Wood and Wood Products as Pathways for Introduction of Exotic Bark Beetles and Woodborers

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Wood and wood products are important pathways for the transport, introduction and establishment of potentially destructive forest insects. Insects that can be transported via these commodities include species with a demonstrated capacity to cause severe damage within their own geographic ranges and, in the absence of natural controls, have the potential to be extremely destructive when introduced and established in new locations. Ever increasing global trade and development of new trading partners have significantly increased the risk of new insect introductions. In recent years, the rate of new introductions, and resulting economic, ecological and social impacts, has increased at an alarming rate.

This paper reviews some case histories of insect introductions via wood and wood products, the types of products that can transport these insects and outlines some methods of mitigating the risk of these introductions.

2. Insects subject to transport via wood and wood products

According to interception records from USDA Animal Plant Health Inspection Service (APHIS), ten orders of insects have been intercepted from wood and wood products in international trade. The most commonly intercepted order is the Coleoptera (beetles). Between 1985 and 1986, of 5885 interceptions associated with wood and wood products, 5513 (94%) were Coleoptera. The most commonly encountered families were the Scolytidae (bark and ambrosia beetles, 72%), Curculionidae (weevils, 13.9%) and Cerambycidae (roundheaded or longhorned woodborers, 6.7%) (Table 1).

In a Canadian study, 1555 adult insects were reared from spruce bolts used as dunnage associated with granite blocks imported from Norway. Ninety five percent (1477) of the insects recovered were of the family Scolytidae (six species). Other families of insects recovered represented the families Cerambycidae, Anobiidae, Curculionidae, Melandryidae (Coleoptera) and Siricidae (Hymenoptera) (Humble and Allen, 1999).

Ironically, these data sets indicate that insects of the family Scolytidae, the bark and ambrosia beetles, were the most frequently recovered. These are generally considered the most destructive group of forest insects, worldwide. Other orders of wood-infesting insects that have been frequently intercepted include the Isoptera (termites) and the Hymenoptera, family Siricidae (woodwasps) (Haack and Cavey, 1998).

Some examples of worldwide forest insect introductions via wood and wood products and their impacts, since the beginning of the twentieth century include:

1. The European woodwasp *Sirex noctilio* (Hymenoptera: Siricidae), into New Zealand during the early part of the twentieth century (Rawlings and Wilson, 1949), followed by subsequent introductions into Australia, South America and South Africa (Ciesla, 2003).
2. The smaller European elm bark beetle *Scolytus multistriatus* (Coleoptera: Scolytidae), a vector of Dutch elm disease, caused by the fungus *Ophiostoma ulmi*, into North America (Boyce, 1961).
3. The spread of the great spruce bark beetle, *Dendroctonus micans* (Coleoptera: Scolytidae), from its original geographic range in the Far East into the Near East and Europe during the early 1900s, and culminating in its discovery in the British Isles in 1982 (Grégoire, 1988; Fielding et al., 1991).

4. The introduction of the eucalyptus longhorned beetle *Phoracantha semipunctata* (Coleoptera: Cerambycidae), native to Australia, to many countries with extensive exotic Eucalyptus plantations (Browne, 1968; Paine et al., 1998).

Since the early 1990s, there has been a significant increase in the number of successful introductions and establishments of bark beetles and wood-boring insects worldwide. These are largely the result of increased world trade, development of new trading partners and new trade routes. Some recent introductions include:

- European pine shoot beetles (*Tomicus piniperda*)
- Asian longhorn beetles (*Anoplophora* spp.)
- Red turpentine beetles (*Dendroctonus valens*)
- Eurasian woodwasps (*Tremex fuscicornis*)
- Emerald ash borers (*Agrilus planipennis*)
- Banded elm bark beetles (*Scolytus schevyrewi*)

**Table 1. Interceptions of Coleoptera (beetles) intercepted by family at USA ports of entry 1985-1996 (source: Haack and Cavey, 1998).**

<table>
<thead>
<tr>
<th>Family</th>
<th>Number of interceptions</th>
<th>Number of world regions represented</th>
<th>Number of countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bostricidae</td>
<td>158</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Buprestidae</td>
<td>104</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Cerambycidae</td>
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<td>8</td>
<td>41</td>
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<tr>
<td>Chrysomelidae</td>
<td>18</td>
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<td>5</td>
</tr>
<tr>
<td>Curculionidae</td>
<td>769</td>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>Dermestidae</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Elateridae</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Lycidae</td>
<td>68</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Family</td>
<td>Bates</td>
<td>CO</td>
<td>T.S.L.</td>
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<tr>
<td>-------------------</td>
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<tr>
<td>Platypodidae</td>
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<td>3</td>
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<td>Scolytidae</td>
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<td>8</td>
<td>72</td>
</tr>
<tr>
<td>Tenebrionidae</td>
<td>6</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5513</strong></td>
<td></td>
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</tr>
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</table>

2.1 European pine shoot beetles

The European pine shoot beetle, *Tomicus piniperda* (Coleoptera: Scolytidae), is native to Eurasia where it attacks a variety of pines and other conifers. Adult maturation feeding in the shoots of host trees causes the damage, which causes shoot mortality resulting in deformity and growth loss. *T. piniperda* was discovered in the USA in 1992 near Cleveland, Ohio. At the end of 1992, infestations were known from 43 counties and six states of the Great Lakes region (Haack and Kucera, 1993; Haack 1997). From 31 December 2000, this insect has been found in 303 counties in 12 states in the eastern and central USA and 43 counties in two Canadian provinces (Haack and Poland, 2001).

2.2 Asian longhorn beetles

The genus *Anoplophora* (Coleoptera: Cerambycidae) consists of 36 species of longhorn beetles indigenous to the temperate and tropical regions of Asia (Lingafelter and Hoebeke, 2002). *Anoplophora* is a genus of strikingly beautiful insects. However, several are extremely destructive and capable of long distance spread via wood products. Two species, *Anoplophora chinensis* and *Anoplophora glabripennis*, have been introduced and established in Europe and North America.

In 1996, an infestation of *A. glabripennis*, a pest of poplar plantations in China, was detected in Brooklyn, New York, USA. Later that same year, a second infestation was detected in nearby Amityville, New York. The Brooklyn infestation is believed to be introduced from Asia via wooden packing materials and the Amityville infestation may have resulted from the transport of infested tree sections from Brooklyn (Haack et al., 1997). In 1998, three separate infestations were detected in Chicago, Illinois. In 2002, an infestation was detected in 98 trees in Jersey City, New Jersey (New Jersey Division of Parks and Forestry, 2003).

The first European infestation of *A. glabripennis* was discovered in July 2001 when 15-20 infested maple trees were detected in Braunau, Austria (Tomiczek, 2002). In September 2003, an infestation was detected in a suburb of Toronto, Canada (CFIA, 2003a).
During 1999, the closely related citrus longhorned beetle, *A. chinensis*, was intercepted from bonsai trees imported from Asia into the USA (Lingafelter and Hoebeke, 2002). Two years later an infestation was discovered in Tukwila, Washington. This species has also been established near Milan, Italy (Colombo and Limonta, 2001).

### 2.3 Red turpentine beetles

The red turpentine beetle, *Dendroctonus valens* (Coleoptera: Scolytidae), is a common but usually minor pest of pines within its geographic range in Canada, the USA, Mexico and Central America. Infestations of this insect were first detected in China in 1998 in Shanxi Province and in 1999 in Hebei Province. Since its discovery, it has become one of China's most important forest insect pests. Infestations presently cover an area of more than 500,000 ha of *Pinus tabulaeformis* plantations and some 6 million trees have been killed (Knizek et al., 2003; Sun et al., 2003).

### 2.4 Eurasian woodwasps

The woodwasp *Tremex fuscicornis* (Hymenoptera: Siricidae), which infests broadleaf species across Eurasia, was detected in Chile in February 2000 and is believed to have been established for at least 2 years prior to its discovery. To date, extensive damage has occurred to poplar shelterbelt plantings (Baldini, 2002). Attacks are typically so heavy that a single poplar can produce 2000 individual brood adults. Another significant impact has been the loss of windbreak plantings around agricultural crops and fruit orchards. This exposes the orchards to high winds resulting in reduced crop yields (Baldini, 2002). A major concern in South America is that since beeches, *Fagus* spp., are hosts within this insect's natural range, southern beeches (*Nothofagus* spp.) are potential hosts. Several species of *Nothofagus* are important components, both economically and ecologically, of approximately 12 million ha of natural forests in central and southern Chile (Baldini, 2002). A similar situation exists in the Andean region of central and southern Argentina.

*T. fuscicornis* is also established in Australia. In 1996, a local outbreak was detected in New South Wales and is believed to have been present for 10-15 years prior to its discovery (CSIRO, 2002).

### 2.5 Emerald ash borers

The emerald ash borer, *Agrilus planipennis* (Coleoptera: Buprestidae), was discovered in south-eastern Michigan, USA in 2002 following reports of extensive mortality of ornamental ash trees, *Fraxinus* spp. in Detroit. By September 2002, the emerald ash borer was found in six counties in Michigan and one county in Ontario, Canada. By August 2003, it had been detected in seven more Michigan counties and two counties in Ohio. Infestations were detected in ash nursery stock in Maryland and Virginia in 2003 (USDA Forest Service, 2003a). This insect is native to Asia
where it attacks several species of *Fraxinus* and other temperate broadleaf species. The emerald ash borer has killed millions of ash trees in south-eastern Michigan, north-eastern Ohio, USA and Ontario, Canada. Ashes are important ornamental trees and can represent 5-20% of all street trees in communities in Canada and central USA (Haack et al., 2002).

2.6 Banded elm bark beetles

The banded elm bark beetle, *Scolytus schevyrewi* (Coleoptera: Scolytidae), is indigenous to China, Mongolia, Korea, Russia and Central Asia, where it attacks elms (*Ulmus* spp.) and other broadleaf species (Michalski, 1973; Krivolutskaya, 1983; Yin et al., 1984; Wang, 1992). During April and May 2003, the banded elm bark beetle was discovered in the USA when adults were collected in pheromone traps established in two sites in Denver, Colorado and four sites in Utah (NAPPO, 2003a). Several trapping sites were in the vicinity of wood recycling plants. Subsequent surveys have also established its presence in Kansas and New Mexico. This insect is presently attacking and killing Siberian elm (*Ulmus pumila*), and two widely planted indigenous North America elms (*Ulmus americana* and *Ulmus thomasii*), in Colorado (Lui and Haack, 2003). On the basis of its wide distribution, this insect was undoubtedly established for a number of years prior to its detection.

3. Pathways of introduction

3.1 Unprocessed logs

International trade in logs containing bark is a major pathway for the introduction of exotic wood-infesting insects. According to data from FAO (2001), 87,793,000 m$^3$ of "industrial round wood" (defined as sawlogs, veneer logs, pulpwood, chips, particles and wood residues) was exported worldwide during 2001. Major exporters of industrial round wood include Russia (19,693,000 m$^3$), the USA (8,959,000 m$^3$), Malaysia (5,670,000 m$^3$) and New Zealand (4,304,000 m$^3$). The major importers of these products include Japan (15,190,000 m$^3$), China (7,148,000 m$^3$), Korea (4,370,000 m$^3$) and several western European countries.

Unprocessed logs are particularly potent sources of bark beetles, woodborers and associated organisms. For example, the smaller European elm bark beetle, *Scolytus multistriatus*, and the Dutch elm disease fungus, *Ophiostoma ulmi*, arrived in the USA in elm burl logs imported from Europe for veneer production (Boyce, 1961). The European woodwasp *Sirex noctilio* and its associated fungus *Amylostereum areolatum* are believed to have arrived in New Zealand during the early 1900s via log imports from Europe (Rawlings and Wilson, 1949). In 1952, infestations were detected on the Australian island of Tasmania and in 1961 on the Australian mainland. The pathway of the Australian introduction is reported as "shipments of timber" from New Zealand (Taylor 1981; Bedding, 1993). Live adults of the Douglas-fir beetle, *Dendroctonus pseudotsugae*, have been detected in Douglas-fir logs imported by China from the USA (Ciesla, 1992) and the recent establishment of the red turpentine beetle, *Dendroctonus valens*, in China may be the result of infestations of this insect in imported pine logs.
Short-distance transport of products such as fuel wood can facilitate the local spread of newly established insect pests. A classic example is the spread of the Asian longhorned beetle, *Anoplophora glabripennis*, from its initial point of introduction in Brooklyn to Amityville, New York by the transport of infested tree sections for final disposal or sale as fuel wood (Haack et al., 1997). Moreover, eucalypt fuel wood serves as excellent breeding sites for Eucalyptus longhorned beetles of the genus *Phoracantha* once they have become established.

### 3.2 Lumber and solid wood packing material

Lumber and solid wood packing, including crates, reels for storage of wire, pallets and dunnage are additional important pathways for the movement of bark beetles and woodborers.

#### 3.2.1 Bark beetles

Wood containing bark strips can harbour bark beetle larvae, pupae or adults. Many examples of the accidental introduction of bark beetles of the family Scolytidae, via lumber or wood-in-use containing bark, are known. The introduction of the North American bark beetle, *Ips grandicollis* (Coleoptera: Scolytidae), into Australia is generally believed to be the result of infested pine slabs used to make machinery crates (Berisford and Dahlsten, 1989). The introduction of three species of European pine bark beetles, *Hylastes ater*, *Hylurgus ligniperda*, and *Orthotomicus erosus* (Coleoptera: Scolytidae), into Chile during the 1980s may also have been the result of solid wood packing material containing bark strips (Ciesla, 1988). Moreover, the recent discovery of *Scolytus schevyrewi* (Coleoptera: Scolytidae) in the vicinity of wood recycling plants suggests that this may have been the introduction pathway for this species.

Interception records from major ports of entry worldwide substantiate the high risk of bark beetle introductions associated with wood containing bark strips. An analysis of port interception records from the USA indicates that 6825 interceptions of Scolytidae occurred during the period 1985 to August 2001. Interceptions occurred at 97 port cities in 35 states and 73% of the interceptions were from solid wood packing materials. Scolytidae were intercepted from 117 countries, with the top 12 countries being Italy, Germany, Spain, Mexico, Jamaica, Belgium, France, China, Russia, India, the UK and Portugal (Haack, 2001). Similar data from Chile also suggests a large number of interceptions of Scolytidae associated with solid wood packing materials (Beéche, 1998).

#### 3.2.2 Woodborers

Because they feed directly in the wood, wood-boring insects (Coleoptera: Buprestidae and Cerambycidae; Hymenoptera: Siricidae) do not require wood containing bark strips to survive. Moreover, most woodborers have life cycles that require one or more years to complete. This virtually assures that they can survive
the long ocean voyages associated with international trade as larvae or pupae, and emerge as adults in a new location.

The introduction of wood-boring insects via lumber and/or solid wood products used in international trade is widely documented. The initial source of the European woodwasp, *Sirex noctilio*, introduced into New Zealand and, possibly, Australia may have been unprocessed logs, whereas the pathway for the infestations established in South America and South Africa is believed to have been solid wood packing material. The source of an infestation in the northern Patagonia region of Argentina, discovered in 1990, is believed to be infested wood transported from Buenos Aires (Klasmer et al., 1998). The source of *S. noctilio* infestations in South Africa has been documented as pine packing crates, which were subsequently transported inland to be used as fuel wood (Tribe, 1995). Many records of Siricid interceptions, including *S. noctilio*, are reported from wood products at USA ports of entry (Ciesla, 2003). The pathway of introduction for another Eurasian woodwasp, *Tremex fuscicornis*, into Chile, is believed to be dunnage and shipping crates arriving from China (Baldini, 2002).

The pathway for an established infestation of the brown spruce longhorned beetle, *Tetropium fuscum*, native to Europe and Asia, in Point Pleasant Park, Halifax, Canada, is reported as dunnage, wood packing material and pallets on board ships coming from this insect’s home range. Point Pleasant Park is adjacent to the container terminal at the Port of Halifax, where this material has been piled (Dobensberger, 2002).

The introduction of the eucalyptus longhorned beetle, *Phoracantha semipunctata*, into the Mediterranean Basin and the Canary Islands is likely to have been caused by its transport in crates containing fresh fruit and Eucalyptus timber (Schedl, 1999).

The introduction and establishment of the Asian longhorned beetle, *Anoplophora glabripennis*, in the USA is believed to have been via solid wood packing material from China. In addition to known established populations, this insect has been intercepted at a number of ports of entry and found in 26 warehouses in 14 states throughout the USA (Lingafelter and Hoebeke, 2002).

Wooden spools, designed to hold wire rope, are another source of wood-boring insects. In 1997, 50 wire rope spools, originating from China and imported into Canada, were evaluated for the presence of wood-infesting insects. Some of these spools may have been in Canada for up to 2 years. Twenty-four percent of the spools examined still contained live woodborers and 31% of the spools showed some evidence of woodborer activity. Six species of longhorned woodborers and one species of Anobiidae were recovered from the spools. In the following year, 16 newly arrived spools, again originating from China, were evaluated and 22% had live insects (Humble and Allen, 1999). A live specimen of the Citrus longhorned beetle, *Anoplophora chinensis*, was detected at Tauranga, New Zealand in 2003 and is believed to have emerged from wooden reels of wire rope imported from China (Bullians and Flynn, 2003).

The exact introduction pathway of the current devastating outbreak of the emerald ash borer, *Agrilus planipennis*, in North America has not been established. However, solid wood packing material seems a logical source. Records from USA ports of entry between 1985 and 2002 indicate that species of *Agrilus* were intercepted on 38
occasions: 28 from dunnage, four from crating and six from other materials (Haack et al., 2002).

3.3 Nursery stock

The wood of living trees and shrubs is another pathway for the introduction and establishment of wood-boring insects. The pathway for introduction of the Citrus longhorned beetle, *Anoplophora chinensis*, in Tukwila, Washington, USA, was ornamental maple nursery stock imported from Korea (Washington State Department of Agriculture, 2001). In September 2003, ash trees shipped from the area of known infestation by the emerald ash borer, *Agrilus planipennis*, in Michigan, into Maryland were found to be infested by this insect (NAPPO, 2003a). Moreover, bonsai trees, imported from Asia, have been established as a proven pathway for the introduction of *A. chinensis*. In 1999, this insect was found on bonsai crepe myrtle (*Lagerstroemia* spp.) imported from China in a greenhouse in Georgia, USA and from bonsai trident maple (*Acer buergerianum*), in Wisconsin, USA (Lingafelter and Hoebeke, 2002). The source material of an established infestation of this insect in northern Italy is also believed to be bonsai trees.

3.4 Special products

Artificial Christmas trees, containing central posts made of wood containing bark, imported from China can be sources of wood boring insects. In 1999, the longhorn beetles, *Callidiellum rufipenne* and *Callidiellum villosum*, were found in artificial Christmas trees in five counties in Wisconsin, USA (USDA Forest Service, 1999).

4. Mitigating the risk of new introductions

Regulatory and pest management measures are available to prevent and manage new pest introductions, including those that arrive via wood and wood products. These include:

1. Pest Risk Analysis (PRA)
2. Monitoring for new pests
3. Quarantine measures
4. Treatment of infested wood and wood products

4.1 International coordination

International coordination and technical guidance in the development and implementation of regulatory measures designed to prevent the introduction and spread of plant pests is provided through an international treaty originally developed in 1951, the International Plant Protection Convention (IPPC). This Convention extends to the protection of natural flora and plant products, and includes both direct and indirect damage by pests, including weeds. The provisions also cover
conveyances, containers, storage places, soil and other objects or material capable of harbouring plant pests. The IPPC Secretariat is located at the FAO headquarters in Rome, Italy. The Interim Commission on Phytosanitary Measures (ICPM) governs the implementation of the IPPC. It is presently composed of representatives from both signatories to the IPPC and FAO members. This Commission provides a forum for the discussion of international plant protection issues and for the development of International Standards for Phytosanitary Measures (ISPMs). Nineteen standards have been developed to date (IPP, 2003), including ISPM 15, which provides guidelines for regulating wood packaging material used in international trade (IPPC, 2002). These standards do not obligate countries to establish regulatory controls, but provide guidelines by which any country may establish regulatory controls in a manner that is internationally harmonized and transparent.

National and Regional Plant Protection Organizations help member countries meet their IPPC obligations. Nine regional plant protection organizations currently exist. These include the European and Mediterranean Plant Protection Organization (EPPO) and the North American Plant Protection Organization (NAPPO).

4.2 Pest risk analyses

Pest risk analyses (PRAs) are the first logical steps to prevent the accidental introduction of new pests. This is a process designed to evaluate biological and economic data to determine if a potential pest should be regulated and the nature of phytosanitary measures to be used for its regulation. These analyses are now required by the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures to justify methods to regulate pest introductions via international trade. Standards for the conduct of PRAs for the European Area have been developed by the European and Mediterranean Plant Protection Organization (EPPO, 1997). Similar standards are in place for North America (NAPPO, 1993b). A recent example of the use of the EPPO process is an analysis of the risk of introduction of the Asian longhorned beetle, Anoplophora glabripennis in the European Community (EC). This analysis established the basis for adding A. glabripennis to the list of quarantine pests whose introduction and spread within all EC Member States is now banned (MacLeod et al., 2002).

In the USA, PRAs are initiated in response to requests to import plant or animal commodities from new sources. Information on potential pests associated with the commodity in question is collected and analysed. This information provides a basis for issuing permits authorizing the import and, if applicable, implementation of procedures designed to mitigate the risk of pest introductions. Recently conducted PRAs, involving teams of specialists under the combined leadership of USDA APHIS and the Forest Service, have addressed importation into the USA of larch (Larix spp.) logs from Siberia and the Russian Far East (USDA Forest Service, 1991); Pinus radiata and Pseudotsuga menziesii logs from New Zealand (USDA Forest Service, 1992); and P. radiata, Nothofagus dombeyi and Laurelia philippiana logs from Chile (USDA Forest Service, 1993) and other log import proposals.

4.3 Monitoring for new pest introductions
4.3.1 Inspections

The inspection of agricultural products and wood at ports of entry provides the first opportunity to detect and intercept potentially damaging plant pests associated with international trade.

In the USA, the responsibility for port inspections rests with the Plant Pest Quarantine (PPQ) unit of APHIS. PPQ officers are stationed at all USA ports of entry and in some foreign countries. All international baggage, cargo, package mail and conveyances are subject to inspection. Since 1985, USDA APHIS has maintained a database of pest interceptions. According to this database, large numbers of wood-infesting insects have been intercepted. For example, between 1985 and August 2001, some 6825 interceptions of beetles of the family Scolytidae were intercepted, mostly (73%) from solid wood packing materials (Haack, 2001).

In Canada, responsibility for phytosanitary inspection is assigned to the Canadian Food Inspection Agency (CFIA). This agency has developed detailed regulations and procedures, which govern the inspection of solid wood packing materials arriving from destinations other than the continental USA using the IPPC standards (CFIA, 2003b).

Chile, with extensive plantations of Pinus radiata and Eucalyptus sp., and large areas of natural forests that have evolved in relative isolation, is at high risk of exotic pest introductions. Phytosanitary inspections at Chilean ports of entry are the responsibility of Servicio Agrícola y Ganadero (SAG). This includes inspection of solid wood products such as crates, pallets and dunnage. SAG interception records indicate numerous interceptions of wood-infesting insects resulting from phytosanitary inspections (Beéche, 1998).

New Zealand is known for its vigilance in protecting its borders against exotic pests and diseases, and also for ensuring that its exports are free of potential pests. The risk of establishment of exotic pests is high. The country’s ca 6 million ha of indigenous forests have evolved in geographic isolation and have few pests. Moreover, the country has 1.6 million ha of exotic plantations, mostly of P. radiata. These forests are highly susceptible to pest introductions. Most of the exotic forest and timber insects that have become established in New Zealand arrived before a formal system of forest health surveillance was established in 1956. The threat of exotic pest invasions is addressed with a four-point strategy:

1. International cooperation, including overseas inspections to identify and exclude infested forest products and plants destined for New Zealand.
2. A highly focused quarantine service that attempts to intercept pests at ports of entry.
3. A comprehensive forest and wood monitoring system to detect pests or diseases that escape the inspection process.

Between 1948 and 1998, 9378 interceptions of bark beetles and woodborers were made (New Zealand Forest Owners Association, 2001).
Austria receives large consignments of unprocessed conifer logs from Russia. These are shipped from the Black Sea to the port of Vienna-Freudenau via the Danube River. Inspections of unprocessed logs in log yards at Vienna-Freudenau during the winter of 1990/1991 indicated the presence of large numbers of bark beetles and woodborers in this material. Most of the species collected were new to Austria and typical of the insect fauna of the boreal forests from which the logs originated. The wood-infesting beetles detected included one species of Melandryidae (Serropalpidae), ten species of Cerambycidae, four Curuliionidae and eight Scolytidae (Holzschuh, 1991). These insects have a high potential for becoming established in the forests of Central Europe.

Despite inspections of plant products at ports of entry, considerable numbers of exotic organisms are not detected and have become established. This is due to a number of factors including the huge volume of material in the pathway, only a small proportion of which is inspected, and the cryptic nature of many organisms, especially those that infest wood and wood products.

4.3.2 Special surveys

Surveys designed to detect the presence of exotic bark beetles and woodborers are an effective supplement to the inspection of commodities at ports of entry.

In the USA, state departments of agriculture, in cooperation with USDA APHIS conduct Cooperative Agricultural Pest Surveys (CAPS) to detect the occurrence of exotic pest species. In recent years, some states have conducted surveys using pheromone traps to detect exotic bark beetles. In 2001, an Exotic Pest Rapid Detection Team was established to coordinate pilot tests for the detection of non-native bark beetles and the nun moth, *Lymantria monacha*, a European forest defoliator. Team members included the Oregon Department of Agriculture, Maryland Department of Agriculture, Cornell University, Agricultural Research Service, APHIS and the USDA Forest Service. The objectives of this team included:

- developing and testing a prototype national survey;
- identifying potential exotic pests and likely pathways;
- identifying detection and management guidelines;
- detecting and monitoring new introductions at selected high-risk sites;
- developing recommendations to address gaps in detection protocols and taxonomic resources;
- using the information collected to set agency protocols and priorities.

Ten non-native bark and ambrosia beetle species were targeted because they were commonly intercepted during port inspections. Baited funnel traps were placed in forests around port facilities, wood-handling facilities and urban forests in three to
four cities in the north-eastern, southern and western USA. As a result, in 2001, *Hylurgops palliatus*, a targeted species, was caught near Erie, Pennsylvania, and new state and county records were established in the south, northeast and west. In 2002, the pilot projects detected three non-native Scolytidae: *Xyleborus similis* in Houston, Texas, *Xyleborus glabratus* in Port Wentworth, Georgia, and *Hylurgops palliatus* at multiple sites in Pennsylvania (USDA Forest Service, 2003b). Extension of this survey to several inland locations in 2003 resulted in the detection of the banded elm bark beetle, *Scolytus schevyrewi* (NAPPO, 2003a).

4.3.3 Quarantine measures

When a new pest species is detected, quarantine measures can be established to restrict its human-assisted spread. Restrictions on the transport of plant materials, including nursery stock, fire wood, logs, lumber and solid wood packing material, from infested areas into uninfested areas, if strictly enforced, can reduce the rate of spread of insects infesting wood and wood products.

4.3.4 Treatment of wood products

Two methods of treating wood and wood products to kill wood-infesting organisms are heat treatment and fumigation. These are currently approved by IPPC (IPPC, 2002).

4.3.4.1 Heat treatment

All wood packaging materials must be heated to a minimum internal wood core temperature of 56°C for 30 minutes. Kiln-drying, chemical pressure impregnation, or other treatments may be used as a means of achieving heat treatment provided that the above temperature and time requirements are met.

In 1998, USDA APHIS mandated that all solid wood packing material from China should be heat treated and certified accordingly by designated government authorities to prevent further introduction of the Asian longhorned beetle (USDA APHIS, 1998). China placed the same requirement on conifer solid wood packing material exported from the USA to China from 1 January 2000 (USDA APHIS, 1999). USDA APHIS has recently published a Draft Rule for new requirements concerning the importation of wood packaging material. This rule requires that, beginning in 2004, all wood packaging material arriving in the USA is appropriately treated and marked under an official programme developed and overseen by the National Plant Protection Organization (NPPO) in the country of export (USDA APHIS, 2003).

4.3.4.2 Other methods

The risk of transporting bark beetles in solid wood packing material can be reduced by the complete removal of bark strips from these products. In some countries, imports of unprocessed logs are off-loaded into salt water at the port of entry. This
will kill most bark beetle broods but its effect on wood-boring insects, which live deep in the wood, is questionable.

5. Conclusions

Wood and wood products are important pathways for the introduction of potentially damaging forest insects. Insects that can be transported via these products include bark beetles and woodborers. A number of species in these groups are considered important pests within their native ranges and several have caused widespread damage when introduced into new locations. The rate of new introductions of wood-infesting insects has increased because of increased global trade, new trading partners and new trade routes.

Primary pathways for the introduction of wood-infesting insects include international trade in unprocessed logs and the use of solid wood packing materials (crates, wire reels, pallets and dunnage) for a wide variety of commodities traded internationally. Wood containing strips of bark can harbour life stages of bark beetles (family Scolytidae), an extremely destructive group of insects. Wood contained in live plant materials, such as nursery stock and bonsai is another proven pathway for the transport of these insects. Special products, such as artificial Christmas trees with central posts that contain bark, can also be a source of wood-infesting insects.

Regulatory and direct control methods are available to prevent the entry of new pests and manage their rates of spread and impacts should they become established. The IPPC is an international forum that develops guidelines by which any country may establish regulatory controls in a manner that is internationally harmonized and transparent. Regional Plant Pest Organizations can help member countries design and implement regulatory controls.

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