreciated some more background and justification for this particular Risk Assessment. The opening line states that 'current regulations require that logs and chips from SA must be treated before importation'. Is there a proposal to import without treatment?" (Hansen)

"The section on Previous Interceptions is very brief and not helpful. I presume this is because there is so little information, and essentially no regulation in other countries, but more explicit descriptions of laws and practice would provide context for judgment. Is there a history of interception in the United States? It would be useful to summarize the known cases where *Eucalyptus* pests have moved, and the local consequences." (Hansen)

"Perhaps more could be said about the current situation in California where many *Eucalyptus* trees have been growing. As I recall, certain Homoptera and perhaps a weevil are now causing damage. A brief review of this situation could be of considerable value since it represents a case study of the situation." (Lattin)

"Considerable work has been done on *Eucalyptus* plants in the United Kingdom (e.g. Evans, 1980). There might be some useful knowledge there on what happens in the upper part of Holarctic Region." (Lattin)

"Figures 2, 3, 4 and 5 (pages 23-26): Abbreviations 'IND, RWD, WIR, C, NC in the legends and tables are difficult to understand. They are not explained anywhere in the assessment. I suggest that you provide footnotes to explain what these abbreviations stand for." (Mireku)

"Resources at Risk. Entry pathways for Eucalyptus pests pose a risk of entry and establishment for harmful invasive pests of other agricultural crops as well. Even though these impacts are discussed in the individual pest risk assessments, for purposes of transparency these impacts need to be captured and thoroughly described within this section. Agricultural crops mentioned in the individual pest risk assessments in addition to the other Myrtaceae previously mentioned (guava and allspice) include citrus, avocado, fig, olive, various stone and pome fruit species, rose apple, coffee, mango, cocoa, tea, and rubber." (Zadig)

"Eucalyptus Plantations in South America. As Eucalyptus is an introduced species to this continent, it would be helpful to describe the reaction of native organisms to its introduction and any pest problems that arose. Although there is some discussion within the trip reports, here it would be additionally helpful if the standard harvesting practices, including debarking can be discussed. This would be particularly helpful when reviewing the risk via movement of chips. In other words, would chips include branch material? The individual pest risk assessment for eucalyptus longhorn borer states that debarking is done routinely as a harvesting practice in Argentina." (Zadig)

Response to comments—Additional background information was added to the appropriate section of the document. References to specific attributes of certain organisms (distribution, nomenclature, typos) were considered and changes made in the individual pest risk assessments. Concerns regarding agricultural resources at risk were addressed by providing additional information to the Resources at Risk section of the document and to individual pest risk assessments.

Two reviewers comments refer to the effects of certain procedures that would be considered pest mitigation measures. These measures and their effects on pest risk are beyond the scope of this assessment. Our charge was to evaluate the risks associated with raw logs and chips, and our discussion of debarking was only intended to identify that practice as being a normal part of processing for only one species of *Eucalyptus* (*E. grandis*) in one country (Argentina).

We typically refer to interception records because they can be a useful source of information for identifying potentially invasive insects. In the case of *Eucalyptus*, this source of information has been of rather limited use for three possible reasons: (1) the relatively limited amount of *Eucalyptus* raw wood moving through the international market, (2) the status of *Eucalyptus* as unregulated in the European market, which limits the amount of inspection that is done on the commodity, and (3) *Eucalyptus* appears to be a relatively clean commodity.

Issue 5: Crossover of Pests (Alternate Hosts)

Reviewers' comments—Reviewers expressed concern that the organisms that crossed over from native hosts to the introduced *Eucalyptus* in South America may cross over to other hosts if introduced into the United States. Some felt that alternative host species should be listed for known pests that occur on *Eucalyptus* in South America. Chilean reviewers stated that even when an insect has a wide host range, it cannot be assumed that plant species in which the pest has never been observed will be hosts for the pest.

"The potential seems to exist that Eucalyptus may be a conduit of indigenous South American pests not normally found on Eucalyptus in other areas to other trees in North America. This is an important aspect not normally considered." (Jacobi)

"I wonder if any of these listed pathogens would cross over to native southern hardwood species. I did not see any evidence that these fungi (pathogen ipras) had any other hosts other than pink disease or Ceratocystis." (Jacobi)

"As noted, *Eucalyptus* is an introduced species in South America. Many of the pests on *Eucalyptus* are native organisms attacking a new host (pp. vii, 135, 139). Unfortunately, the native hosts for these pests are rarely or inconsistently listed within the PRA. A list of alternate host species may help identify other susceptible hosts in the U.S. (p. 13). These alternate hosts, including potential herbaceous hosts (e.g., for *Armillaria* spp.), should be included either in Tables 8 and 9 or in the IPRA." (Johnson/Osterbauer)

"Also, the ability of native South American pests to cross over to the introduced *Eucalyptus* was an important issue that was covered quite well in the PRA." (Johnson and Osterbauer)

"Again, the alternate hosts for the *Eucalyptus* pests must be included in the PRA. An accurate prediction of the economic and environmental impacts of these pests cannot be made without this information." (Johnson/Osterbauer)

"The second lesson brought out by this report is that some organisms native to South America have made the host shift onto these non-indigenous trees—this too, is an alarm not to be ignored. Far too often we are told that such host shifts are not likely to occur—but they do." (Lattin)

"The lack of presence of *Ch. valdiviana* in plantations of *E. globulus* is something that has been studied in Chile [including] in situations where infested plantations of *E. nitens* have been found growing adjacent to plantations of *E. globulus* without ever having observed the moth attacking the latter species. In the process of Pest Risk Assessment, special attention must be given to pest/host associations, considering that even when the pest being examined is an insect with a wide host range, as is *Ch. valdiviana*, it cannot be assumed that plant species in which the pest has never been observed will be hosts for the pest. This is the case for *Ch. valdiviana* with respect to *E. globulus*, in which a Pest Risk Potential of Moderate has been assumed without the existence of observations and/or publications that support an association between both species." (Peña Royo) (translated from Spanish)

Response to comments—The adaptation of native South American organisms to the introduced *Eucalyptus* is a key part of this risk assessment. The issue of crossover pests is significant since the commodity under consideration (*Eucalyptus* spp.) is not native to the area of import (the United States). This was recognized during the assessment and was addressed in the summary (Chap. 4). Because of concerns raised by reviewers' comments, the discussion in the summary was expanded to point out the large number of pests that fit into this category. Many of the organisms of concern in South America are indeed native to those environments and have utilized *Eucalyptus* as an occasional host. In many cases, their entire native host range is poorly known. However, if they have been reported on various genera of hosts as well as on *Eucalyptus*, they were likely to be rated high for colonization and spread potential, on the basis of their polyphagous habits and their demonstrated adaptability by utilizing *Eucalyptus* as a new host. In addition, each assessor reviewed their IPRA to assure that known South American hosts other than *Eucalyptus* were included in their assessment.

Issue 6: Import of Potential Pests on Chips

Reviewers' comments—Several reviewers felt that the risk of importing pests on untreated chips was higher than the draft risk assessment suggested or was unclear and that some IPRAs did not consider chips as a pathway.

"Another troublesome area in this PRA is that logs and chips generally are lumped together, even though APHIS regulations treat them differently. The authors stated that 'the risk-rating of potential pest species was based on the concept of whole log importation.' They also pointed out that 'clearly, debarking and reducing logs to chips will seriously impact the survival and hence the risk of importation of certain pests.' 'Thus, of the IPRAs for insects, all would be rated at moderate to low risk of surviving chipping and transport.' The effect of chipping on fungi is not clear. Further research on the presence and persistence of potential pests in wood chips is strongly encouraged.” (Cameron)

“Several of the individual pest risk assessments (IPRA) (e.g. root and stem rots and most of the insects) only consider introduction, spread, and establishment from *Eucalyptus* logs. Since many companies are planning to import chips, the IPRA should also consider this pathway especially for the fungi. We realize that hot and anaerobic conditions may occur in the centers of piles of chips (p. 139). However, chips on or near the surface or edges would not be subject to those conditions.” (Johnson/Osterbauer)

“Recent research on the survival of insects and the pitch canker pathogen in chipped Monterey pine branch material is relevant to your document and hence you may wish to reference the findings (chipping reduced the emergence of branch-infesting insects by about 95%; the pitch canker pathogen was readily isolated from chipped material, including asymptomatic branches; phoresy rates among insects that survived chipping was quite high—up to 67%) and consider the consequences in your discussion.” “Given that approximately 5% of the insects survived and emerged from chips, I have concern that chips could pose a significant risk for insect establishment as well. The shear volume of chips that are likely to be imported would suggest that 5% survival could easily translate into a significant number of insects.” (Owen)

Response to comments—The team discussed the research findings of William McNee, who noted that 5% of the beetles in branches infected with the pitch canker pathogen survived the chipping process. His research was conducted on very small branches, mostly less than 2.54 cm in diameter. These branches contained tiny *Pityophthorus* spp. bark beetles. Mr. McNee felt that the surviving insects were probably callow adults or young adults at the time the host material was chipped and that earlier developmental stages would be less likely to survive the chipping process due to the drying of the host material. He also felt that larger insects present in the bole would be less likely to survive chipping than the insects in his study. In this assessment, the team evaluated bark and wood boring insects that would be sensitive to the drying of their host material that would result from the chipping process. For insects under the bark or inside the wood of the bole, we would still consider the entry potential to be low after chipping of infested host material.

Mr. McNee’s work found a higher level of viable *Fusarium circinatum* in branch chips than in unchipped material. This would be expected, because more surface area suitable for sporulation is available. In general, the smaller the wood chips, the quicker they would dry out and the less the risk of pathogens of concern surviving. An exception would be the canker-causing fungi, which can survive for long periods in a desiccated state. Chipping can have different effects on different fungi, both positive and negative with respect to survival, and generalities cannot be made.

Issue 7: Pest Risk Criteria

Reviewers’ comments—One reviewer provided suggestions for improving the pest risk criteria used in the draft to assign ratings for risk elements.

“Presence with host at origin potential. The ‘host’ should be clarified to specify the part/s of the host under assessment and associated with the pathway. The pest may well be associated with the host at origin and intercepted with the host repeatedly. But, if that part of the plant isn’t the plant part being transported for the purposes of this assessment, that element is irrelevant. For purposes of transparency, it would be helpful here to include an element such as ‘Organism is associated with plant part to be imported’.” (Zadig)

“’Organism can cause catastrophic outbreaks’ needs to be clarified if it means that outbreaks can result in a larger level of inoculum, if that is its intended meaning. It would be helpful to clarify whether or not debarking is/not, under criterion ‘h’, part of standard harvesting and handling, and/or itemize anticipated standard harvesting and handling activities.” (Zadig)

“Entry potential. Here standard practices, particularly debarking, will greatly influence the probability of the organism surviving transit and entering undetected, thus the ranking of the elements.” (Zadig)

“Spread potential. ‘Eradication techniques are unknown, infeasible, or expected to be ineffective’ seems more appropriate, and indeed is essentially repeated under economic damage potential. ‘Mitigation measures’ might work better than ‘eradication’ here. Where high rainfall is necessary for the spread of disease pathogens, a review of orchard irrigation practices, or even greenhouse production, would be helpful where applicable as an artificially produced humidity could facilitate spread. Irrigation practices for citrus in California often create a humid microclimate, Eucalyptus is planted as windbreak with citrus orchards throughout large part of the state, particularly along the coast.” (Zadig)

“Environmental damage potential. Disruption of biological control should be considered as an element here.” (Zadig)

Response to comments—The pathway (commodity) evaluated in this risk assessment was *Eucalyptus* logs and chips, with the presumption that bark would be associated with the commodity. Although debarking is generally done in conjunction with harvesting of *Eucalyptus*, there are sometimes individual logs in export decks that contain some or all of their bark. The tolerances for debarked logs allow for a small percentage of the material to contain bark, an allowance that takes into account the difficulty of removing absolutely 100% of the bark from a log. In South America, the team noted only one situation where debarking could be considered a standard harvesting procedure, the case of *E. grandis* in Argentina where trees are debarked before they are felled. In other situations, logs are debarked, generally within 3 days after felling, but some pieces of bark may remain on the logs. In general, *Eucalyptus* logs are debarked, but we cannot say with certainty that 100% of the bark is removed. Shipments of well-debarked logs can still harbor insects associated with bark, given the allowance of 5% bark within a shipment.

At the suggestion of the reviewer and others, the wording "presence with host at origin potential" was changed to "presence with host–commodity at origin potential" and the wording "organism can cause catastrophic outbreaks" was changed to "organism has capability for large-scale population increases."

Issue 8: Pest Risk Potentials

Reviewers' comments—One reviewer felt that in some instances, assessment of risk was higher than warranted.

"The authors generally take the 'safe approach' by assigning a higher assessment of risk when there is uncertainty. However, this process results in higher than likely risk potentials due to the compounding of conservative estimates. For example, the authors speculated that several pest species (*Ceratocystis*, *Botryosphaeria*, *Phoracantha*) that already are established in the U.S. might be genetically different. The authors followed with the assumption that all of the South American pests would be more virulent than the U.S. counterparts, or they would spread farther than those already present." (Cameron)

"The summary of risk potentials presented in Table 13 includes eight out of 18 high-risk pests, nine mediums, and one low. This might logically lead to the conclusion that importing *Eucalyptus* logs or chips from South America would be highly risky. However, the authors conclude: 'the risk is probably less in this assessment than the previous assessments.' The authors point out that pest risk is likely to be reduced in this case because: 1) the proposed export crop is relatively free of insects and pathogens because of the exotic nature of the host, 2) *Eucalyptus* is not native to the U.S., and 3) *Eucalyptus* occurs in limited locations in the U.S." (Cameron)

"In Hawaii, increased risk has been assumed for some pests because of increased risk of establishment and spread associated with climate and native hosts. This risk would be eliminated by not considering Hawaii as a potential port of entry. In addition, the need to import *Eucalyptus* logs and chips in Hawaii is probably very limited due to a paucity of forest industry operations in that state." (Cameron)

Response to comments—The team followed a cautious approach when assigning pest risks. The reviewer is correct in stating that, when uncertainty as to risk was encountered, a higher rating was assigned. The USDA Forest Service risk assessment team and APHIS recognize that organisms demonstrating a high degree of biological uncertainty do represent a real risk. The need to balance demonstrated risks against biological uncertainty is and will continue to be a difficult issue to address. The wording in Chapter 4 (Conclusions) was changed to correct the inconsistency between the text and Table 13 pointed out by the reviewer. Hawaii was included in this pest risk assessment because the current log import regulations are applicable to that state, because Hawaii is developing a *Eucalyptus* chipping industry and because the state's climate increases risk from *Eucalyptus* pests that are more tropical in nature.

Issue 9: Unknown Virulence–Genetic Variability of Pests

Reviewers' comments—Several reviewers commented that the individual pest risk assessments for certain pathogens should include more consideration of unknown virulence and should assume existence of different strains. Others felt that genetic differences or variations must be demonstrated through scientific evidence and not assumed.

"My major concern is that we do not forget that species of insects, fungi etc. are not clones. These organisms have great genetic variability and there may be races that are more virulent so that the risk is high even if we already have the same species present in North America. You do seem to address this issue in the document." (Jacobi)

"Thank you for taking the genetic variability of the pest organisms into consideration in the PRA. Genetic variability can be critical in pests like *Ceratocystis fimbriata* with its interfertile pathogenic strains." (Johnson and Osterbauer)

"The definition of Category 3 makes reference to non-native plant pests present in the United States that differ genetically from the plant pests present in the United States. In this sense, we believe that possible genetic differences between populations of a pest should be supported scientifically through published studies that demonstrate these differences, such as [studies] of population genetics, molecular biology, and others." (Peña Royo) (translated from Spanish)

"The definition of Category 3 makes reference to species native to the United States which differ genetically from plant pests present in the United States. Similarly to the previous case, we consider that the eventual genetic differences between populations of the same pest species should be supported through scientific studies that show these differences." (Peña Royo) (translated from Spanish)

"The definition of Category 4a makes reference to plant pests native to the United States which *could* differ in their ability to cause damage, based on genetic variation exhibited by the species. We consider that any genetic difference between populations of a pest should be supported scientifically through published studies that demonstrate [those differences]." (Peña Royo) (translated from Spanish)

"In the case where the pest is a species native to the United States, the totality of the genetic variation for the pest should be known throughout its entire range of natural distribution beforehand, and that variation should be compared afterwards to genetic variations of the pest populations outside of the United States." (Peña Royo) (translated from Spanish)

"As indicated before, we believe that the fungal species *Botryosphaeria obtusa* and *Botryotinia fuckeliana* (anamorph *Botrytis cinerea*), both classified in Pest Category 4a, would not qualify as quarantine pests until scientific studies are made available that judiciously demonstrate the existence of such genetic differences." (Peña Royo) (translated from Spanish)

Response to comments—The individual pest risk assessments for a number of the fungal pathogens discuss the possibility of more virulent strains or different strains in South America. The possible existence of virulent or new strains was the basis for increases in the economic, environmental, and political and social consequences potentials in individual pest risk assessments. The assumption of possible other strains was made where there was some indication that this variation may exist in the species. Because of limited research on this subject, especially in South America, a cautious approach was taken when assessing risk. Whether the strains of fungal pathogens are different than those in the United States and if so, whether the different strains are more virulent remains unknown. When uncertainty as to virulence was encountered, a higher rating was assigned.

Issue 10: Unknown (Sleeper) Pests

Reviewers' comments—One review pointed out that organisms not recognized as pests in their country of origin may reach pest status when introduced into a new environment and that maximum mitigation measures should be required to assure against introduction of unknowns.

"Like the WIPRAMET team, we are very concerned about the unknown pathogens found associated with carpenterworm (pp. 70-74) damage in Chile and with the unidentified blue stain observed on logs in Argentina (Appendix A—Reports on Team's Site Visits to South America). Their presence suggests that APHIS should require the heat treatment (71.1ºC for 75 minutes at the core) of all shipments of *Eucalyptus* prior to entering the U.S. Heat treatment is the only mitigation method proven effective against all potential pests." (Johnson and Osterbauer)

Response to comment—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 *Eucalyptus* logs and chips from South America.

In response to the reviewer, the specific concern about unknown pathogens associated with carpenterworm in Chile was addressed in the individual pest risk assessment.

Issue 11: Issue of Tropical Hardwoods

Reviewers' comments—Several reviewers suggested that the document should include an explanation of the current regulation that discusses requirements for tropical versus temperate hardwoods and where species of *Eucalyptus*, and other hardwoods, would fit into those regulations.

"Under section 319.40-6, Universal Importation Options, logs must be debarked and heat treated. On the other hand, wood chips or bark chips from outside of Asia, derived from live, healthy, tropical species of plantation-grown trees grown in tropical areas that are processed within 30 days in a manner that will destroy any plant pests are allowed to enter the U.S. It is unclear as to whether *Eucalyptus* species would be considered tropical. Questions may arise in the future about the possibility of importing logs or chips from other species (*Gmelina*, *Paulownia*) grown in plantations in South America and for *Eucalyptus* grown in Central America countries. These questions are outside the limitations of this PRA, but are still pending." (Cameron)

"Chapter 4, Background: Wasn't there something in the current regulations about treating logs of tropical species differently? You might recall the discussions on which species of eucalypts were tropical and which were not." (Hodges)

Response to comments—The risk assessment team recognizes that the genus *Eucalyptus* contains species that grow in a wide range of environmental conditions. The team made no attempt to distinguish between temperate or tropical species in this document. Rather, our task was to assess the risk of importation into the United States of pests on all species of *Eucalyptus* that may be exported from South America, regardless of the climate in which they may be growing. The risk assessment team evaluated the pest risk of *Eucalyptus* spp. without regard to any existing or future APHIS regulations. As one reviewer pointed out, the question of which tree species are tropical and which are temperate is outside the scope of this risk assessment. The question is regulatory in nature and falls within the purview of APHIS to determine.