Quarantine risks associated with solid wood packaging materials receiving ISPM 15 treatments

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Summary

Surveys on solid wood packaging material (SWPM) such as crates, dunnage or pallets (pieces) displaying the ISPM 15 stamp under the *International Standards for Phytosanitary Measures No. 15: Guidelines for Regulating Wood Packaging Material in International Trade* (ISPM 15) were conducted by the Australian Quarantine and Inspection Service (AQIS) during 2005 and 2006 at various locations in Australia. These surveys were to evaluate the quarantine risks and or performance of SWPM receiving ISPM 15 treatments and the proportion of untreated SWPM used in air and break-bulk cargo. About 20 000 crates, dunnage or pallets (pieces) used in containerised sea cargo were inspected in Sydney, Melbourne and Brisbane. Nine percent of SWPM surveyed exhibited something of quarantine concern; of this bark represented 8.5%, fungi 5.9% and live insects, frass and soil, 3.2%, 2.8% and 1.7% respectively — these categories not being mutually exclusive. Before the introduction of mandatory treatment requirements, a large amount of SWPM entering by less-frequented routes such as air and break-bulk cargo was not ISPM 15-compliant or did not receive any treatment. Ongoing review of the ISPM 15 standard and its existing treatments, as well as auditing regimes for treatment providers, are essential to continue to improve the standard and reduce the risk of pests using SWPM as an entry pathway.

Keywords: wood; packaging materials; quarantine; risk; pests; diseases; interceptions; standards

Introduction

Introduction of exotic timber pests to an importing country through the movement of solid wood packaging material (SWPM) is a worldwide problem. The number of exotic pest introductions has increased rapidly in recent years as a result of increased trade (Levine and D'Antonio 2003). Timber pests, pathogens and other pests can survive transport if SWPM is processed poorly or untreated in the exporting country. From 1975 to 2003, Australian Quarantine and Inspection Service (AQIS) intercepted over 5500 arthropod pests that were likely to be associated with wood packaging material (DAFF 2006). Introductions into the United States (USA) of exotic plant pests such as the pine shoot beetle *Tomicus piniperda* (Scolytidae) and the Asian longhorned beetle *Anaplophora glabripennis* (Cerambycidae) have been linked to the importation of SWPM (Federal Register 2004). The exotic timber pests introduced in the USA as well as other plant pests that can be carried by imported SWPM including non-compliant ISPM 15 wood packaging could pose a serious threat to Australian agriculture and to natural, cultivated and urban forests and amenity trees.

The ISPM 15 mark (Fig. 1) must be applied to wood packaging material to certify that it has been subjected to a treatment measure approved under ISPM 15. To be compliant with the standard, the mark should at a minimum include:

- the International Plant Protection Convention (IPPC) symbol
- the ISO two-letter country code (XX) followed by a unique number (000) assigned by the country's national plant protection organisation to the producer of the wood packaging material who is responsible for ensuring appropriate wood is used and properly marked

Figure 1. Template for the ISPM 15 mark (copied from IPPC 2006) (top) and an ISPM 15-compliant Australian stamp (bottom)

ISPM 15 = *International Standards for Phytosanitary Measures No. 15: Guidelines for Regulating Wood Packaging Material in International Trade*

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- the IPPC abbreviation (YY) for the approved treatment used (e.g. HT, MB). Where debarking is required, the letters DB should be added to the abbreviation of the approved measure.

Since Australia's implementation of the *International Standards for Phytosanitary Measures No. 15: Guidelines for regulating wood packaging material in international trade* (ISPM 15) for imported commodities in 2004, AQIS has had concerns regarding post-treatment infestation and or reinfestation and the presence of bark, pathogens or pests on ISPM 15-compliant SWPM. This is because ISPM 15-compliant wood packaging may include a high proportion of non-durable sapwood, bark or wane from the outside of the stem, insect grub holes, and fungal decay or stain (Allen 2001a). Also the nutrient-rich inner bark and the cambium on wood packaging material provides a food source for arthropod pests and fungi, and could become a pathway for the introduction and spread of pests (IPPC 2002). Since implementation of ISPM 15 in Australia, AQIS has been raising its concerns at international fora (Walsh and Zahid 2005) and a technical justification for risk associated with bark on SWPM was published by Biosecurity Australia (DAFF 2006).

Preventing the introduction of exotic insects and pathogens remains a challenge, despite wide-scale adoption of ISPM 15 across the globe, because of movement of poorly treated or non-compliant ISPM 15 wood packaging. Examples of alien forest insects and pathogens that have caused significant damage to North American forests include European gypsy moth (*Lymantria dispar*), balsam woolly adelgid (*Adelges piceae*), chestnut blight fungus (*Cryphonectria parasitica*) and many other forest pest species. About 35% of exotic insect species established in the USA have harmful effects, whereas 91% of plant pathogens established have harmful effects (Pimentel *et al*. 2000). One estimate cites plant pathogens and pests as costing $US14 billion annually in loss of forest products in the USA. Thirty percent of these pathogens and pests are non-indigenous, meaning that forest losses attributed to invasive forest species are $US4.2 billion per year (Pimentel *et al*. 2000). Dutch elm disease fungus (*Ophiostoma ulmi*) was probably introduced into North America, along with its insect vector (*Scolytus multistriatus*), on unpeeled veneer logs from Europe. It was first reported in the USA in 1930 and by 1968 had spread throughout the eastern half of the North American continent. By 1977, 60% of the 77 million planted elms in the USA had been killed by the disease.

The risk of introducing pathogens through SWPM has not been adequately addressed in the ISPM 15 standard. This is because the heat and methyl bromide treatment schedules used in the ISPM 15 standard are not adequate to address all decay fungi and pathogen risks. Also, the process of detecting plant pathogens is difficult given inspection is visual and latent fungal infections are virtually impossible to detect through inspection of outer wood surfaces (Allen 2001b). This is complicated further by the presence of bark in large amounts on SWPM, which also increases the potential for transport of contaminants of quarantine concern, including soil, as indicated by United States Department of Agriculture (USDA) pest risk assessments (USDA 1992; Tkacz *et al.* 1998; Kliejunas *et al.* 2001).

Australia is relatively free from many pests and diseases that are present in other countries because of its unique geographic location as an island continent. Eradication of an established exotic pest or pathogen is expensive and often impossible. For example, Australia's *Management Plan Response to an Incursion of Pine Pitch Canker* emphasises that there is little chance of containment and or eradication without widespread removal of high-value plantation forests and amenity plantings (Gadgil *et al.* 2003).

Information on pest risks associated with ISPM 15-compliant wood packaging is scarce. A survey is currently being planned by national plant protection organisations at the request (CPM 2007/25 2007) of the Food and Agriculture Commission on Phytosanitary Measures. Also, information is lacking on the treatment status of wood packaging coming through avenues other than sea cargo. The use of these avenues — such as air and break-bulk cargo — has increased significantly in recent years.

This paper reports the performance of ISPM 15-marked wood packaging used in sea cargo consignments and assesses the amount of treated SWPM coming into Australia through air and break-bulk cargo.

Materials and methods

2005 survey

AQIS inspectors examined 19 522 crates, dunnage or pallets (pieces) displaying the ISPM 15 stamp in Sydney, Melbourne and Brisbane from 1 January 2005 to 11 November 2005. Inspecting officers were trained on technical aspects of the ISPM 15 standard and relevant stamp or ISPM 15-marking requirements. Data were collected using a tablet computer. Information recorded was country of origin, treatment and presence of bark, mould and live insects. Insects collected on SWPM were recorded, preserved in bottles containing ethyl alcohol and sent to an AQIS entomologist for identification. SWPM exhibiting either fungal infection or possible nematode infection was collected, labelled and processed at AQIS laboratories for fungal identification and extraction of nematodes (Fig. 2). Nematodes were extracted using modified Barman funnel techniques (Barker 1985). Wood fungi were isolated by surface sterilising pieces of timber containing healthy and apparently infected tissue and placing them on a cycloheximide streptomycin malt agar (CSMA) medium. Cultures that originated from suspected wood pieces were subcultured, purified and examined microscopically. All regional data were collated and analysed to determine the national extent of contamination or non-compliance.

2006 survey

A second snapshot survey was conducted in March 2006 to assess the amount of untreated SWPM entering Australia accompanying air and break-bulk cargo consignments. This survey entailed examining SWPM accompanying air and break-bulk cargo on two specific dates in May 2006 at seaports and air freight depots across AQIS regions. Data were collected on country of origin and the presence or absence of the ISPM mark on SWPM.

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Figure 2. Sample collection (left) and nematode isolation in the laboratory (right)

Results

2005 survey

Of the 19 522 pieces of SWPM marked as ISPM 15-compliant examined during the 2005 survey, 1823 or 9.3% were found to be non-compliant with the standard. Of the 1823 non-compliant SWPM, 1749 were so assessed due to something of quarantine concern while the remainder did not meet the labelling requirement of the standard.

About 86% of the quarantine concerns of the non-compliance (1823) were related to bark. Bark represented 8.06%; live insects 0.51%; live insects with bark 0.4%; fungi, 0.5%; fungi with bark 0.25%; and fungi, bark and live insect 0.23% respectively (that is, some samples were non-compliant for more than one reason) (Figs 3 and 4).

Of the surveyed SWPM, 2.8% of the pieces were found to be compliant with ISPM 15 but also to exhibit something of quarantine concern (Fig. 4). A range of timber insects, along with fungi and nematodes, were detected in ISPM 15-compliant SWPM (Table 1). The major group of timber insects detected included beetles belonging to the genera *Heterobostrychus*, *Monochamus* and *Dinoderus*. A number of saprophytic moulds such as *Penicillium* as well as other ascomycota fungi were detected using standard fungal isolation media. Nematode genera extracted include spiral nematode (*Helicotylenchus*) and some *Aphelenchus* spp. (Table 1).

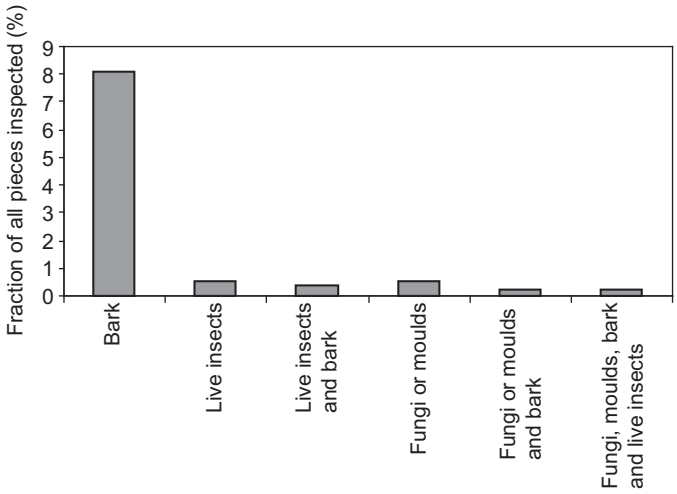

Figure 3. Incidence of non-ISPM-compliant SWPM attributed to factors of concern (N = 19 522)

Among the non-compliant SWPM, 0.1% did not meet the ISPM 15 mark requirement while 1.2% did not meet the ISPM 15 requirement and also had quarantine concerns (Fig. 5). About 50% of the SWPM pieces, with 766 of the non-conformities, were inspected in Brisbane, about 31% of the pieces in Sydney and 19% in Melbourne (Fig. 6).

Table 1. Categories of pest intercepted

Class	Order	Family	Genus	Species
Insecta	Coleoptera	Bostrichidae	*Dinoderus*	*D. minutes*
	Coleoptera	Bostrichidae	*Heterobostrychus*	*H. aequalis*
	Coleoptera	Cerambycidae	*Monochamus*	*M. alternatus*
	Coleoptera	Bostrichidae	*Sinoxylon*	*S. anale*
	Coleoptera	Cerambycidae	*Stromatium*	—
Fungi	Ascomycetes	Dothideomycetidae	*Aureobasidium*	—
	Ascomycetes	Eurotiomycetidae	*Penicillium*	—
Nematoda	Aphelenchida	Aphelenchidae	*Aphelenchus*	—
	Tylenchida	Aphelenchoididae	*Bursaphelenchus*	*B. mucronatus*
	Tylenchida	Hoplolaimidae	*Helicotylenchus*	—

Figure 4. Examples of non-compliant SWPM encountered during the 2005 survey

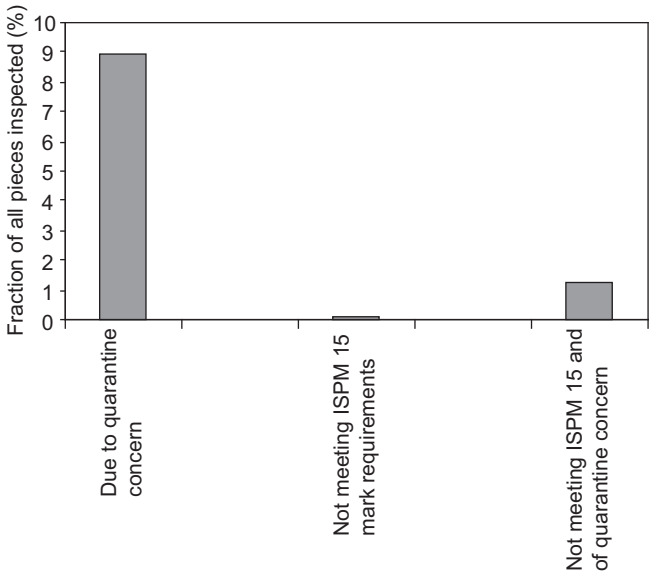

Figure 5. Broad classification of reasons for non-compliance of surveyed pieces of SWPM with ISPM 15 (N = 19 522)

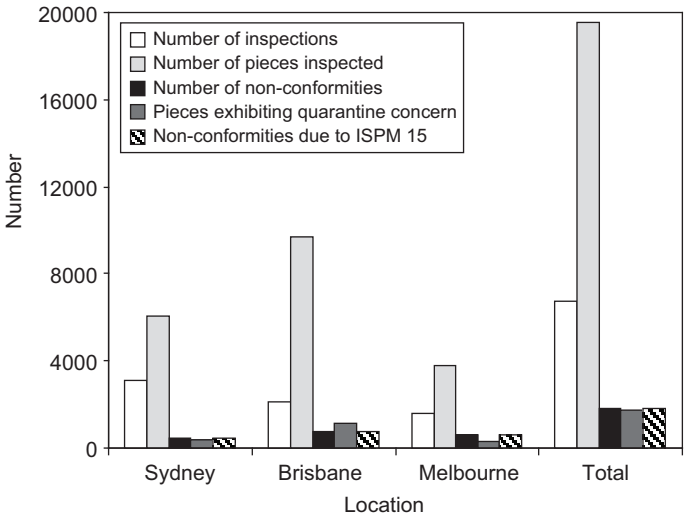

Figure 6. Inspections by location and detection of ISPM non-conformities

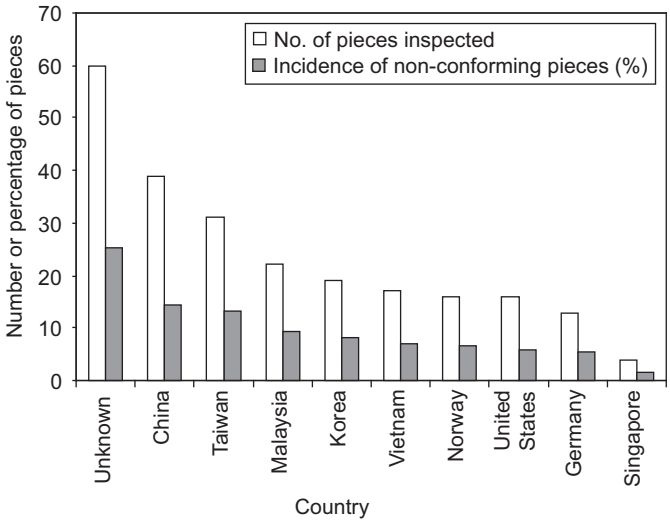

Figure 7. Countrywide detection of quarantine concerns on ISPM 15-marked SWPM

About 78% of the insects were detected where the SWPM had bark. Overall 96% of the quarantine concerns detected were due to bark, while the rest were due to insects or to fungi or mould with or without bark. The country of origin was unreadable on 25% or 15 of the non-conformities from 60 inspected pieces of SWPM (Fig. 7). The highest percentages of non-conformities were from China, followed by Taiwan, Malaysia and Vietnam (Fig. 7), with Singapore the lowest.

2006 survey

The 2006 survey established the number of pieces of SWPM marked as ISPM 15-compliant, as well as of unmarked or untreated SWPM, that arrived in Australia through air and break-bulk cargo on two one-day sample periods. The amount varied across the AQIS locations, with South Australia receiving the greatest number of ISPM 15-compliant pieces of SWPM. Nationally, however, 50% of the SWPM accompanying air and break-bulk cargo had no ISPM mark or had no treatment at all (Fig. 8).

Discussion

The results of the 2005 survey demonstrated that despite being ISPM 15-compliant, a good proportion of SWPM may pose significant quarantine risks and may provide a pathway for the introduction of exotic timber pests. The 2006 survey also demonstrated that a large number of untreated SWPM is still being used in air and break-bulk cargo across the world. The number of pests detected during the 2005 survey indicated that environmental conditions in shipping containers and cargo holds are likely to be suitable for survival of some pests.

Despite Australia requiring SWPM to be bark-free, the 2005 survey showed that about 9% of SWPM labelled as ISPM 15-compliant had bark (Fig. 3). There is much published evidence that the presence of bark on SWPM increases the chance of pests in the form of eggs, larvae or spores surviving during shipment (Tkacz *et al.* 1998; Allen 2001a; Kliejunas *et al.* 2001). The presence of bark on wood packaging material slows the seasoning process, provides shelter for invertebrates and allows the survival of many potential pests that feed in the cambial layer. These include bark beetles (Scolytidae) and their associated species of fungi such as *Ophiostoma*, *Leptographium* and *Ceratocystis*, as well as mites that also spread blue stain fungi (Stone and Simpson 1991). The high-risk nature of bark attached to wood packaging material has been acknowledged by many countries. For example, US inspectors found that 9% of maritime and 4% of air shipments containing SWPM had bark present, despite there being a pre-ISPM 15 bark-free requirement in place (USDA 2000). The 2005 survey in Australia also demonstrated that 78% of the insect detections were from wood packaging that had bark.

The large number of insects detected during the survey supports the notion that insects can survive in the timber, while the presence of fungi on timber may make it more attractive to attack by some insects. The use of faulty or improper methods to treat the SWPM may have contributed to the number of insect detections during the 2005 survey. Concerns about the efficacy of the heat and methyl bromide treatments in ISPM have been raised during review processes. There is evidence that treatments currently prescribed by ISPM 15 may not be effective against some timber pests. For example, Allen (2001a) cites work by Snyder (1923) indicating

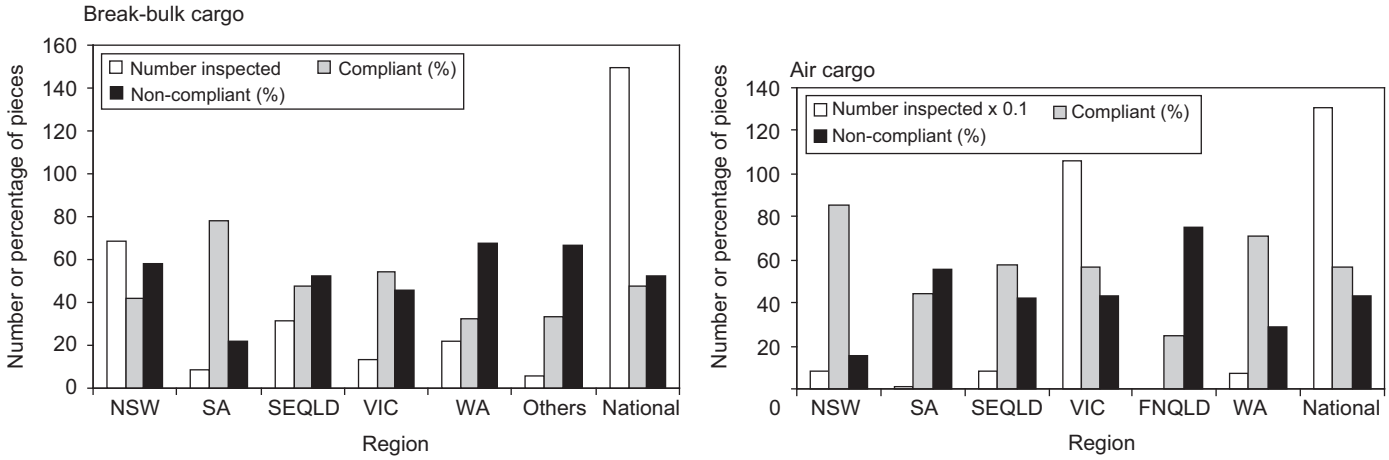

Figure 8. Distribution of ISPM-compliant and untreated SWPM in break-bulk and air cargo by regions: NSW = New South Wales; SEQLD = South-eastern Queensland, FNQLD = Far north Queensland; SA=South Australia; WA = Western Australia

that for eradication some *Lyctus* species require treatment for 30 min at 82°C. More recent data for *Lyctus brunneus* showed no survival when timber was heated from 24.5°C to 50°C in a time of 2.5 h (Ertelt 1994). Similar concerns were raised by the USDA during adoption of the ISPM 15 standard (USDA 2003, pages 24, 51, 60 and 61). The USDA raised concerns over the effectiveness of both the prescribed methyl bromide treatment and heat treatment on fungi and reinfestation of treated SWPM (USDA 2003, pages 24, 51, 60 and 61).

The number of fungi and nematodes isolated and or extracted in this survey also raises concerns about the efficacy of the methyl bromide and heat treatment schedules prescribed by ISPM 15. The IPPC expert working group responsible for developing the ISPM 15 heat treatment protocol was aware that the protocol would not adequately control fungi (Dwinell 2005). A core temperature of 56ºC for 30 min will not kill all fungi (Allen 2001a; Kieran and Allen 2004). Also, if heat-treated wood is not dried it will develop a luxuriant growth of moulds and other fungi. There is a potential threat of introducing fungi if SWPM is not treated adequately. To date, there has not been a systematic survey of forest pests in Australia. A review of Australian literature by Clarke (2004) revealed the introduction of nine exotic pathogens on forest trees and only two species of exotic forest pests during the period 1971–1995. Similarly, during 1988–1997 a systematic survey in New Zealand resulted in the discovery of 91 new introductions of forest pests and pathogens; 84% were forest fungi (Clarke 2004).

The current methyl bromide schedule (IPPC 2006) in the standard may not address the quarantine risks of a range of pathogens and other organisms. Cross (1991) quotes Harris (1963) as finding that the late larval and pupal stages of *Sirex noctilio* require dosages of 650 mg h L^{-1} (650 g h m^{-3}) for a reliable kill. A methyl bromide schedule for the giant African snail (*Achatina fulica*) of 128 g m^{-3} for 24 h at 12.5°C or above has been suggested in the United States (Armed Forces Pest Management Board 1990). Similarly a study of mortality of the pine wilt nematode (*Bursaphelenchus xylophilus*) in red pine (*Pinus densiflora*) boards at 15°C found 0.01% survival at a dosage of 1174 g h m^{-3} in wood with a 25% moisture content, and 100% mortality at 1188 g h m^{-3} in wood of 33% moisture content (Soma *et al.* 2001). Many of the pathogens and decay fungi of quarantine concern to Australia are primarily associated with bark, and can be transported with bark on solid wood or SWPM (USDA 1992; Tkacz *et al.* 1998; Kliejunas *et al.* 2001). For example, *Fusarium circinatum* and *Phytophthora ramorum* can have a direct association with bark (Owen and Adams 1999; Cree 2002), as do ophiostomatoid fungi (Hansen and Lewis 1997).

It is possible that insects, fungi and nematodes detected in this survey were due to reinfestation after treatment or during transit. However, this requires further investigation by exposing wood treated as per ISPM 15 to favourable conditions such as high humidity. It has been reported that colonies of ants in the genus *Camponotus* (carpenter ants) inhabit heartwood of living trees, trunks of standing dead trees, stumps, fallen logs and wooden structures (Hansen and Akre 1985). European house borer (*Hylotrupes bajulus*) lays its eggs in cracks and crevices of bark on logs and stored wood (Jacobs 2003). This species is unusual as it is capable of infesting seasoned timber and may reinfest the timber from which the adults have emerged (Ebeling 1975).

Large amounts of SWPM are used in the movement of cargo through air and break-bulk cargo consignments. Our 2006 survey revealed that about 50% of SWPM used in air and break-bulk cargo is not ISPM 15-compliant or has not received any treatment. This signifies the importance of implementing a mandatory treatment requirement for all SWPM regardless of the avenue (air, sea, break-bulk) by which it enters a country.

The results of two surveys of ISPM 15-compliant SWPM in Australia lend support to concerns raised during the early stages of development of ISPM 15 by USA and many other countries as well as by individual scientists (USDA 2000). Continuing improvement of the treatments currently in the standard and the addition of new treatments to the standard are essential to prevent the spread of timber pests through use of SWPM in international trade.

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