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Organización Norteamericana de Protección a las Plantas

NAPPO Regional Standards for Phytosanitary Measures (RSPM)

RSPM 41
Use of Systems Approaches to Manage Pest Risks Associated with the Movement of Forest Products

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Review

NAPPO Regional Standards for Phytosanitary Measures are subject to periodic review and amendment. The next review date for this NAPPO standard is 2023. A review of any NAPPO Standard may be initiated at any time upon the request of a NAPPO member country.

Approval

The Specification for this standard was approved by the North American Plant Protection Organization (NAPPO) Executive Committee on August 3, 2015. This Standard was approved by the North American Plant Protection Organization (NAPPO) Executive Committee on October 22, 2018 and is effective immediately.

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Amendment Record

Amendments to this Standard will be dated and filed with the NAPPO Secretariat.

Distribution

This standard is distributed by the NAPPO Secretariat to the Industry Advisory Group (IAG), the Secretariat of the International Plant Protection Convention (IPPC) and to other Regional Plant Protection Organizations (RPPOs).

Introduction

Scope

This standard provides NAPPO member countries with guidance on the use of integrated measures to mitigate pest risks associated with the movement of specified wood commodities (i.e., Forest Products Systems Approach (FPSA)) and provides guidelines for their development and implementation. Due to the varying risks associated with the wide range of commodities and pests addressed by this RSPM, it does not provide specific requirements to be addressed in any particular FPSA, but rather outlines the basic elements of a generic FPSA and considerations to be undertaken in developing and implementing such. The standard applies to trade into and among NAPPO member countries.

This standard covers round wood, sawn wood, wood chips and other specified wood commodities. It does not include wood packaging material, and wood commodities which meet the phytosanitary requirements of the National Plant Protection Organization (NPPO) of the importing country. Also excluded are Christmas trees, boughs, wreaths, and other non-wood forest products.

References

ISPM 4. 1995. *Requirements for the establishment of pest free areas*. Rome, IPPC, FAO.

ISPM 5. Updated annually. *Glossary of phytosanitary terms*. Rome, IPPC, FAO.

ISPM 10. 1999. *Requirement for the establishment of pest free places of production and pest free production sites.* Rome, IPPC, FAO.

ISPM 13. 2001. *Guidelines for the notification of non-compliance and emergency action.* Rome, IPPC, FAO.

ISPM 14. 2002. *The use of integrated measures in a systems approach for pest risk management*. Rome, IPPC, FAO.

ISPM 23. 2005. *Guidelines for Inspection*. Rome, IPPC, FAO.

ISPM 24. 2005. *Guidelines for the determination and recognition of equivalence of phytosanitary measures*. Rome, IPPC, FAO.

ISPM 39. 2017. *International movement of wood.* Rome, IPPC, FAO.

ISPM 11, 2001. Pest risk analysis for quarantine pests

Definitions

Entity - the term entity (or entities) is used throughout the standard to denote the facility, organization, party or producer responsible for a given action involved in a forest products systems approach.

All other definitions of phytosanitary terms used herein can be found in ISPM 5 and Annex 1 to Appendix 1 of this standard.

Background

Wood and wood products are known to be pathways for the spread or introduction of pests, yet a limited number of phytosanitary measures to manage pest risks associated with the international movement of wood and wood products are available to countries (ISPM 39, 2017). In particular heat or methyl bromide fumigation treatments are widely used in pest risk management of several traded wood commodities, but access to methyl bromide is diminishing in response to the Montreal Protocol[1] and heat treatment is not practical for many end uses or specific wood species or is not commercially available.

A systems approach (ISPM 14, 2002) may provide a more effective or practical option for risk management in the movement of wood commodities because it combines multiple measures to address pest risks. Integrated measures may address pest risks that are not fully managed by a single measure or may provide additional options for facilitating trade which may otherwise be impacted by the lack of appropriate measures (ISPM 24, 2005).

Phytosanitary measures combined in a systems approach for forest products may include actions taken during the growth and harvest of trees, the processing of trees into wood commodities, or the shipping of commodities to the importing country. Other measures may be carried out once products enter the importing country. In combination, these measures reduce the risk of introducing regulated pests into the importing country and thus facilitate safe trade.

Outline of Requirements

This standard describes the available measures and their integration as well as the oversight needed in the implementation of a systems approach. Integrated measures applied during pre-harvest, harvest, storage, transportation and/or post-shipping can reduce significantly the risk of regulated pests moving with wood commodities.

1. General Requirements

1.1 Basis for Regulating

[1] Montreal Protocol on Substances that Deplete the Ozone Layer, United Nations Environment Programme (1987).

Wood commodities may provide a pathway for the introduction and spread of pests. A systems approach integrates different risk management measures, at least two of which act independently and cumulatively, to reduce pest risk. The identification of specified pest risks associated with a pathway or pathways and the application of multiple measures integrated into a single systems approach for that pathway may reduce risks to an acceptable level.

1.2 Regulated Commodities

This standard provides guidance for the development and implementation of systems approaches to mitigate pest risk associated with the international movement of round wood, sawn wood, wood chips and other wood commodities.

1.3 Exempt Commodities

This standard excludes wood packaging material, and wood or commodities produced from wood which have undergone sufficient processing or treatment to meet the phytosanitary requirements of the NPPO of the importing country. Also excluded are Christmas trees, boughs, wreaths, and other non-wood forest products.

2. Specific Requirements

2.1. Developing a Forest Products Systems Approach

Successful development and implementation of a particular FPSA requires the coordinated effort of all entities involved in the forest products production chain for the commodity or commodities in question, including but not limited to NPPOs and other relevant government organizations of both the importing and exporting countries, forest industry representatives, exporters and importers and other stakeholders.

The development of an FPSA requires:

- understanding the nature of the pest risk(s);
- describing the pathway;
- identifying where, when and how phytosanitary measures can be applied;
- evaluating the individual and collective effectiveness of measures that are potential components of the FPSA;
- assessing their feasibility and impacts; and
- determining which will form part of any specific FPSA.

Documenting the FPSA, providing supporting information and instruction, and good communication between NPPOs and entities responsible for the relevant forest products in both importing and exporting countries ensures its successful implementation at each applicable point along the forest products chain (i.e., pre-harvest, harvest, post-harvest, processing, pre-shipping and storage, transport and/or arrival at destination).

An FPSA may include measures that are added or strengthened to compensate for uncertainty due to data gaps, variability, or lack of experience with the pests or measures in question. The extent of such compensation in a FPSA should be commensurate with the level of risk and associated uncertainty based on the PRA (ISPM 11, 2001), after appropriate communication between NPPOs.

Experience and additional information may provide the basis for renewed consideration of the number and strength of measures with a view to modifying the FPSA accordingly.

2.1.1. Responsibility of Parties to an FPSA

2.1.1.1 Responsibilities of the NPPOs

Specific requirements for any particular FPSA may be developed by the NPPO of either the exporting or importing country but ideally an FPSA is developed cooperatively by the NPPOs of both countries, in consultation with industry and the scientific community. The NPPO of the importing country, in consultation with the NPPO of the exporting country, should select least trade restrictive measures for inclusion in the FPSA. Alternative measures which result in an equivalent level of risk mitigation should be recognized. It is the NPPO of the importing country, however, that ultimately determines the suitability of the FPSA to meet the appropriate level of protection, subject to consideration of technical justification, minimal impact, transparency, non-discrimination, equivalence and operational feasibility.

The NPPOs in both the exporting and importing countries share responsibilities which include ensuring, to the best of their ability, that relevant phytosanitary information is published and transmitted immediately to the impacted NPPOs or other parties that may be affected by such measures.

The responsibilities of the NPPO of the importing country include but are not limited to:

- providing specific information regarding its phytosanitary import requirements, including but not limited to its:
  - list of regulated pests; and
  - phytosanitary import requirements including type of documentation or certification required; and
- completing a PRA (ISPM 11, 2001) identifying the pest(s) potentially associated with the wood products in question and potential mitigation measures.

Furthermore, the NPPO of the importing country may:

- propose options for mitigations to be included in the FPSA;
- perform periodic audits, evaluation and verification of the system, product inspection (ISPM 23, 2005), etc.; and

- review and provide information to the NPPO of the exporting country on the effectiveness of the FPSA.

In cases where the NPPO of the importing country agrees to the implementation of certain of the measures identified in the FPSA in their own territory, they are responsible for verifying the implementation of those measures.

The responsibilities of the NPPO of the exporting country may include but are not limited to:

- communicating the importing NPPO's phytosanitary import requirements and the requirements, specifically, of the FPSA, to all implicated entities, including exporters;
- ensuring the registration and maintenance of a list of participating entities;
- monitoring, auditing and reporting on system effectiveness at the frequency agreed upon by the NPPOs of the exporting and importing countries;
- implementing necessary corrective actions and follow-up audits when non-conformities have been detected; and
- maintaining appropriate records as per program requirements.

Additionally, where appropriate, the NPPO of the exporting country should:

- oversee third parties to ensure that audits are conducted according to program specifications;
- provide phytosanitary certification in accordance with program requirements;
- ensure adequate mechanisms are in place to monitor and supervise participating entities and any third parties overseeing the program;
- propose improvements or alternative options for improvement of the FPSA; and
- inform the NPPO of the importing country on corrective actions taken in the case of non-compliances identified by the NPPO of the importing country.

2.1.1.2 Entities Responsible for the Forest Product in the Exporting Country

Once the FPSA is in place, the entities responsible for the forest product production system in the exporting country (e.g., producers or processors of product destined for export etc.) should:

- develop and maintain a Production Manual which specifies the measures identified in the FPSA to be undertaken prior to or during export, as applicable and including schedules for their application;
- maintain adequate personnel, with the required training and experience to consistently carry-out activities described therein;
- apply measures as specified in the Production Manual;

- maintain detailed records on the application of measures, including information on pests found and corrective actions taken for a period negotiated between the NPPOs of the exporting and importing countries;
- designate a point of contact responsible for communicating with the NPPO of the exporting country;
- undergo inspections and audits;
- address any non-compliances and non-conformances; and
- document corrective measures taken.

2.1.1.3. Entities Responsible for the Forest Product in the Importing Country

The entities responsible for the forest product production system in the importing country, e.g., importers or processors of imported products should:

- develop and maintain a Production Manual which specifies the measures identified in the FPSA to be undertaken after arrival in the importing country, as applicable, including schedules for their application;
- maintain adequate personnel, with the required training and experience to consistently carry-out activities described therein;
- apply measures as specified in the Production Manual;
- maintain detailed records on the application of measures, including information on pests found and corrective actions taken for a period negotiated between the NPPOs of the exporting and importing countries;
- designate a point of contact responsible for communicating with the NPPO of the importing country;
- undergo inspections and audits;
- address any non-compliances and non-conformances; and
- document corrective measures taken.

2.1.2 Pest Risk Management options

In an FPSA, pest risk management options may be applied in the exporting country (e.g., during pre-harvest production, harvest, post-harvest, processing, pre-shipping storage), in transit, and/or after arrival in the importing country. Specific pest risk management options to be included in an FPSA should be appropriate for the commodity and pest in question and should be negotiated between the NPPOs of the importing and the exporting countries prior to finalization of the FPSA.

Pest risk management options may include:

- **Pre-harvest:** selecting harvesting or processing sites as a basis for identification of pest free areas (ISPM 4, 1995), pest free places of production or pest free production sites (ISPM 10, 1999); applying silvicultural techniques (e.g., thinning, stump treatments, roguing, selecting tree species or cultivars at the time of planting)

- **Harvest:** selecting trees during a specific period or selecting tree species or cultivars at time of harvest in order to limit likelihood of pest infestation on the product
- **Post-harvest:** safeguarding the wood commodities in a manner that prevents infestation during processing, transport or post-shipping; conducting inspections at harvest and post-harvest grading to remove infested product
- **Forest Commodity Processing:** debarking, sawing or trimming to mitigate the risks associated with certain pests; conducting inspection or testing during processing to remove infested material; applying treatments such as chemical(s), heat or drying following primary processing or prior to any remanufacturing to mitigate specific regulated pests; auditing to validate integrated measures or to verify system integrity
- **Storage:** storage area sanitation including removing bark and wood debris from debarked wood storage areas may mitigate pest risk and thereby prevent infestation
- **Transportation:** avoid shipping during known periods of pest activity; protection during transport in sealed containers to prevent the spread of pests during transport; cleaning containers inside and outside between shipments can reduce contamination of wood commodities from previous shipments
- **Post-shipping:** limited distribution or restricted use at destination

Appendix 1 provides detailed information on measures which could be integrated into an FPSA. All those that may be applicable in any given FPSA should be considered and evaluated in the course of developing the FPSA.

2.1.3 Documentation

Documents which can contribute to effective communication and successful implementation of an FPSA include:

- Forest Products Systems Approach
  - a description of requirements and instructions to applicable entities
- Production Manual
  - processes and procedures for implementing the FPSA in each applicable entity
- Pest Management Plan
  - a response plan for use in the case of pest detections
- Record Keeping related to training, verification activities, compliance/non-compliances, audits etc.

Each of these is discussed in some detail in the appropriate sub-section of Section 2.2 which follows.

2.2 Implementing a Forest Products Systems Approach

2.2.1. Production Manual

Production Manuals describe the requirements, elements, processes, and operational systems that make up the FPSA and describe the respective roles and responsibility of entities implementing an FPSA or part thereof.

The NPPO of the exporting country is responsible for ensuring that all participating entities have developed, implemented, and maintained approved Production Manuals. In cases where FPSA measures include those that are to be conducted after importation, it is the importing country's NPPO that is responsible for ensuring that all participating entities in the importing country have developed, implemented, and maintained approved Production Manuals. If an FPSA manual is amended to reflect a proposed change in production practices it should be resubmitted for approval by the NPPO of the exporting country prior to implementation.

In situations where multiple entities are involved in the harvest and production of a regulated forest product, roles and responsibilities of each entity relative to the requirements of the FPSA should be clearly defined for each stage in the forest products production chain.

The Production Manual may include, but is not limited to, the following elements:

- description of the organizational structure and responsibilities of the relevant personnel, including name and position of the person designated as responsible for the performance of the FPSA;
- procedures associated with maintaining relevant records for the measures in the FPSA for the period negotiated between the NPPOs of the exporting and importing countries;
- procedures used to ensure the competency of staff responsible for implementing the FPSA;
- description of the measures that are part of the FPSA (Section 2.1.3) including but not limited to:
    - place(s) of harvest and/or production;
    - the taxa grown, harvested and processed;
    - Pest Management Plan;
    - procedures used in processing the wood,
    - procedures for treatment, storage and movement, and other pertinent factors;
- procedures for handling, segregating and traceability of the wood products in question;

- procedures used by the facility to record, address, and correct non-conformities that may occur during activities described in the Production Manual; and
- description of all relevant activities carried out by entities, if any (e.g., harvesting, shipping, treatment).

2.2.2 Pest Management Plan

A Pest Management Plan, designed to aid in preventing infestations and controlling pests, should be included as part of the Production Manual when appropriate. The manual should include:

- description of the phytosanitary requirements of the NPPO of the importing country and the measures to be taken to meet these requirements;
- roles and responsibilities of the implementing entity and the NPPO of the relevant country in the case of pest infestations or detections; and
- description of procedures or processes to control pests and ensure compliance with the phytosanitary requirements of the importing country.

2.2.3 Training

The Production Manual should describe the training of staff who perform duties related to the FPSA in managing pest risks associated with the movement of forest products, including the specific training elements, and frequency of training or retraining as agreed between the NPPOs of the exporting and importing countries. Records of all training provided should be maintained.

2.2.4 Traceability and Segregation

Traceability may be beneficial in circumstances such as: identifying the origin of non-compliant material, responding to notifications of non-compliance, expediting the implementation of corrective measures, preventing future occurrences of non-compliances.

In cases of consolidated shipments, traceability procedures should allow traceback of material to all source entities. Only articles originating from source entities operating within the FPSA or otherwise meeting the phytosanitary requirements of the NPPO of the importing country should be included in the consolidated shipment and should be clearly identified.

Therefore, approved entities should ensure that adequate record-keeping procedures are in place for traceability related to all critical points along the FPSA by the NPPO of the exporting country for those measures that are applied pre-export or during transit, or by the NPPO of the importing country in cases where FPSA measures are to be undertaken in the importing country.

Entities approved by the NPPO of the exporting country should specify how compliant wood is segregated from non-compliant wood in their Production Manual.

2.2.5 Record Retention

Records documenting the application of measures should be retained by the relevant entities for the period negotiated between the NPPOs of the exporting and the importing countries and as specified in the FPSA.

2.3 Evaluating a Forest Products Systems Approach

2.3.1 Verification

The NPPO of the exporting country maintains ultimate responsibility for reviewing the implementation and effectiveness of the FPSA. In cases where measures are applied following entry into the importing country, the NPPO of the importing country will be responsible for verification. The NPPO of the importing country may audit an FPSA. Such an audit should be conducted in accordance with terms agreed upon by the NPPOs of the importing and the exporting countries. The frequency of verification of the FPSA should also be agreed upon by the NPPOs of the importing and exporting countries.

In cases where verification of the FPSA demonstrates that one or more of its components is not providing adequate pest risk management, a review of the FPSA should be conducted. This review may or may not necessarily involve the suspension of the entity or of the FPSA.

2.3.2 Non-compliance and Non-conformity

A non-compliance is a failure to adhere to phytosanitary import requirements as established in an Act of Law or its Regulations. A non-conformity is a failure to comply with a requirement of an FPSA. It is the responsibility of NPPOs in both importing and exporting countries to address non-compliances or non-conformances which arise in their respective countries and share information on non-compliance with each other promptly on such occasions.

2.3.2.1 Non-compliance

Phytosanitary action in response to non-compliance should be proportional to the risk presented or otherwise based on existing bilateral agreements. If regulated pests are detected on imported consignments, the NPPO of the exporting country should be notified promptly, in accordance with ISPM 13 (2001). This will allow the NPPO of the exporting country to follow up with the facility to ensure that corrective actions are taken to prevent recurrence. The NPPO of the exporting country should report back to the NPPO of the importing country on corrective measures taken. Where it is evident that non-compliance is a result of the failed application of measures undertaken following entry to the importing

country, the NPPO of the importing country is responsible to follow up with the facility to ensure that corrective actions are taken to prevent recurrence.

Depending on the nature or the frequency of the non-compliance, the facility may be suspended or terminated from participating in the program. The facility may be reinstated by their relevant NPPO once they demonstrate the ability to maintain compliance. The NPPO of the importing country may take necessary immediate corrective actions on any non-compliance identified.

The NPPO of the importing country may also increase the frequency of inspection or the sampling rate or implement other measures to verify that the imported product is in compliance.

Contingency plans may be negotiated between the NPPO of the exporting country and the NPPO of the importing country in advance to ensure alternative measures are available in the event a non-compliance of the FPSA is detected.

Detection of non-compliant wood products by the NPPO of the importing country following completion of all elements of the FPSA may result in the destruction or refused entry of the entire shipment.

2.3.2.2 Non-conformity

A non-conformity is any failure of products or procedures to adhere to the requirements of the FPSA. Two types of non-conformities are recognized, taking into account the severity of the non-conformity:

- critical non-conformities are incidents that compromise the efficacy or integrity of the FPSA; and
- non-critical non-conformities are incidents that do not immediately compromise the efficacy or integrity of the FPSA.

Non-conformities can be detected during audits or examination of commodities produced under the FPSA. The consequences resulting from the different types of non-conformities should be negotiated between the NPPOs of the exporting and the importing countries. Detections of critical non-conformities may or may not result in the suspension of the non-conforming entity from the FPSA and the immediate suspension of non-conforming exports. Detection of non-critical non-conformities requires immediate corrective action. Multiple or repeated non-critical non-conformities may be addressed in the same manner as critical non-conformities.

Failure to consistently comply with the conditions of the FPSA or otherwise meet the phytosanitary requirements of the importing country may result in suspension of the responsible entity's eligibility in the FPSA. Reinstatement should occur only once corrective action has been put into place and an audit by the NPPO of the exporting or

importing country, as appropriate, has confirmed that the non-conformities have been corrected. Corrective actions may require a change to the requirements and should include measures to prevent recurrence of the failures identified.

Appendix 1: Guidance on the Use of Systems Approaches to Manage Pest Risks Associated with the Movement of Forest Products

This appendix is for reference purposes only and is not a prescriptive part of the standard.

This Appendix provides additional information, literature citations and examples to support RSPM 41: 2018 for use as a stand-alone document and details the structure and components of forest products systems approaches (FPSAs) as described in the standard. This Appendix includes a short background on the need for relevant standards, explains concepts integral to a systems approach and gives examples of procedures occurring during pre-harvesting, harvesting, post-harvesting, processing, transportation, storage and post-shipping where pest-reducing measures can be implemented as part of a system approach. Risk reduction options specify the types of pests that are mitigated, and how pest mitigation results may be verified and, where possible, quantified.

Haiku:
a single measure
may not be acceptable;
a systems approach?[2]

Introduction and Scope

In 2002, the Commission on Phytosanitary Measures (CPM) adopted International Standard for Phytosanitary Measures 14 on *The use of integrated measures in a systems approach for pest risk management* (ISPM 14, 2017). ISPM 14 provides guidelines for the development and evaluation of integrated measures as an option for pest risk management. However, more specific guidance on the combination of measures, and quantification of the resulting pest mitigation was considered necessary to support international trade in wood commodities (round wood, sawn wood or wood chips, with or without bark). Regional Standard for Phytosanitary Measures 41 (RSPM 41) on the *Use of Systems Approaches to Manage Pest Risks Associated with the Movement of Forest Products* was developed by subject matter experts working on behalf of the North American Plant Protection Organization (NAPPO) to improve harmonization and support negotiations among its member countries and other trading partners interested in the application of systems approaches for forestry. RSPM 41 provides guidance on the development of Forest Products System Approaches (FPSA) for round wood, sawn wood, and wood chips and other wood commodities. The scope of RSPM 41 excludes wood packaging material, wood, and commodities produced from wood which have undergone sufficient processing or treatment to meet the phytosanitary requirements of the National Plant Protection Organization (NPPO) of the importing country. Also excluded are Christmas trees, branches or boughs, wreaths and other non-wood forest products.

This Appendix was written to provide supporting information to RSPM 41: 2018 and details the components of systems approaches described in the standard. The risk reduction options specify the types of pests that are mitigated, how pest mitigation results may be verified and, where possible, quantified.

1. General Requirements/ Basis for Regulating

A systems approach is defined in International Standard for Phytosanitary Measures 5, the *Glossary of phytosanitary terms*[3] (ISPM 5) as "a pest risk management option that integrates different measures, at least two of which act independently, with cumulative effect". The identification of specified pest risks and the combination of several phytosanitary measures into a systems approach may reduce the risks to acceptable levels, thus facilitating safe international trade.

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[2] Haiku authored by Brian Double (CFIA) was included in Canada's topic submission to the IPPC.
[3] ISPM 5 is updated annually and is available on the International Phytosanitary Portal (IPP – www.IPPC.int) at: https://www.ippc.int/en/core-activities/standardssetting/ispms/

A phytosanitary measure is "any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests" (ISPM 5).

Historically, where countries have specified import regulations for the international movement of wood commodities, most have required the application of a treatment[4], commonly heat or fumigation, as a single phytosanitary measure. However, there may be instances where the application of a single measure does not sufficiently reduce pest risk, is not economically or environmentally viable (Nabuurs et al 2007), or renders the commodity unmarketable. In these instances, a combination of measures may be more effective or acceptable than a single measure, and better able to meet the level of phytosanitary protection of the importing country.

Phytosanitary measures combined in a systems approach for forest products could include a wide range of conditions or actions that occur during the growth and harvest of trees, the processing of trees into wood commodities, or shipment to the importing country. Other measures might be completed once the forest products have entered the importing country. Examples of these are provided in ISPM 14 and include measures such as pest-free areas, pre- or post-harvest inspections, certification of production processes that reduce pest prevalence, treatments, port of entry inspections, etc.

2. Specific Requirements

Developing and implementing an FPSA requires coordination of various entities (government or private sector agencies, organizations, companies, facilities, persons, parties, importers, exporters, brokers, producers, etc.) involved in operations along the forest products production chain (e.g. growing, harvesting, processing, etc.). Specific measures combined into a systems approach are agreed upon by the National Plant Protection Organizations (NPPOs) of the importing and exporting countries. The NPPO of the exporting country should work with participating entities to develop and document practical and economically feasible phytosanitary measures for managing pest risks in the country of origin. Measures applied at each point along the forest products production chain (pre-harvest production, harvest, post-harvest production, processing, pre-shipping storage, transport and/or post-shipping) are addressed in greater detail in the following subsections.

Quantification of risk reduction by each element of a systems approach is valuable to determine its effectiveness and may provide an importing country with information to evaluate alternative import requirements (e.g. single measure versus systems approach). A systems approach may be composed of independent and dependent measures. By definition a systems approach must have at least two independent measures. An independent measure may be composed of several dependent measures" (ISPM 14,

[4] Treatment is defined in ISPM 5 as an "Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalization".

2017). The probability of failure of a systems approach using dependent measures is additive thus all dependent measures are needed for the system (or independent measure composed of dependent measures) to be effective. If only two independent measures are used both measures must fail in order for the system to fail and the probability of failure is the product of all the independent measures (ISPM 14,2017). In an FPSA, determining the suitability of dependent and independent measures requires knowledge of the tree species, the quarantine pests of concern, and the risks associated with the forest product being produced for export.

For example, an FPSA incorporating two independent measures for western redcedar (*Thuja plicata* Donn ex D. Don) green sawn wood required to be free of powderworm (*Trachykele blondeli* Marseul) could include harvest in an area free of *T. blondeli* (typically *T. plicata* above 250 m elevation is free of *T. blondeli*; Duncan 2001) and use of strict lumber grading rules which select for the best quality sawn wood (i.e. sawn wood carefully inspected by certified graders which has no visible signs of pests). In this example, one measure alone should result in wood that is free of powderworm; however, when applied together if one measure fails, the other measure will still result in wood that is free of powderworm.

Although not common in forest products at this point in time, systems approaches (SA) are well understood and used in other commodity sectors (Jang and Moffitt 1994; Quinlan et al 2016). The following is an example taken from an agricultural commodity illustrating why dependent measures alone are not sufficient in a SA. To ensure that tomatoes (*Lycopersicon esculentum*) shipped from Africa to the USA are free of the Mediterranean fruit fly, *Ceratitis capitata*, tomatoes may be grown and harvested within insect-proof greenhouses (inspected by a registered regulatory agency) and packed in insect-proof boxes to prevent Medfly infestation after packing (Hallman 2007). If either of these dependent measures fails, pest risk will not be adequately mitigated, demonstrating that dependent measures alone are insufficient when establishing a SA.

Scientific data should be used as the basis for the development and acceptance of a systems approach. Data provide technical justification and measurable quantification to demonstrate that measures used in an FPSA are effective at mitigating pest risk.

2.1 Pre-Harvest Pest Risk Reduction Measures

Before trees are harvested, there are opportunities to reduce pest risk. Best practices used to promote healthy trees can be an integral part of an FPSA, a concept addressed in the FAO *Guide to the implementation of phytosanitary standards in forestry* (FAO 2011). Listed below are a number of pre-harvest measures that could be integrated into a systems approach. A single or a combination of measures may be implemented according to the specificities of a particular commodity, tree species and importing country's regulated pest list.

Pest Monitoring to determine Pest Prevalence

Monitoring pest conditions in both natural and planted forests allows for early intervention when pest outbreaks occur. Well-planned and managed natural and planted forests provide an opportunity to maximize and monitor tree health while optimizing timber production. While planted forests can be vulnerable to pest problems associated with low-diversity monoculture plantations (Jactel et al. 2005) planting appropriate trees species and cultivars for a particular geographic region, soil and climatic conditions can reduce plant stress and susceptibility to pests (FAO 2011).

Forested areas that are free of regulated pests can be formally recognized as pest free areas (ISPM 5) by the NPPO of the importing country through audits overseen by the NPPO of the exporting country (RSPM 1, 1994; ISPM 8, 2016).

Use of Less Susceptible Genotypes

Additionally, planting pest-resistant or less-susceptible genotypes, selected for environmental conditions of the planting area can reduce pest load through host resistance (Yanchuk and Allard 2009). Significant progress has been made in developing insect- and disease-resistant trees for a number of pathogens of international phytosanitary concern (Sniezko 2006; McKinney et al. 2014; Kanzler et al. 2014; Mitchell et al. 2012). Authorized certifying agencies can verify genotypes and genetic class codes (Alfaro et al. 2013).

Silvicultural Practices

A number of planning and operational practices that can result in pest risk reduction may be applied to both planted and naturally regenerated forests. Post-planting assessments may be conducted to monitor the progress of planted seedlings. Silvicultural practices such as thinning and spacing may be implemented to remove unhealthy or infested trees and improve growing conditions. Similarly, roguing (routine removal of plants that exhibit evidence of disease, infestation, off-type characteristics or undesirable traits) may also improve harvest quality.

Planting forests with mixed species rather than monoculture or clonal trees can reduce forest pest vulnerability (Jactel et al. 2005). Pre-harvest surveys that identify pest issues can be used to guide harvest-planning decisions and avoid inclusion of infested trees for export. Conversely, this information can be used in the recognition and certification of pest free areas. In areas where root rot disease has been present, removing stumps can lower future disease (Cleary et al. 2013). When moving between planted or replanted forest areas sanitizing equipment, footwear, vehicles and tools can reduce or eliminate the spread of pests (Hansen et al. 2000; FAO 2011).

Semiochemical Controls

Semiochemical controls in managed or planted forests can also be used to reduce regulated pests via techniques such as pest mating disruption particularly where

insecticide use is not an option (Waters and Stark 1980; Rothschild 1981; Sharov et al 2002; Brockerhoff et al. 2006; Gillette et al 2006; Tcheslavskaia et al 2005). The use of attractants to monitor regulated insect pests may result in early detection of pests and be used to determine whether further measures in a systems approach are needed to reduce pest risk (Nadel et al. 2012). Anti-aggregation pheromones (chemical substances which interrupt aggregation on a resource; Furniss et al. 1974; Skillen et al. 1997) may be used to reduce pest populations or protect healthy tree stands that may be susceptible to quarantine pests (see section 2.3 Post-harvest for more detail; Ross and Daterman 1995, 1997). Pesticide applications can reduce pest levels during vulnerable periods. These programs can be verified by audits of the pest management plan.

Table 1: Summary of Pre-Harvest Pest Risk Reduction Measures

Risk Reduction Measure	Verification Method
Pest Monitoring and Establishment of Pest free areas	Ongoing monitoring and audits overseen by exporting NPPO
Planting forests with pest resistant genotypes	Authorized certifying agency-genotype certification
Silviculture practices- mixed species, post-planting assessments, thinning, roguing, sanitization of equipment, stump removal	Silviculture Certification program Verification, record keeping and auditing
Managed forests - semiochemical control or pesticide application and monitoring	Control program registration and schedule

2.2 Pest Risk Reduction Measures during Harvest

Measures applied during harvest can provide opportunities to identify and reduce pest risks. These may include selection of areas to be harvested, timing of harvest and grading of standing trees.

Pest Free Areas or Areas of Low Pest Prevalence

Among the risk reduction measures that can be used at harvest is the recognition of pest free areas (PFAs) or areas of low pest prevalence (ALPP). A pest free area is defined as an "area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained" (ISPM 5). Delimitation of a pest free area requires knowledge of pest biology. The official establishment of a PFA must be based on specific survey data and once this status is given, the PFA must be periodically surveyed or inspected during the growing season. Documentation should be made available to other regulatory authorities when requested. Where a designated PFA is part of a systems approach, evaluation or verification processes by the NPPO of the importing country may be required (ISPM 4, 2017; ISPM

29, 2017). An example of an ongoing PFA status-verification process is found in North America for a serious pest of deciduous trees, *Lymantria dispar dispar* (L.) (gypsy moth). *L. dispar dispar* is not established in western North America or Mexico, nor does it occur in portions of provinces or states in eastern Canada and the United States. However, *L. dispar dispar* is frequently moved from infested to uninfested areas as egg masses laid on conveyances (e.g. vehicles, boats, trailers). To maintain the PFA status, NPPOs in North America conduct annual surveys to verify the distribution of the pest, using an extensive pheromone trapping program. Such programs allow the movement of regulated articles to non-infested areas (FAO 2011).

An ALPP is defined as "an area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specific pest is present at low levels and which is subject to effective surveillance or control measures" (ISPM 5). The distinguishing difference between an ALPP and a PFA is the accepted presence of the pest below a specified population level in an ALPP in contrast to the absence of a pest in a PFA. A low amount of a pest may be tolerated on imported commodities where phytosanitary measures manage the pests to a level acceptable to the importing country (ISPM 22, 2015). The establishment and verification of ALPPs are detailed in ISPM 22 (*Requirements for the establishment of areas of low pest prevalence*). Where trade within areas of low pest prevalence is allowed, monitoring surveys are used to provide continued evidence for the ALPP designation.

Timing of Harvest

Timing of harvest can affect pest risk. Predicting the timing of insect emergence and host suitability can be achieved using published literature and phenology models (Gray 2012). Managing the timing of harvest, storage and processing of round wood can minimize insect attack and population build-up of, for example, ambrosia beetles in conifers. In temperate forests removal and processing of round wood harvested in the fall and winter prior to the spring flight of bark beetles, ambrosia beetles and other wood-boring pests can reduce levels of attack and therefore pest infestation (Gray and Borden 1985; Nijholt 1978; Shore 1992).

Understanding the biology of the regulated pest is an important factor in determining whether timing of harvest can be used as a mitigation measure in an FPSA. While it may be feasible to manipulate timing of harvest to mitigate specific quarantine pests exhibiting distinct seasonality in temperate forests this is not possible in tropical forests (Latifah 2005). In tropical environments pest species may have multiple overlapping generations throughout the year (Lu et al. 2011) or year-round activity with peak levels of activity in the dry or wet season (Flechtmann et al 2001; Sittichaya et al. 2012). In these circumstances, the use of semiochemicals may be a strategy that can be employed in the FPSA (see section 2.3 Post-harvest for more detail). As in temperate forests, detailed knowledge of the spatial and temporal distribution of the regulated pests is necessary before any manipulations of harvest schedules can be developed.

Evaluation of Individual Standing Trees for Quality and Pest Presence

Identifying and addressing pest problems on individual standing trees at the time of harvest may be possible under certain harvesting situations. Pest reduction at this point could be part of a certified grading procedure. Grading (classification of wood quality) and selection at the time of harvest is advantageous as more of the harvestable round wood is visible, thus infested trees can be flagged, removed or treated and those with visible decay or disease can also be removed (Calvert and Petro 1993). Trained personnel (scalers) responsible for evaluating harvested trees to determine the volume and quality of the wood are certified and accountable to a local governing body or accreditation body.

Where possible, harvest information should be tracked and certified by the NPPO of the exporting country for commodities destined for export.

Table 2: Summary of Harvest Pest Risk Reduction Measures

Risk Reduction Measure	Verification Method
Harvesting from Pest Free Areas	Registered program with area audits
Timing harvest during low insect prevalence	Phenology models
Quality evaluation of individual standing trees	Certified grader/ trained personnel

2.3 Post-Harvest Pest Risk Reduction Measures

After harvest, round wood is generally evaluated for quality and volume by trained personnel at the harvest site, either after being loaded for transport, or at the shipping or processing yard. During this evaluation, evidence of pests regulated by the importing country may be identified and round wood segregated according to risk. Evaluation techniques, standards and post-harvest risk reduction opportunities are described below.

Inventory Control and Timely Processing of Round Wood

Season of harvest, the period of time that round wood remains in the forest post-harvest, and the time to load, time spent loaded, and the time spent enroute to the processing or holding yard may have an effect on the potential for post-harvest infestation of round wood.

For example, it may take multiple days to accumulate bundles of round wood before loading onto barges or trucks. Depending on the time of year and where round wood bundles are accumulated, there may be opportunities for post-harvest insect attack (Leland Humble pers comm). Chilean forest researchers have found that the risk of insect

and pathogen infestation increases depending on the type of harvesters used, damage to round wood during harvest and the time spent in the forest post-harvest (Lanfranco et al. 2004). Similarly, round wood often accumulates at ports awaiting export, making it vulnerable to attack by bark beetles and wood-boring beetles known to infest cut logs.

Screening for Pests During Volume and Quality Determination

During the time period spent calculating round wood volume (termed log scaling in North America) and classifying the wood quality (grading; BCFLNRO 2016; MFLNRO 2011; Fonseca 2005), round wood can be inspected for evidence of pests by trained personnel, providing an effective and verifiable risk reduction opportunity. This examination may be performed before, during or after transportation from harvest location to the processing or shipping yard and can provide an opportunity for identification of pest infestation. Inspection to detect insect presence can be difficult unless obvious signs such as exit holes, frass, pitch tubes, or egg masses are evident. For example, trees newly attacked by some bark beetles (e.g. *Dendroctonus ponderosae* Hopkins and *D. valens* LeConte) may have visible signs of boring dust, pitch tubes or pitch nodules (Bright 1976) though it is unlikely that fallen and transported round wood will have these signs by the time it reaches a lumberyard.

Signs of infestation may not be evident in cases of cryptic organisms like buprestid and cerambycid beetles and siricids (wood wasps). For example, *Agrilus planipennis* Fairmare, the emerald ash borer, oviposits in bark crevices beneath loose pieces of outer bark. Attack is not easily identified until tree crown thinning or dieback occurs which may not be evident for one or more years after infestation (Van Driesche and Reardon 2015). Detection of cryptic insect infestation may be possible once round wood is debarked. For example, presence of the cerambycid beetle *Neoclytus acuminatus* (Fabricius) the redheaded ash borer attack is not evident on the outside of the bark. However long narrow mines can be observed on the surface of sapwood beneath the bark (Solomon 1995).

The presence of microscopic organisms such as fungi and pinewood nematode on outer surfaces or inside round wood may also be difficult or impossible to detect through visual inspection (Leal et al 2007). Where fungal infection is more advanced and visible, scaling and grading processes may detect fungi causing diseases such as: root diseases (butt rot), heart rots, sapwood rots, canker diseases, sap rots and abiotic diseases (BCFLNRO 2011; Allen et al. 1996).

Scaling and grading varies from country to country depending on the national standards. In many countries, there are no national standards for grading round wood (MFLNRO 2011). Hardwood is typically graded according to standards set by the individual mill. Softwood is often sold by volume or weight and is usually not scaled and graded prior to sale. Grading and scaling of round wood can be a component of an FPSA, but are unlikely to provide mitigation in and of themselves

Anti-Aggregation Pheromones to Deter Insect Attack

Anti-aggregation pheromones, if available, may be used to repel regulated pests from areas of natural disturbance (e.g. windthrow) or logging and storage areas (see section 2.1 Pre-harvest for more on anti-aggregation pheromones).

Aggregation or sex pheromones can be used to reduce populations of some species and thereby reduce levels of damage during storage at log yards or mill sites (McLean and Borden 1977; 1979). In forests of the temperate and boreal zones of the northern hemisphere, tree removal with trucks during the harvest period (spring) is difficult due to conditions during snow-melt, thus trees must be protected until vehicle access is possible (Bakke 1986; Ross and Daterman 1995). Several anti-aggregation pheromones have been used to deter bark and ambrosia beetles from attacking felled logs. For example, methylcyclohexenone (MCH) an anti-aggregation pheromone for Douglas-fir beetle (DFB) *Dendroctonus pseudotsugae* Hopkins has been shown to be effective for reducing DFB in healthy stands (Ross and Daterman 1995; 1997). While anti-aggregation pheromones repel target species they may not be 100% effective and may be attractive to other insects. Each suggested method must be tested and verified before incorporation into an FPSA and should be verified through a registered program with regular audits.

Protection of Round Wood After Harvest

Insect attack of trees after felling is a concern for many tree species (Haack 2006). Ambrosia beetles like those belonging to the genera *Trypodendron* and *Gnathotrichus*, attack recently felled or dead conifer trees as well as round wood (Chapman and Nijholt 1980; Daterman and Overhulser 2002). Rapid removal and processing of round wood avoids ambrosia beetle attack in the late winter and early spring (Leal et al. 2010). Protection of round wood after harvest before transportation via storage in water or sprinkling round wood with water on land has been used to prevent new attack by bark beetles and wood-borers as well. However, this method is not effective against all insect pests. Depending on the location and pest of concern, this may be an option for pest risk reduction after proper testing and certification.

Table 3: Summary of Post-Harvest Pest Risk Reduction Measures

Risk Reduction Measure	Verification Method
Inventory control- rapid processing of round wood	Verified through records
Screening for pests during volume and quality determination	Trained personnel are certified to estimate volume and quality of wood and are accountable to a local governing body

Anti-aggregation pheromones deter bark and ambrosia beetles from attacking harvested round wood	Efficacy of such programs must be verified and registered with regular audits
Protection of round wood after harvest	Verified method

2.4 Forest Commodity Processing

Forest commodities including round wood, sawn wood and wood chips possess different pest risks dependant on a variety of factors such as tree species, harvest location, harvest time, etc. Processing wood reduces pest risk. The following section describes these three forest commodities, their associated phytosanitary risks and the pest risk reduction achieved via different types of processing. In the following section, pests are grouped by guild (i.e. organisms with similar biological characteristics).

2.4.1 Forest Commodities

Round wood with bark

Round wood with bark (related names: logs, poles, posts, timber, pilings), is the least processed forest commodity and carries with it the most inherent pest risks. By definition round wood is "wood not sawn longitudinally, carrying its natural rounded surface, with or without bark" (ISPM 5). Often the first step in commodity processing is removing bark from round wood, which reduces the probability of introducing a number of quarantine pests.

Round wood without bark

Debarked or bark-free round wood presents a lower risk than round wood with bark. Pests that colonize bark or the portion of wood immediately below the bark will generally be eliminated and those that are not removed have reduced chance of survival with bark removal.

Sawn wood

Sawn wood (lumber) is defined as "wood sawn longitudinally, with or without its natural rounded surface with or without bark" (ISPM 5). Sawn wood may include squared pieces of wood without bark or partially squared wood with one or more curved edges that may or may not include bark. In the commercial production and sale of sawn hardwood commodities, curved edges are commonly left for subsequent trimming. Where this is the case and there are associated bark remnants, pest risk may be greater than entirely squared wood. Sawn wood without bark has a lower overall pest risk than sawn wood with bark because sawing removes most of the bark as well as some of the outer wood thus eliminating pests living in or just under the bark. Sawn wood with rounded edges possess more risk than square edged sawn wood as a larger percentage of the wood just below the surface of the bark is included. Pest risk associated with sawn wood may also depend on the moisture content of the wood (ISPM 39, 2017).

Wood chips

Wood chips are wood fragments with or without bark produced mechanically from various harvested tree parts and processing residues or post-consumer wood material (EPPO 2015). The pest risk associated with wood chips varies with source material, chip size and uniformity, and method of storage (see 2.4.4 Wood chips section below).

2.4.2 Grouping Quarantine Pests

Quarantine pests associated with trees can be grouped according to the plant tissues they use to live and reproduce. For example, many insects and fungi are found exclusively on foliage and branches and would therefore never be associated with wood commodities derived from the stems of trees. Within tree stems, quarantine pests can be grouped into two broad categories: those that live in and around the bark and those that live below the bark, predominantly in woody tissues. (Some organisms live under the bark and pupate in the wood or in the bark depending on bark thickness ex. Emerald ash borer.) Pests that live predominantly in woody tissues can be further sub-divided into organisms that are found in the outer several centimeters of the wood (often restricted to water-conducting tissues in trees with sapwood) and those that can be found deeper in the wood or throughout the stem. Understanding where pests live in trees can be of great value in developing an FPSA strategy. The physical removal of all or most organisms within these groupings can be achieved through different processing steps (e.g. debarking and sawing).

Organisms associated with foliage and branches

Many forest quarantine pests live and reproduce exclusively on foliage and branch tissues. Since round wood, sawn wood and wood chips do not include these tissues none of these pests needs to be considered in the international movement of wood commodities.

Organisms associated mostly with bark

Certain species of insects, fungi and nematodes live in or just under the bark in phloem tissues. This includes the bark beetles – (Coleoptera: Curculionidae: Scolytinae) which is divided into 29 tribes with more than 6000 species known to date (most of which are tropical or subtropical). Scolytinae are a highly diverse subfamily that spend most of their life histories under the bark of their host trees (Vega and Hofstetter 2015) foraging on the inner bark and phloem. Many bark beetles feed on fungus-infected phloem for nitrogen requirements.

Fungi – Many fungal quarantine pests including stem rusts (*Cronartium* spp.) and canker fungi grow and sporulate in close association with bark and phloem tissues. Although few published data are available, expert opinion is that bark removal would seriously impair the ability of these fungi to reproduce.

Organisms associated mostly with wood

This group includes ambrosia and wood boring beetles as well as nematodes and many fungi. This group can be further divided into organisms that inhabit the outer 1-2 cm of wood and those that are generally found deeper in older xylem tissues.

Ambrosia beetles – (Coleoptera: Curculionidae: Scolytinae: Corthylini, Xyleborini, Xyloterini and Platypodinae) are found in the inner bark, phloem and xylem. Ambrosia beetles are considered wood-borers due to their ability to tunnel into sapwood and heartwood (Vega and Hofstetter 2015). The ambrosia fungi that they introduce provides their nutrition (Baker and Norris 1968) and stains the wood, lowering its value (Furniss and Carolin 2002).

Wood Borers *(Coleoptera: Cerambycidae, Curculionidae, Buprestidae; Diptera: Pantophthalmidae; Hymenoptera: Siricidae; Lepidoptera: Cossidae and Sesiidae; and* Isoptera) – Feed on or excavate phloem and xylem (Leal et al 2010). Although most bark beetles are found exclusively in bark and phloem tissues, life stages of some (e.g. Vega and Hofstetter 2015) form larval galleries or pupal chambers in xylem tissues. Similarly, some Buprestidae, notably *Agrilus planipennis* (emerald ash borer) feed as larvae mostly in the phloem and produces pupal chambers generally restricted to the outer 1 cm of the sapwood.

Fungi – Many species of fungi inhabit the woody portion (xylem) of tree stems. The success, location and extent of fungal colonization is largely governed by the nutritional requirements of the fungi, physical characteristics of the wood (chemical composition, cell structure, etc.) wood moisture, temperature and the presence of competing organisms. Decay fungi may be present throughout the xylem or depending on species may be restricted to the sapwood or heartwood. Most canker and rust infections of stem wood are restricted to the outer several cm of wood. An exception is western gall rust (*Endocronartium harknessii* (J.P. Moore) Y. Hiratsuka)) where woody galls extend to the pith (Hiratsuka and Powell 1976). Bluestain fungi, typically in the genera *Ceratocystis, Ophiostoma, Grosmania, Leptographium,* and *Sphaeropsis,* colonize the moist sapwood of conifers and are generally dispersed and introduced to new hosts by insects. Vascular wilt fungi (e.g. *Ceratocystis fagacearum* (Bretz) Hunt, *Ophiostoma ulmi* (Buisman) Nannf., *O. novo-ulmi* (Brasier) are generally restricted to the sapwood. Wood decay fungi may be found in both sapwood and heartwood and, depending on the fungal species, may colonize living or dead tissues. Spores of fungi and fungus-like organisms (e.g. *Phytophthora* species) may be present as contaminants on the outer surfaces of wood commodities. The probability of contaminant spores surviving to establish in the environment of an importing country is low, dependant on environmental conditions, duration of transit and the longevity characteristics of the spores.

Nematodes – The pinewood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle is the causal agent of pine wilt disease and the only wood-inhabiting nematode causing serious damage to trees. Larvae and adults of the nematode live mainly in living cells of the host (primarily the sapwood).

2.4.3 Commodity Processing Pest Risk Reduction Measures

Removal of branches (or boughs)

Many quarantine pests occur only in association with foliage and branches and not the main stems (round wood) used for wood production. Therefore, branch removal is a very effective method to prevent the movement of these pests in international trade. Although branches are not addressed in this standard, where fresh branches are moved as a commodity it is recommended that they should be treated with the same phytosanitary measures as plants for planting (ISPM 36, 2016).

Removal of bark

Some quarantine pests are found in or just beneath the bark. As a phytosanitary import requirement, the NPPO of an importing country may require removal of bark to reduce pest risk. Removal of bark or peeling of round wood effectively eliminates pests inhabiting the outer surface (e.g., aphids, adelgids, scale insects, non-wood-boring moths and rust fungi) as well as those found directly beneath the bark (e.g., bark beetles and buprestid beetles). Bark removal prevents post-harvest infestation by most other wood pests such as wood wasps and large wood-borers.

Debarked wood is round wood where some residual bark remains due to irregularities in the wood surface, while round wood with complete bark removal is referred to as bark-free wood (ISPM 5). The efficiency of debarking varies among tree species, round wood size and shape and time of year (Laganière and Bédard 2009) as well as the type of equipment used. Industry estimates show that up to 3% of bark may remain on softwoods and up to 10% of bark may remain on hardwoods following debarking (Leal et al. 2010). Removal of bark not only removes bark beetles but also reduces the risk of infestation of bark beetles after wood is harvested. It also facilitates inspection for the presence of some fungal pathogens (e.g. *Geosmithia morbida* M. Kolařík, Freeland, C. Utley and Tisserat, thousand cankers disease) and boring insects. Tolerance levels for residual bark may be set and treatments implemented to reduce pest risk associated with bark. Where wood is required to be bark-free no visible indication of bark should be found other than ingrown bark around knots, inclusions and bark pockets between rings of annual growth (ISPM 15, 2017).

Sawing wood

The presence or absence of bark and the thickness of a piece of sawn wood will affect pest risk (ISPM 39, 2017). Pest risk from bark-related organisms is dependent on moisture content of the wood and amount of bark present (decreasing with moisture content and size). Debarking, sawing and edge trimming wood generally removes the pests just beneath the bark (Haack and Petrice 2009).

Sawn wood grading / quality control

Wood with insect galleries or fungal decay can be removed from the production stream or marked for treatment (sanitation). Untreated sawn wood without bark may still contain canker fungi, pathogenic decay and stain fungi, vascular wilt fungi, nematodes, ambrosia beetles and other wood boring insects. For those organisms where visual detection is possible, personnel should be trained or wood scanners programmed to identify infested wood. In certain instances, sawn wood quality and grade may contribute to meeting phytosanitary requirements. Sawn wood may be graded for visual defects or tested for structural qualities (Oh and Lee 2013; USDA 2015). Each country has its own set of grading rules most of which follow the same general principles.

Heat treatment

Heat treatment involves heating wood to a minimum temperature for a minimum period of time according to an official specification (treatment standard or treatment schedule) to kill, or otherwise cause sublethal effects that eliminate a target pest's ability to cause unwanted phytosanitary impacts. A minimum treatment time is specified to heat the wood throughout its profile. The overall time required to achieve the minimum temperature will depend on the wood's dimensions, species, density and moisture content. Types of heat treatments include steam and vacuum steam heating, kiln-heating, solar heating, joule heating and dielectric heating (microwave, radio frequency). Heat may also be combined with chemical treatments as heat-enabled chemical pressure impregnation (ISPM 15, 2017).

Exposure of insects (Denlinger and Yocum 1998; Neven 2000) or fungal propagules (Lifshitz et al. 1983; Assaraf et al. 2002) to high temperature affects the synthesis and structure of cellular macromolecules and cellular structures causing death or resulting in sub-lethal effects (reduced fecundity, sterility). Where heat treatment of wood does not result in mortality of pathogenic fungi, colonization by saprophytic organisms following treatment has been shown to outcompete some pathogens (Uzunovic et al. 2008).

Standards for heat treatment schedules are set by NPPOs. In Canada, for example, the NPPO establishes heat treatment standards under the Canadian Heat-Treated Wood Products Certification Program (CHTWPCP[5]). This is an official certification system for the export of wood products to countries requiring heat treatment prior to import. ISPM 15 outlines the heat treatment for wood packaging material, which is an internationally accepted method for wood sanitation. Heat treatment using a steam or dry kiln heat chamber to achieve a minimum temperature of 56°C for at least 30 minutes throughout the entire profile of a wood product (including its core) can be measured by inserting temperature sensors in the core of the wood. When dielectric heat treatment is used, wood must be monitored to demonstrate a minimum temperature of 60 °C for 1 continuous minute throughout the entire profile of the wood (including its surface) (ISPM

[5] CHTWPCP - Canadian Heat-Treated Wood Products Certification Program is an official certification system for the export of wood products to countries requiring heat treatment prior to entry. Member countries of the European Union, and the Republic of Korea. Australia, the United States, Mexico and others recognize Canada's heat treatment program and utilize treated wood within their own phytosanitary certification programs.

15, 2017). Treatment schedules may be developed for specific commodities or pests and must be approved by the NPPO. Treatment facilities should be certified by the NPPO and records of heat treatments and calibrations should be maintained for auditing purposes.

Drying

When wood is air-dried, it eventually reaches the equilibrium moisture content (EMC) of its ambient surroundings. EMC is generally considered to be 4–21% at a global level (Simpson 1998) and may require a period of several weeks to a year, depending on species and dimensions of the wood, the temperature, and moisture conditions (Simpson and Hart 2000). Many pests present in trees at the time of harvest or death are capable of completing development to the adult stage despite reductions in moisture content (Eyre and Haack 2017; Haack 2017; Haack et al. 2017). Accelerating the drying process (e.g. kiln drying), particularly during the early larval stages of insects, when they are most dependent on moisture, will greatly increase mortality (Haack and Benjamin 1980). Kiln-drying is defined in ISPM 5 as "a process in which wood is dried in a closed chamber using heat and/or humidity control to achieve a required moisture content". Kiln-drying can alter the physical structure of wood thus preventing resorption of moisture. This process renders the wood inhospitable to some pests and generally lowers the probability of infestation after treatment. Heat treatment can be achieved during the kiln drying process if specific requirements of the heat treatment are met.

Irradiation

Irradiation or ionizing radiation such as accelerated electrons or x-rays can be used to sterilize pests (ISPM 18, 2016; Van Haandel et al. 2017). Gamma radiation (GI) is commonly produced by cobalt-60 or cesium-137 sources. Gamma rays can penetrate deep into wood and have been proven capable of killing insects, fungi and nematodes when the irradiation dose is high enough. Lester et al. (2000) reported that 99% of the larvae of *Prionoplus reticularis* White in pine wood were killed by 3677 Gy of irradiation three days post treatment. At this time, GI has limited commercial application as a phytosanitary treatment for sawn wood due to the high facility cost, operation cost, high dose required and the effect of high-dose irradiation on wood mechanical (tensile and compression strength) properties (Despot et al. 2012). A further drawback is that GI does not immediately kill organisms, and during post-treatment, phytosanitary inspectors could still find moribund organisms, making it difficult to accept the commodity as safe. Gamma irradiation is a broad-spectrum treatment that shows potential as a treatment against a range of organisms; however, its use at an industrial scale for wood commodities is as yet untested.

Electron beam radiation, which is similar to gamma irradiation except that the source of radiation is electrons generated by a machine rather than by radioactive isotopes, may be an alternative as a wood phytosanitary treatment. Electron beam radiation is used commercially for sterilizing a wide variety of agricultural products.

Fumigation

Fumigants used to treat wood products include but are not limited to phosphine (PH, aluminum phosphide AP and magnesium phosphide MP), methyl bromide (MB) and sulfuryl fluoride (ISPM 28, 2017). There are other fumigants at various stages of testing and registration around the world among them is ethanedinitrile. Because of environmental considerations, the use of methyl bromide is being reduced significantly or phased out by many countries. Processes to recapture MB used to fumigate forest commodities have been successfully developed. Use of MB where it is recaptured after treatment is an option and where alternatives do not exist MB will mitigate most wood pests (wood-boring beetles, bark beetles, termites, nematodes and some fungi; FAO 2011).

Anti-fungal sapstain chemical dips

Anti-fungal sapstain chemical dips may be used to protect wood other than wood chips. Colonization by fungi may be prevented by spraying or dipping wood in a dissolved chemical product. Chemicals may also be applied using impregnation under vacuum, pressure or thermal process that forces the product deep into the wood (Chen et al. 2008). These preservatives may reduce the likelihood that a wood product is infested post-harvest but may not be effective in killing quarantine fungi inhabiting the wood.

Modified atmosphere treatment

Modified atmosphere treatments include all treatments that involve manipulation of normal atmospheric conditions to kill or inactivate pests. These may include but are not limited to low oxygen and/or high carbon dioxide levels for extended periods of time (Heather and Hallman 2008). Modified atmospheres can be generated in sealed chambers or may occur naturally (i.e. during water storage; ISPM 39, 2017) and are often used in combination with high temperature treatment.

Sanitation and inventory management

Post-harvest inventory management and keeping storage and production areas free of wood debris are important factors reducing the risk of pest infestation of wood commodities post-harvest. Inventory management that segregates wood into different phytosanitary risk categories at appropriate stages of the process can be an important component of the FPSA. Facilities may be certified and audited.

Pest free place of production

Where possible a pest free place of production may be established depending on the biology of the regulated pest, the characteristics of the place of production, the operational capabilities of the producer, and the requirements and responsibilities of the NPPO (ISPM 10, 2016). Establishing a pest free place of production requires establishment of an appropriate buffer zone, documentation of the system and the maintenance of adequate records.

Survey and trapping

Surveillance using approved traps and lure combinations, for example aggregation pheromones or kairomones, and colour traps may be used to monitor pests around a production facility as well as those within the facility. Regular maintenance of traps and record keeping for auditing can demonstrate pest free status for regulated pests.

Inspection of articles

At any point along the production chain inspection, as part of the FPSA, may be used to identify specific signs or symptoms of pests such as bark beetles, wood-borers and fungi on round wood and sawn wood. Inspection may be useful to determine if the phytosanitary measures applied have been effective. For example, untreated, debarked round wood may be inspected during scaling and grading, post-transport, after debarking, segregation and post-shipping. Challenges to inspections may be presented by the size and disposition of the articles and the cryptic nature of some pests (ISPM 23, 2017).

2.4.4 Wood chips

Wood chips are manufactured from various harvested tree parts, processing residues or post-consumer wood material (e.g. used wood packing material; EPPO 2015). Wood chip consignments containing a mixture of tree species should be considered a mixed species commodity when considering phytosanitary measures.

Pest risk for wood chips varies depending on the presence of pests in the original material (tree species, location harvested, pest incidence), bark content, chip size and intended use (i.e. fuel, landscape mulch, or pulp for fibre production; EPPO 2015). Commercial specifications for chip quality related to specific end uses may be used to mitigate pest risk. For example, chips for fibre production have minimal bark, consistent moisture content and uniform shape and size, resulting in low pest risk for some organisms (Morrell et al. 1998) compared with chips used as a bio-energy source that may have greater variation in size and may contain bark.

Some insects are attracted to the volatile compounds given off by freshly cut wood, and in rare instances may infest freshly processed wood chips. More frequently, insects attracted to freshly chipped wood will be present as contaminants. Many species of pathogenic decay fungi, canker fungi and nematodes may be present in wood chips with or without bark.

The physical process of wood chipping or grinding is lethal to many insect pests; the process can destroy living organisms or disrupt the host material so that the insect cannot complete its life cycle (Kliejunas et al. 2001; Wang et al. 2000; McCullough et al. 2007; Sweeney et al. 2008). Small size chipping (e.g. max 2.5 cm in two dimensions) is an effective method for mitigation of *Anoplophora glabripennis* (Motschulsky) and *A. chinensis* (Förster) and *Agrilus planipennis* (Wang et al. 2000; McCullough et al. 2007; Sweeney et al. 2008; Kopinga et al. 2010).

Heat treatment or aerobic composting of wood chips can be an FPSA measure (Lamers et al. 2012). Heat treatment achieving a minimum core temperature of 56°C for at least 30 minutes is recognized by certain countries as a measure for treating North American (NAPPO 2014) bark-free coniferous wood before chipping. Different pests may be mitigated by aerobic composting to specified core pile temperatures for specific periods of time.

Treating wood chips with topical fungicides and insecticides can effectively reduce pest risk and be easily adjusted and monitored (Morrell et al. 1998). This type of treatment has been shown to be effective against mold and sapstain including *Alternaria alternata* (Fr.) Keissl. *Ophiostoma piceae* (Münch) Syd. & P. Syd. (Index fungorum current name *Pesotum piceae* J.L. Crane & Schokn), *Phialophora* spp., *Aspergillus niger* Tiegh., and *Trichoderma* spp. Fumigation of bulk wood chips may not be the most effective pest risk reduction method.

Table 4: Summary of Forest Product Processing Risk Reduction Measures

Risk Reduction Measures	Verification Method
Removal of branches or boughs	Visual Inspection
Removal of bark-eliminates insect pests and pathogens on the outer surface as well as those just beneath the bark (bark beetles), prevents infestation by most wood borers	Inspection
Sawing wood-wood with insect galleries or fungal decay can be identified or marked for treatment	Trained and certified scanners, scalers and graders responsible for quality checks and controls
Heat treatment (HT)	HT standards are regulated by NPPOs and treated wood identified by phytosanitary certification
Kiln-drying (KD) renders wood inhospitable to pests and reduces probability of infestation post treatment	KD standards are prescribed by industry grade rules
Irradiation- used to sterilize pests	Certification program
Fumigation e.g. Phosphine	Certification program
Anti-fungal sap stain- protects wood from fungi associated with sapstain and prevents infestation post-treatment	Certification program

Modified atmospheric treatment – inactivates pests	Certification program
Facility certification	Certification program
Monitoring and trapping	Record keeping and audits
Inspection of articles	Certified inspection program
Chipping - can destroy living insect organisms or disrupt the host material so that the insect cannot complete its life cycle	Certification of chip dimensions

2.5 Storage Pest Risk Reduction Measures

Storage is required in cases where schedules do not permit shipping a commodity immediately following processing. Commodities may be stored in a variety of places and conditions. Storage requirements may be specified by the NPPO of the importing country. Depending on the commodity and type of storage there may be risk of pest infestation or re infestation during this period. Storage options may vary depending on the type of commodity, time of year and potential associated phytosanitary risks.

Depending on the risk reduction measures applied throughout the production stream, different storage conditions will be appropriate for FPSA.

Limit storage time

Shipping wood commodities within a specified window of time after harvest reduces the post-harvest period where wood could become infested. This reduces the chance for pests to infest or emerge, survive or reproduce. Storage requirements should be tracked through record keeping and audits (USDA 1998).

Shipping conditions and timing

Shipping outside known periods of activity for regulated pests in either the importing or exporting country may be a component of an FPSA. In the northern hemisphere, harvesting and shipping only in the winter when pests are not active and treating upon arrival in the importing country may effectively mitigate pest risk. For example, round wood potentially containing *Tomicus piniperda* (Linnaeus), from the United States may enter Canada during the beetle non-flight period. The round wood must be processed within a specified time-frame before the beetle becomes active (CFIA 2011). Shipping windows should be based on biological data and technical justification, demonstrating that this measure is effective at mitigating pest risk.

Storage areas/ segregation

Storage areas and segregation refers to storing regulated commodities in a manner that prevents infestation or reinfestation by pests. Segregated areas may be designated and

monitored to demonstrate reliability. Segregation may be achieved by covering, containerizing or storing in monitored buildings (i.e. with pheromone trap surveillance). Depending on pest mobility, segregation may not be practical.

Storage area sanitation

In cases where processed commodities cannot be physically segregated or protected pre-shipment, storage area sanitation and monitoring may be implemented and certified. For example, when debarking round wood, regular bark removal from the storage area (to eliminate pests in bark from infesting or contaminating debarked round wood) should be practiced with regular monitoring for post treatment infestation and careful record keeping.

Storage conditions/ contaminating pests

Pre-shipment protection may be included in a systems approach depending on the phytosanitary risks associated with a particular wood commodity. A storage building can be very effective at protecting commodities from infestation before shipping. For commodities such as wood chips, contact with the ground may pose the risk of contaminating fungal and insect pest infestation, thus storing on cement pads may be required. Contaminating insect species which are not associated with a particular wood commodity are of growing concern (FAO 2014). For example, in countries where Asian gypsy moth (*Lymantria dispar asiatica* Vnukovskij, *Lymantria dispar japonica* (Motschulsky), AGM; Pogue and Schaefer 2007) is present, the use of surveillance combined with pest exclusion measures such as host removal, reduction or altering of port lighting or pesticide application may be used to ensure that stored shipments during AGM moth flight are not contaminated. In NAPPO member countries certification is required to ensure that shipments and or vessels visiting a port in the infested area during the period of female flight are free from AGM (RSPM 33, 2017).

Water spraying

Water spraying is used in some storage areas to reduce insect attack and blue stain on raw round wood and sawn wood (Leal et al. 2010). Depending on the location and pests of concern this may be an option for pest risk reduction. However, this method is not effective against all insect pests. Water used should be recaptured and treated to address potential phytosanitary concerns and reduce environmental effects.

Monitoring and trapping

Outer perimeter pull-push systems with aggregation and anti-aggregation pheromones and funnel traps may be used to monitor and manage some insect pests (e.g. certain bark and ambrosia beetles). Aggregation pheromones are chemical substances that attract both male and female conspecifics to a breeding resource while anti-aggregation pheromones interrupt aggregation on a resource. For example, methylcyclohexanone (MCH) an anti-aggregation pheromone for Douglas-fir beetle *Dendroctonus pseudotsugae* has been used to repel beetles from healthy stands of Douglas-fir (Ross and Daterman 1995; 1997) and has been suggested as a management technique to deter

beetles from infesting harvested timber in dryland sorts (Humble and Noseworthy unpub.).

Topical biocide

To prevent insect pests and diseases from contaminating processed wood products chemical anti-sapstain treatments may be applied. For example, anti-sapstain treatments also prevent surface discoloration caused by fungi which thrive on freshly cut round wood and sawn timber during transit and storage. Often these fungi are already present in the wood at the time of milling (Leal et al 2010).

Sawn wood wrapping or packaging

Wrapping and packaging is designed to prevent soil contamination and weather protection. It may also provide some protection from insect pest contamination before and during transport. In some cases, wrapping may be counterproductive in preventing insect infestation. Some organisms take advantage of the tucks and folds in the wrapping that create protected environments to hide. In New Zealand wood shipped during the flight time of *Arhopalus ferus* (Mulsant), burnt pine longhorn beetle, must be treated and then sealed under insect proof covers or within containers or sealed ship holds (Biosecurity New Zealand 2008; Brockerhoff and Hosking 2001; Hosking and Bain 1977). KD-HT sawn wood may be protected from perching insects but the sawn wood must be kiln-dried as wrapping wood with higher moisture content will facilitate fungal growth and wood degradation.

Pre-shipment inspection

To ensure phytosanitary requirements of the importing country are met. Inspections by authorized entities may occur at various points within the FPSA: NPPOs should audit these inspections as required by the negotiated FPSA (ISPM 12, 2016).

Table 5: Summary of Storage Risk Reduction Measures

Risk Reduction Measure	Verification Method
Limit storage time	Record keeping and audits
Shipping period- outside periods of pest activity for post shipping treatment	Records keeping and certification
Storage areas and segregation	Certified designated storage areas
Storage area sanitation	Certified and audited
Storage area conditions monitoring	Surveillance, pest exclusion, certified program

Water spraying	Based on technical justification, inspection and audits
Monitoring and trapping	Tested and verified, audited and certified
Topical biocide	Record keeping and audits
Insect proof covers	Record keeping and audits
Pre-shipment inspection	Phytosanitary certificate

2.6 Transportation Pest Risk Reduction Measures

Transportation includes movement by any means of conveyance at any point from time of harvest to arrival at the port of import.

Protection during transport

Protecting the forest product during transport may serve to reduce the likelihood or severity of pest attack during transport. For example, wood chips may be covered or sealed or stored in closed containers to prevent the spread of pests during transport.

Treatment during transport

Commodities can be treated in either containers or ships' holds while in transit from the exporting to importing country. For example, New Zealand has employed phosphine to fumigate round wood while in transit (Biosecurity New Zealand 2009). This type of treatment and risk reduction option will depend on the type of container required or available, expertise of fumigators, shipping laws (including occupational and health requirements), the commodity being shipped and the importing country's requirements.

Shipping routes planned

Choice of shipping route may be influenced by the known phenology of the pest and the weather and climatic conditions that would be expected during transit. For example, avoiding warm temperatures and insect emergence through a registered trackable shipping plan which takes the shipment through cooler weather conditions may result in slower or no pest development during transit.

Cleaning containers

Cleaning the inside and outside of containers between shipments can reduce contamination of wood commodities from previous shipments. For example, cleaning the outside of containers, inspecting ships and containers during Asian Gypsy Moth flight times in Asia, and inspecting export ships for AGM egg masses prior to sailing and before port entry helps to reduce the likelihood of AGM introduction to North America (RSPM 33, 2017). The North American Sea Container Initiative provides guidance for cleaning and inspecting sea containers - (http://inspection.gc.ca/plants/plant-pests-invasive-

species/sea-container-cleanliness/eng/1508779809618/1508779809944), as does the Australia Department of Agriculture and Water Resources: http://www.agriculture.gov.au/import/before/prepare/sea-container-cleaning-standards.

Table 6: Summary of Transportation Risk Reduction Measures

Risk Reduction Measures	Verification Method
Protection during transport	Certification system
Treatment during transport	Certified system
Shipping routes with low risk planned	Records and certification system
Cleaning containers	Certified and audited

2.7 Post-Shipping Pest Risk Reduction Measures

Depending on the wood product in question, the specifications of the particular FPSA and the resources of the importing country, risk reduction measures may be employed upon entry to the importing country. Where agreed upon, the importing country may require phytosanitary measures such as quarantine, treatment, site sanitation or processing be undertaken following arrival in the importing country and these may be included in an FPSA (ISPM 14, 2017).

Post-shipping mitigation

The post-harvest mitigations described above for application prior to or during shipping may also be applied in the importing country and can, therefore, be considered for inclusion in an FPSA where applicable.

Storage post-shipping

Storage post-shipping can be included as a risk reduction measure in an FPSA. For example wood chips may be stored post-shipping on a tarmac or cement pad which can prevent the spread of organisms into soil and water. US regulations for the import of eucalyptus chips from South America require this type of storage and set-up and surveillance systems around ports of entry (Crowe 2001).

Wood commodities may also become infested by organisms native to or established in the importing country. NPPOs should consider this possibility when investigating pests found in association with imports.

Restricted use and distribution

Limited distribution or restricted use at the destination (ISPM 14, 2017). Considerations could include the relevant environmental and climatic conditions where the product will be distributed and used. For example, wood chips destined for pulp or biofuel may be subject to such restrictions.

Table 7: Summary of Post-Shipment Risk Reduction Measures

Risk Reduction Measures	Verification Method
Post-shipment mitigation	Verification system
Post-shipment storage	Certification system
Restricted use	Records, audits

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Annex I - Definitions

This section includes definitions derived from the Oxford English dictionary and some ISPM definitions as relevant to this document.

Audit - periodic review, evaluation and verification of a system (ISPM 4, 2017; ISPM 14, 2017)

Anti-aggregation pheromones - chemical substances which interrupt insect aggregation on a resource

Entity - the term entity (or entities) is used throughout the standard, RSPM 41, as a global term denoting the facility, organization, party or producer responsible for a given action involved in a wood products systems approach

Grader – is a person or machine which assess wood products

Systems approach - the integration of different risk management measures, at least two of which act independently, and cumulatively achieve the appropriate level of protection against regulated pests (ISPM 5)

Roguing - routine removal of plants that exhibit evidence of disease, infestation, off-type characteristics or undesirable traits (OED)

Scaler - is a person who measures or estimates the quantity, expressed as the volume, area, length, mass or number or products obtained from trees after they are harvested (BCFLNRO 2016)

Segregation - is the physical separation of wood commodities to ensure that mixing of compliant and non-compliant product does not occur. Untreated wood may be physically separated from treated wood, or other methods such as clearly marking treated versus untreated wood or clear signage; etc. may be used

Traceability - the documentation and verification of the movement of a commodity from the initial control point to the final product of the FPSA

Verification - in the context of a phytosanitary document the term verification is similar to the dictionary definition: *process of establishing the truth, accuracy or validity of something*

Wood chips - are wood fragments with or without bark that have been produced mechanically from various harvested tree parts and processing residues or post-consumer wood material (EPPO 2015)

Wood commodities- round wood, sawn wood or wood chips, with or without bark (ISPM 5)

Heat chamber - any enclosure used for the heat treatment of wood

Moisture content (of wood) - the amount of water within wood measured as a percentage of the weight of oven-dried wood

Relative humidity - the ratio of the amount of water vapour in the air as compared with the amount of water vapour the air is capable of holding measured at a particular temperature.