3. Good practices for forest health protection

Forests are ecosystems that are composed of all forms of life. Insects and micro-organisms live in and on trees, exploiting their leaves, bark, wood and roots for shelter and food. Forest products are therefore likely to contain these organisms at any time. Many species that are considered pests[8] in some importing countries may not be considered pests in their native range. Thus, while it is obvious that a forest that is undergoing a disease or insect outbreak poses a more immediate threat to international trade, products from a healthy forest may also pose a pest risk. Nevertheless, good forest health should be a minimum aim of sound commercial forest management. Keeping forests healthy requires careful planning throughout all of the resource management phases from planting or regeneration to harvest. Harvest planning should include careful consideration of what will likely grow back and how the next generation of forest will be managed. This chapter provides basic information on integrated pest management (IPM) as well as pest management practices for all of the phases of, and sites involved in, forest resource management, including:

- forest operations: planning, harvest and transportation;
- forest nurseries;
- planted forests;
- naturally regenerated forests;
- post-harvest treatments and sawmills;
- product transportation and distribution.

Many of the suggested practices, such as sanitation, surveillance, and quick reporting to the national plant protection organization (NPPO),[9] are applicable and good for all phases of forest management. These management options can be selected and adapted to individual conditions. It should be noted that, in some countries and in some situations, it may not be possible to implement all of these best practices, particularly after natural disasters and unexpected events which may create economic constraints and the need for immediate actions such as salvage.

3.1 INTEGRATED PEST MANAGEMENT FOR FORESTRY

The most effective way to deal with forest pests is integrated pest management (IPM). IPM can be defined as a combination of prevention, observation and suppression measures that can be ecologically and economically efficient and socially

[8] Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products (ISPM No. 05, 2010, *Glossary of phytosanitary terms*).

[9] The full list of NPPOs and their official contact persons can be found on the IPPC Web site: www.ippc.int.

BUGWOOD.ORG/W.M. CIESLA/3943032

Release of Pauesia *parasitoids for biocontrol of cypress aphid,* Cinara cupressivora*, in western Kenya*

acceptable, in order to maintain pest populations at a suitable level. Prevention may include proper tree, variety and site selection, natural regeneration, and planting and thinning practices that reduce pest populations and favour sustainable control by natural enemies. Careful monitoring of pest populations, for example through visual inspection or trapping systems, determines when control activities are needed. For suppression, mechanical control, biological control through the use of natural enemies and biopesticides, or other sustainable control methods are preferred over synthetic pesticides. IPM relies on understanding the biology of the tree, forest and pest as well as the biology of natural control agents that can help keep pests under control. Therefore, for IPM to be effective, field staff must be trained to recognize pests, monitor population levels and use biological control agents and other suitable control methods.

Biological control through the use of natural enemies is an essential component of IPM. Beneficial natural enemies may be promoted by suitable silvicultural practices (biological control by conservation) or by supplemental releases (biological control by augmentation), the latter including also the use of biological pesticides, based on microbial diseases of pests and weeds. A third approach commonly used in forestry, classical biological control, consists of controlling non-indigenous pests and weeds by importing natural enemies (parasitoids or predators or pathogens for pests; arthropod herbivores and phytopathogens for weeds) from their country of origin. This approach has been carried out successfully for well over a century. However, over the years, practitioners have become increasingly aware that introduced biological control agents may have undesirable side-effects.

Initially, this concern was limited to the possible impact of these introduced agents on economically important plants and insects (notably honey bees, silk moths and weed biological control agents). More recently, increased environmental awareness has drawn attention to the potential danger to all indigenous fauna and flora, particularly rare and endangered species. ISPM No. 03 provides guidelines for the safe use of exotic natural enemies in biological control programmes. When considering biological control agents, it is vitally important to have information on the pest (its identification, importance and known natural enemies), the natural enemy (identification, biology, host specificity, hazards to non-target hosts, natural enemies and possible contaminants, and procedures for their elimination), and human and animal health and safety issues. Ultimately the decision whether to use a biological control agent may depend on economics and science-based estimates of the likely results of biological control agent introduction versus the economic and environmental costs of other control options, such as pesticides, or doing nothing and accepting the losses due to the pest.

3.2 FOREST OPERATIONS

Forest operations personnel can minimize pest movement through careful operational planning, harvesting, wood storage and transport (see also Section 3.8). The movement of pests from the harvest location to the processing site can be prevented during timber marking and harvesting, particularly when wood volume and quality are evaluated. Personnel should be trained to recognize and report unusual pests and symptoms of diseased or infested trees, and to carry out practices that reduce the risk of pest populations moving to other locations.

FAO/FO-6064/R. BILLINGS

Debarking infested logs can help avoid the spread pests from the harvesting site to the processing site; here workers remove bark from logs infested with the southern pine beetle, Dendroctonus frontalis*, in Honduras*

Minimizing pest population levels during harvest and processing will reduce the incidence of pests in the commodity prior to export and make transport easier and safer. This is particularly important if the harvested wood is to be moved internationally. In addition, potential impacts of phytosanitary measures on trade can be reduced by identifying and reporting unusual pests to the NPPO, particularly if the pest is detected early and can be eradicated (see Section 4.6). Box 4 offers more specific guidance on operational practices that reduce pest presence.

Phytosanitary considerations are particularly critical when targeting international markets. These considerations need to be balanced against other important forest resource management decisions such as meeting biodiversity goals, recreational uses and fire suppression. Economics and local regulations are also important factors in forest operations decision-making.

BOX 4

Planning and operational practices that minimize pest presence in forests

- Select the appropriate genotype of trees for the site. If the trees are not well suited to the soil or climate then they will become weakened and susceptible to attack by insects and pathogens.
- Identify any pest outbreaks during the field planning phases and report these to a pest professional. If relevant, report them to the NPPO or other regulatory authority. Species that are not considered pests in one country may be considered pests in another.
- In addition to recording all pest outbreaks, record where the pests occur. This will assist in determining pest free areas in the future.
- Conduct systematic surveys designed to detect and assess increases in levels of forest insects and pathogens and their resultant damage. Report unusual pest occurrences to forest managers, NPPOs, forest landowners and other stakeholders in a timely manner.
- Use knowledge of pest development biology and weather events to predict pest emergence and choose an optimal time to apply control measures to prevent outbreaks.
- Consider harvesting those stands with a high incidence of dead and dying trees to prevent more loss of stock by damage and to reduce the risk of pest spread. Extract and burn dead trees on site or use locally to avoid the spread of pests to other areas.
- Consider layout of harvest boundaries to reduce the chance that trees remaining after the harvest might blow down and provide food for pest build-up.
- Prevent erosion and subsequent weakening of trees which can make them more susceptible to pests, through harvesting practices appropriate to the landscape.
- Avoid damage to standing trees during forest operations as this can affect vigour, enable infection by wood-degrading fungi, and increase susceptibility to other pests.

- Remove felled trees from the forest quickly to avoid a build-up or an outbreak of pests.
- When felled trees have to be stored near or in the forest, consider removing the bark. This will help avoid spreading pests such as some wood borers and bark beetles.
- Transport logs during the dormancy period of known pests and apply appropriate control measures at the final destination before the pests emerge.
- When moving or storing wood originating from natural disturbances such as wind storms and fire, ensure operations do not allow the spread of pests.
- Where appropriate, store wood under cover, under water sprinkler systems or in ponds, and install pheromone or light traps to reduce further infestation or outbreaks spreading to surrounding areas.
- Properly dispose of, or manage, debris from harvesting, thinning and pruning to ensure that associated pests are not spread to other areas.*
- Sanitize equipment and transport containers to avoid transfer of pests.
- Permit harvesting of branches for commercial purposes (including Christmas trees or tree parts) only in areas that are not infested with pests.
- Provide training to foresters, forest landowners and other stakeholders on how to recognize key pest species and their damage and on the procedures for reporting pest occurrence.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

3.3 FOREST NURSERIES

Since each forest nursery can supply plants for planting to many geographic areas, keeping pests out of nurseries is especially important. Buying healthy stock and carefully monitoring the condition of seedlings and cuttings are important practices. If possible, keep new plant materials separate from the main growing area for a period of observation, to prevent bringing pests into the nursery. Forest nurseries use intensive management practices which, if not properly done, may promote pest build-up. The artificial environment of the nursery, such as planting density, species or clone choice, and monoculture, can be favourable to pest development.

To minimize damage, detecting and treating pests before they spread is essential. Operational procedures should require that any workers who see symptoms of pests that are unknown in the nursery must report immediately to their manager. Nursery managers should notify the NPPO or other appropriate officials if an unknown organism or an important or regulated pest is found. Further guidance on good nursery practices is provided in Box 5.

If forest nursery plants are intended for international trade, it is necessary to follow the importing country's phytosanitary requirements. A phytosanitary certificate may be required to certify to the NPPO of the importing country that the consignment has been inspected and found free of regulated pests and that it fulfils the phytosanitary import requirements (see Section 4.10).

BOX 5

Good nursery management practices that minimize pest presence

- Provide the best possible growth conditions (e.g. nutrients, water, light, appropriate spacing and weed control) to raise healthy, vigorous and resistant plants.
- Collect or obtain seed from good quality genetically superior trees; use multiple sources of planting material to increase genetic diversity; use certified seed if possible and store seed in conditions that limit pest attack; test seed prior to planting to ensure good germination and seed health; and apply seed treatments, if needed. If possible determine pest resistance to the main pests in the country; multiply and distribute the resistant stock.
- Locate the nursery producing the seedlings away from commercial stands to prevent contamination and the subsequent spread of pests around the country. Keep new plant material isolated from main growing areas, where it can be monitored for pests without risk of them spreading to the whole nursery.
- Keep appropriate records that permit identification of sources of production material, and where it is grown and planted out, so that the source of any infestation/infection may be traced.
- Use soil or an inert growing medium that is free from insects, pathogens and weed seeds.
- Treat soil if necessary to kill pests before planting.
- Establish monitoring systems to permit the early detection of pests. Use adhesive traps to detect the presence of insect pests and spore traps to detect fungal spores.
- Take immediate action if pests are detected.
- Use appropriate preventative silvicultural, chemical or biological control methods.
- Ensure irrigation water is free of pathogens and other contaminants such as pesticides, particularly if the water source is a pond where water accumulates from infected or treated fields or is suspected to be contaminated. Simple filtration systems can be installed to sanitize infested water.
- Avoid leaving leaves wet, especially when watering at night, as this can allow pathogens to infect plants. Trickle irrigation rather than sprinklers can help keep leaves dry.
- Install screens or nets in plant production facilities to prevent insect entry or spread.

- Inspect materials prior to transport to ensure plants are free of pests.
- Nursery managers should notify the NPPO or other appropriate officials if an unknown, important or regulated pest is found.
- Rotate crops to avoid recurring pest problems; make sure the alternative crop is not susceptible.
- In infested areas, limit the entry of visitors to reduce the risk of pests and pathogens moving on their clothing and footwear. Measures to limit the entry of animals and birds, which may spread pests, should also be considered.
- Clean (thoroughly remove all soil and plant materials from all surfaces and crevices) and, if necessary, disinfect all tools, footwear and equipment before entering and before leaving the nursery area, especially if a pathogen is present. Clean and disinfect tools that are used for different operations within the nursery before and after use.
- Dispose of infested soil or growing media carefully so as not to contaminate new plants or soil.
- Collect and remove dead plants and debris every week to decrease the probability of infestation. Destroy or sanitize infested plant waste by burning, composting or treating with heat to kill the pest. If composting, make sure that a high enough temperature is reached to kill the pest.
- Use deep burial (2 m) to dispose of plant waste that cannot be destroyed or sanitized by other means.*

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

FAO/FO-7038/J. CARLE

Forest nursery, Angola

3.4 PLANTED FORESTS

Some of the nursery IPM practices are also useful in managing planted forests. Forest health problems can be prevented by using appropriate genetic material that meets provenance (geographic origin) and species requirements, or the appropriate size and type of seedlings or cuttings. Choosing the most suitable species for the site's soil and climatic conditions reduces plant stress, and thus susceptibility to infestation by pests. Understanding local pest status can also help avoid placing susceptible species into conditions that favour the pest.

Field surveys, including evaluation of forest health condition, can help with early detection of any new pest introductions, and ensure prompt action. Surveys are also needed to make sure that seedlings will be free of competition from weeds. Control of weeds may help promote tree growth and facilitate silvicultural activities. However, the potential for negative effects of weed control, such as soil erosion and reductions in biodiversity, should be considered. Further guidance on planting practices is provided in Box 6.

Diseases, insect pests and weeds can be spread from one location to another during the movement of site preparation equipment and routine silvicultural activities, such as pruning and thinning. Proper cleaning and sanitizing of equipment is therefore important. Equipment, tools, footwear and vehicle tyres should be cleaned of soil and organic matter before spraying with a disinfectant, such as industrial alcohol, when working in areas infected with diseases of quarantine significance. Flame sterilization can be used for some kinds of tools. If none of these are available, vigorous washing with steam or soap, if available, will reduce risk.

FAO/17936/L. DEMATTEIS

Planting a diversity of species or block planting of species in planted forests can help reduce susceptibility to forest pests; trees planted in this forest in Viet Nam are a combination of pine and acacia

BOX 6

Good planting practices that minimize pest presence

- Be aware that monocultures and clonal plantations can be more vulnerable to pests than mixed forests.
- Avoid reliance on a single tree species or clone.
- Choose the correct provenances (geographic origin) and tree species appropriate to the site and climate to ensure strong and healthy plants.
- Select appropriate growing sites to ensure healthy plants and avoid future pest problems.
- Consider the potential of the species to become a pest when selecting non-indigenous tree species for planting.
- Be cautious when moving plants with soil; if possible use bare rooted plants.
- Move bare root plants when dormant and less likely to spread forest pests. This also reduces plant stress. The potential of termite attack should be taken into consideration when planting bare root crops.
- Provide healthy growing conditions, with sufficient water, sunlight and nutrients to avoid stress.
- Provide adequate spacing between field-planted seedlings to reduce susceptibility to pests.
- Consider appropriate cultural practices to allow for good drainage and root expansion and breathing.
- Clean and disinfect footwear and equipment (e.g. tools, vehicles) before entering and before going off-site, particularly if the site is infested, to help reduce the spread of diseases such as root rot. Disinfect tools after each use.
- Survey often, particularly after planting, to ensure forest management goals are met and to ensure pests are not prevalent.
- Control weeds to ensure that crop plants are able to grow well. Consider encouraging weeds that promote natural enemies of pests without harming trees.
- Where silvicultural wastes from pruning and thinning can be a breeding substrate for pests, dispose of them properly by burning, deep burial, composting or heat treatment sufficient to kill pests.*
- Notify the NPPO or other appropriate officials if an unknown organism or an important or regulated pest is found.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

As planted forests mature, activities such as spacing, pruning, thinning and fertilization may be practiced depending upon available resources and management objectives. Forest managers must be ever vigilant to preserve and enhance forest health during these management activities.

Agroforestry systems, where trees are integrated into farms and agricultural landscapes, pose a complicated situation for pest management considerations. Pests can sometimes spread between agricultural crops and trees. The crop or tree can act as host for a given pest or as trap crop. Extra care must be taken when harvesting non-wood forest products particularly fruits and nuts to ensure that diseases are not transmitted through wounds caused by harvesting techniques.

3.5 NATURALLY REGENERATED FORESTS

Forests can be naturally regenerated by the sprouting of roots or stumps from the previous harvest, or natural seeding. In some forested areas, understory plants that are present prior to harvesting may help fill-in the natural seeding process. However foresters need to work for several years prior to harvest to ensure that these existing plants, called "advance regeneration", are present and vigorous. In some cases natural regeneration is more resilient to environmental stresses because the species are well adapted for the site and they can be more vigorous. Using natural regeneration also reduces the likelihood of introducing new pests with plants for planting.

Even when using natural regeneration, the reforestation of any site requires planning and follow-through. In some cases, specific management and harvest practices can be selected to promote natural regeneration and minimize the impacts on the ecosystem. Surveys of the advance regeneration will be needed to ensure that these plants are undamaged and healthy enough to compete with weeds and become part of the new forest.

FAO/FO-7027/H. BATUHAN GUNSEN

Natural Pinus sylvestris *forest with regeneration, Turkey*

It is important that natural seeding be adequate to meet long-term management objectives, based on tree species and stocking requirements. To ensure that healthy trees are established, monitoring and pest surveys in the appropriate follow-up time frame are necessary.

Later, monitoring and pest surveys will be necessary to determine whether or not the natural regeneration is sufficiently free from weeds or competition from understory plants. Competition may also come from root-suckering of some deciduous species or overstocking by natural seeding of certain conifers.

During silvicultural activities such as density control, pruning and fertilization it is imperative to ensure that these activities and the associated equipment and tools do not move pests or intensify their impacts (see Box 7).

BOX 7

Good practices for naturally regenerated forests that minimize pest presence

- Choose the most appropriate regeneration process, or combination of processes, to ensure healthy and vigorous forests.
- Conduct pest surveys to determine the probability of success of the natural regeneration process.
- Choose the most appropriate silvicultural, pest protection and harvesting practices to promote regeneration and reduce pest populations in the future forest.
- Conduct follow-up surveys to verify that regeneration is successful and to check for pests.
- Ensure appropriate spacing between naturally regenerated plants to reduce susceptibility to pests of concern and to promote tree growth.
- Control weeds when and where appropriate, giving due consideration to their potential as hosts of natural enemies of pests.
- Properly dispose of silvicultural wastes from pruning and thinning where they can be a breeding substrate for pests.*
- Perform activities, such as pruning, thinning and harvesting of non-wood forest products (i.e. chestnuts, resin, sap and branches), during periods of low risk so that wounds do not allow the entry of pathogens.
- Clean and disinfect footwear and equipment (e.g. tools, trucks) before going off-site, particularly if site is infested, to help reduce the possibility of spreading diseases such as root rot. Disinfect operational tools after each use.
- Notify the NPPO or other appropriate officials if an unknown organism or an important or regulated pest is found.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

3.6 SAWMILLS AND POST-HARVEST TREATMENTS

Following harvest and transportation of the forest products to the sawmill, it is important to process the roundwood promptly and carefully to reduce existing pest populations and minimize opportunities for pests to attack the wood. Debarking logs can be helpful if sawing will not occur promptly. The range of post-harvest treatments is wide. Treated commodities for export should be kept isolated to minimize the risk of post-treatment infestation.

All roundwood should be visually examined on arrival at the sawmill for signs of insects and disease. Ideally, those who provide logs should alert the sawmill operator about any potential pest problems. These should be investigated and reported to the NPPO or other appropriate authority if the pest is unusual or not known. An important determinant of whether pests can spread from stored forest products to forests is the proximity of the storage site to forest.

Even when it is planned to move the harvested trees during the pests' dormant period, seasonal weather patterns may change the timing of pest emergence. Some action in the storage area (either in the forest or at the sawmill) may therefore be necessary, such as placement of pest traps or application of cover sprays. For example, the cut surfaces of oak roundwood intended for production of valuable wood-based panels such as veneers are treated with wax to prevent oxidation and to reduce humidity. Some sawmills sprinkle water on log piles or submerge logs in ponds to reduce bark beetle attack until the wood can be processed. Pest forecasts can also be developed to predict when pests are likely to emerge and spread. These can be elegant models based on host and pest development biology and climate data, or simple systems based on previous experience. For example, following a mild winter more bark beetles survive which may lead to increased damage or faster spread. Local technical experts can advise sawmill operators if there are practical solutions for the types of insects and pathogens likely to be present locally.

Ensuring that vehicles and other equipment used to transport wood from the forest to the sawmill are cleaned of bark, plant debris and soil immediately after unloading is good practice and will substantially reduce the risk of accidental spread of pests. If infested wood is transported then it is better to use covered, enclosed trucks if possible to minimize the risk of pest escape.

Bark and other residual products should be gathered and stored securely for further utilization or safe disposal. It is quite common for pests to be present in residual or waste materials and these materials need to be properly managed to prevent pest infestations from occurring near the sawmill.

Processed wood and wood products should be monitored and graded to remove those products that show the presence of pests such as signs of fungi, insect holes and frass (debris or excrement). This quality grading step provides further assurance that the products being delivered or dispatched are less likely to create insect or disease outbreaks. Those products that have been removed because of the presence of a pest risk should be safeguarded and processed, or disposed of where it is safe to do so. Treatment to kill the pest, such as pasteurization by heat treatment, irradiation or fumigation, may be an option. Box 8 lists general good practices for sawmills.

E. ALLEN

Sorting wood in a sawmill, Canada

BOX 8

Good practices for sawmills and post-harvesting treatments to reduce pest spread

- Consider on-site treatment of freshly felled logs where practical.
- Examine harvested logs prior to entering the sawmill to determine if pests are present and might spread to surrounding products or areas.
- Logs with advanced decay should be set aside so that decayed sections can be removed and used or disposed of in a way that safeguards the remainder. This reduces the amount of visual examination in the production process.
- If new, important or regulated pests are discovered or if there appears to be a potential pest outbreak in the harvesting, manufacturing or storage areas, contact your NPPO or other regulatory authorities.
- If feasible, store log piles under cover, under water sprinkling systems, or in ponds to reduce existing or potential infestations. Pheromone or light traps, strategically and carefully placed to minimize pest spread, may be a part of the solution to reduce and control insect infestations.
- Transport infested loads in covered, enclosed trucks.
- Clean vehicles that transport logs and remove bark and debris for safe disposal immediately after unloading.

continues

- Continually gather up bark and debris from the storage yard for further utilization or disposal in a safe manner to prevent pest build-up and spread.*
- Monitor all products during the manufacturing process for the presence of disease or insect pest indicators. Separate infested products for safe utilization or disposal to prevent the movement, spread or introduction of pests elsewhere.
- Store infested products in a separate area to avoid contamination of pest-free products while in storage or awaiting transport or disposal.
- Post-harvesting treatments such as heat treatment, irradiation or fumigation may manage the risk of many pests. Contact your NPPO for further information on phytosanitary import requirements in the target market, and what treatments might be suitable for your products and the pests associated with them.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

3.7 PRODUCT TRANSPORTATION AND DISTRIBUTION CENTRES

The import and export of forest commodities relies heavily on seaports, temporary handling facilities, airports and train depots for the unloading and loading of containers and ships. Owing to the large number of forest commodities in movement and storage, these areas are critical in helping prevent the spread of pests.

To minimize pest contamination or infestation in ports, storage areas should be built on a hard or permanent surface (e.g. paving, concrete, gravel) and be free of vegetation, dead or dying trees, refuse and soil. It is important that the surrounding areas where export wood is stockpiled are kept free of pests.

To avoid cross-contamination, imported wood and wood for export should be stored separately with a suitably sized buffer zone between them. Similarly, treated and untreated wood should be separated. If there are places assigned for fumigation of wood, physical barriers should be constructed with insect-proof materials or covers to avoid recontamination of treated wood.

Potential pest infestation sources such as rejected logs, dunnage, broken wood pieces, or plant waste should be removed promptly and safely disposed of to avoid potential pest build-up.

Containers should be inspected prior to loading, to ensure that pests or soil and debris do not pose a pest risk. Container cleaning programmes using pressure washing or sanitation treatment may be necessary. Written procedures are needed to ensure worker safety and that phytosanitary goals are achieved.

Immediately prior to loading, it is also advisable to inspect forest products to ensure that they have not been infested while in storage. The record of this inspection can also serve as a monitoring record if pests are detected during inspection at the destination.

The proximity of transportation and distribution centres to forests greatly influences the probability that outgoing consignments can become infested with pests. Similarly, the proximity of forests to such centres influences the probability of successful pest establishment due to the availability of suitable habitat. Where product entry and exit facilities are located near forests it is useful to conduct surveys or other monitoring activities to detect establishment of new forest pests (see Section 4.6). In some cases, forests located near product entry and exit facilities may serve as sentinel or indicator plants. In addition, sentinel plants can be planted or located at points of entry such as ports and container terminals. With regular surveys they can help in the detection of any forest pests entering the country if they begin to exhibit signs of infestation. Monitoring tools, such as pheromone or light traps, and regular survey sites are recommended to help detect some insect pests, such as bark beetles. Traps are not effective against most wood borers, although trap logs can be effective for monitoring these pests, as well as some bark beetles.

There may be a need to protect consignments on conveyances from insects in those areas where insects, such as *Lymantria dispar* (gypsy moth, Asian subspecies in particular) and *Arhopalus ferus* (burnt pine longhorn beetle), are attracted to light. It is helpful to minimize the intensive lighting at ports and on vessels during periods of high risk and conduct loading operations and arrange departure times at periods of low insect activity. Pre-departure inspections or treatments of the commodity or conveyance may also be necessary.

By working with local scientists and national plant protection organizations, practical working solutions can be developed to improve pest management in the facilities engaged in the movement and distribution of forest products and thus protect forest health (see Box 9).

BOX 9

Good practices for product transportation and distribution centres to reduce pest spread

- Build forest product storage areas on hard surfaces (e.g. paving, concrete, gravel, etc.) free of potential pest infestation sources such as soil and debris.
- Recycle or reuse off-loaded dunnage and wood packaging materials in consultation with the NPPO.
- Dispose of potential pest infestation sources such as waste from conveyances and broken products.*
- Implement standards and procedures for cleaning containers to ensure pests are not moved during the transportation process.
- Inspect products and remove infested wood prior to loading.
- Prevent cross-contamination between imported and exported products, and between treated and non-treated products.

continues

- Keep treated (ISPM No. 15) wood packaging materials separate from untreated wood packaging. Do not load treated wood onto untreated wood packaging materials.
- Implement monitoring programmes, including trapping, in those areas where entry and exit facilities are adjacent to forested areas, in collaboration with the NPPO.
- Promote awareness of pest infestations near seaports and develop systems to ensure conveyances and consignments are clean of hitch-hiker (contaminating) pests, including egg masses.
- Work with the NPPO to develop practical solutions for managing the risk of pest movement for facilities where the import and export of forest products are concentrated.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

3.8 USING A SYSTEMS APPROACH TO MANAGE PEST RISKS IN FORESTS

A systems approach in the regulatory world is the use of at least two independent risk management measures to reduce the risk of pests in order to meet import requirements. Foresters often apply many practices to reduce pest problems throughout the entire production process, from planting and managing forests to harvesting operations. These practices, often called integrated pest management (see Section 3.1), can help form the basis of a systems approach (see Section 4.5). Box 10 gives examples of pest management measures that foresters can use to reduce pest populations before products are sold and dispatched, and before associated pests pose a risk to forests abroad or affect profits at home.

3.9 CHALLENGES IN PREVENTING PEST SPREAD THROUGH WOODFUELS

The international woodfuel market is rather new, but appears to be growing as countries seek renewable energy sources to replace fossil fuels (Box 11). Woodfuel is a broad category that includes roundwood, wood residues, wood chips, wood pellets, fuelwood, charcoal and black liquor. Processed products present lower pest risks and pellets and charcoal, for example, need not be regulated.

Trees damaged by pests are frequently cut for fuelwood. Many of the pests that caused the tree to decline or die can survive in the wood for several years and be transported to new areas. Wood-boring beetles (e.g. *Agrilus planipennis* [emerald ash borer] and *Anoplophora glabripennis* [Asian longhorned beetle]) are the pests most frequently spread through this pathway, but *Sirex noctilio* (European woodwasp), termites and pathogens can also be transported on or in logs or branches.

It is becoming increasingly evident that even domestic movement of these commodities can cause undesirable spread of pests, and national regulations may be needed to prohibit movement from infested areas to pest-free areas, as China has adopted for the Asian longhorned beetle.

BOX 10

Examples of forest pest risk management measures that may be included in a systems approach

Before trees are planted

- Register seed and plant producers and provide training in proper handling methods
- Select appropriate genetic material
- Select healthy planting material
- Select resistant or less susceptible species or varieties
- Identify pest free areas, places or sites of production
- Consider ecological characteristics, such as soils, vegetation, biodiversity and other resource values, in planning and site selection and preparation

During growing seasons

- Perform inspections to detect pest presence
- Perform testing for diseases, e.g. root rot or *Phytophthora* spp.
- Reduce pest populations using practices such as disrupting pest breeding, preharvest treatments, biological control and pheromone trapping
- Reduce pest populations using appropriate silvicultural practices, such as sanitation to remove potential breeding substrates and avoid damaging crops during weed control, thinning, pruning, harvesting non-wood forest products and tree salvage
- Maintain surveys needed to certify low pest prevalence

At harvest

- Harvest trees at a specific stage of development or time of year to prevent the increase of pest populations
- Inspect and remove infested trees and logs
- Use sanitation practices, such as removing any waste that could be a potential breeding substrate for pests
- Use harvesting or handling techniques that minimize damage to trees and soil
- Remove felled wood quickly to avoid pest build-up
- Debark trees as soon as possible after felling
- Remove stumps or treat surfaces where necessary to reduce root rot or other pest problems
- Clean equipment between sites

Post-harvest treatment and handling

- Treat logs or other wood products to kill, sterilize or remove pests using heat, fumigation, irradiation, chemical treatment, washing, brushing or debarking
- Store logs or other wood products in ways that reduce pest buildup, such as under water

continues

- Inspect and grade logs and other wood products
- Use sanitation measures including removal of infested or infected parts of the host plant
- Sample and test forest products for pests
- Install insect screening in storage areas

In association with export and import

- Treat or process forest commodities to kill pests
- Apply phytosanitary restrictions on end use, distribution and points of entry
- Apply restrictions on the import season to avoid pest introduction
- Select appropriate method of packing, such as closed or covered containers, to prevent infestation or accidental escape of pests during transport
- Require post-entry quarantine of plants for planting to enable the detection of any latent infections
- Inspect and/or test forest commodities to verify pest status
- Use good sanitation practices for conveyances such as ships, containers and trucks

FAO/FO-5549/J. LE JEUNE

Even domestic movement of fuelwood can spread pests

BOX 11

Volume of woodfuels traded internationally (average 2001 and 2002)

Charcoal: 1 255 288 tonnes
Wood chips and particles: 26 742 650 m^3
Fuelwood: 1 926 946 m^3
Wood residues (wood waste): 6 282 628 m^3

Source: Hillring and Trossero, 2006

Some countries have import regulations requiring heat treatment or fumigation to reduce pest risk on fuelwood. These requirements are easier to monitor and enforce in large commercial concerns, but small operations often lack this capacity. Enforcement of regulations on individuals moving fuelwood is next to impossible. Public education may be the best approach to reducing the spread of pests through fuelwood.

For international transportation, regulations for roundwood often apply to fuelwood. Treatments such as debarking or chipping can greatly reduce the survival of bark beetles, but heat treatment or fumigation provide better protection from pests, including fungal pathogens, that live deeper inside the wood.

3.10 CHALLENGES IN PREVENTING PEST SPREAD THROUGH PLANTS FOR PLANTING

Many forest pests are thought to have been introduced into new locations and hosts via plants for planting. Plants for planting may include roots, stem, branches and leaves, and sometimes even fruit, intended to be planted. With so many plant parts, they can potentially carry many diverse pests. Plants in growing media (unsterile soil) are generally considered higher risk. Pathogens are particularly hard to detect in plants for planting. Some examples of pathogens believed to be spread by plants for planting include: horse chestnut bleeding canker (*Pseudomonas*), ash dieback (*Chalara*), pitch canker (*Gibberella*), and several *Phytophthora* species including *P. ramorum*, *P. cinnamomi*, *P. alni*, *P. kernoviae*, *P. lateralis* and *P. pinifolia.*

There is little scientific literature on pests present on ornamental plants. Furthermore, scientists estimate that as few as seven percent of the world's fungi are known to science. Some pathogens hybridize in the nursery environment, creating new organisms and adapting to new conditions and hosts. Special culturing methods and molecular tools, such as DNA sequencing (i.e. polymerase chain reaction [PCR]) and immunological detection (i.e. enzyme-linked immunosorbent assay kits [ELISA]), may be needed to confirm the presence of pathogens. These tools, and the time to use them, are rarely available to the inspectors assigned to monitor imported plant material. Undetected pathogens may spread via plants for

FAO/22117/R. MESSORI

Forest nursery, Egypt

planting and establish in natural ecosystems causing significant damage through spread to native and commercial plants.

The risk has been significantly increased by the rise in the volume of the ornamental plant trade as a result of shifts in global plant production. Owing to the huge volume of trade and the manner in which consignments are sent (typically tightly packed in containers), often only a small sample of the plant material is actually inspected (usually through visual inspection only). Current regulatory systems screen for regulated pests, but some pests are difficult to detect and some pests are not yet known. Some plants may look healthy but may contain latent or dormant pathogens.

It is therefore a huge pest management challenge to support the plant trade but at the same time to regulate pest spread and prevent potential devastating impacts on natural ecosystems. Possible solutions may include developing systems that attempt to reduce the incidence of pests on plants and in the surrounding environment throughout the production process. The European Union (EU), which at present comprises a single market of 27 member states without border controls, has introduced a "plant passport" system. The EU registers producers of high risk nursery stock and makes inspections to confirm the nursery is pest free, before authorizing the producer to issue "plant passports". The plant passport accompanies the plants to the final end user. This system enables regulatory personnel to track down the source of infested plants quickly and reduce pest spread within the EU territory.

Continuous updates of science databases, data sharing, and improved and updated inspection and diagnostic methods at various inspection points are also needed. In general, very efficient growing techniques to produce the healthiest plants are recommended. Additional measures may include efficient tracking of plant origin and voluntary or regulated exclusion of some types of the commodities at highest risk, e.g. large plants for planting with soil which are

used to create instant woody landscapes. Education may be another tool to raise awareness of the potential danger and the global scale of the problem.

A new ISPM on integrated measures for managing pest risks associated with the international trade of plants for planting has been drafted within the IPPC and is in the review process.

3.11 CHALLENGES IN PREVENTING INTENTIONALLY INTRODUCED TREE SPECIES FROM BECOMING PESTS

Many non-indigenous plant and animal species that have been intentionally introduced into ecosystems outside their native range for their economic, environmental or social benefits have subsequently become serious pests. This problem is of considerable concern in the forest sector. Non-native tree species are often used in agroforestry, commercial forestry and desertification control. Many of these tree species are highly valued for their exceptional adaptability to a wide variety of sites, their rapid growth and the multiple uses of their products. However in some cases these same species have become serious threats to their ecosystems (Box 12). It is vital to ensure that such species serve the purposes for which they were introduced and do not become pests.

Careful pest risk assessment is recommended before introducing new plant species. The Australian Weed Risk Assessment (Pheloung *et al.*, 1999) has proven reasonably accurate over a broad range of ecological conditions (Gordon *et al.*, 2008) and is currently the most widely used system. For examples of the application of this assessment, see: www.weeds.org.au/riskassessment.htm.

FAO/CFU000420/R. FAIDUTTI

Many forest tree species, such as this young Acacia albida *in the Niger, are planted for the positive benefits and products they provide but have the potential to become invasive*

BOX 12

Examples of intentionally introduced tree species becoming pests

The forest sector often uses non-native tree species to provide a variety of benefits. Many of these have become major problems around the world.

- *Leucaena leucocephala* has been widely used as a source of wood, fuelwood, fodder and shade and to restore degraded lands, improve soils and stabilize sands. It is a fast-growing, nitrogen-fixing tree that is tolerant of arid conditions and saline soils and as such is highly regarded in arid regions in Africa and Asia. In areas where it has been introduced however, this species tends to form dense thickets and readily invades forest margins, roadsides, wastelands, riparian areas and agricultural lands (McNeely, 1999). Also, the toxicity of its seeds and foliage decreases its value as a source of fodder.
- *Prosopis juliflora* is very useful in controlling soil erosion, reducing the aridity of an area, and providing a source of fuelwood as well as fodder and shelter for both wild and domesticated animals. It has been introduced into many countries in Africa and Asia with some significant environmental and socio-economic impacts. This species displaces native flora resulting in reduced biodiversity and reduced diversity of products available to rural communities (McNeely, 1999). Its dense thickets also render invaded lands useless for agricultural purposes.
- Commercial tree species such as pine (*Pinus* spp.), eucalypt (*Eucalyptus* spp.) and rubber (*Hevea brasiliensis*) are important sources of wood and fibre and thus have been planted in many areas where they are not native. Several of these species have spread outside the areas in which they were planted with devastating impacts on ecosystems including reduced structural diversity, increased biomass, disruption of existing vegetation dynamics and altered nutrient cycling (Richardson, 1998).
- Many Australian *Acacia* species have been introduced into South Africa for timber and fuelwood as well as for tannins, which are used by leather industries, and for sand stabilization. Such species have radically altered habitats for wildlife resulting in major changes in the distribution of species, particularly birds. They have also altered nutrient cycling regimes in nutrient poor ecosystems due to their ability to fix atmospheric nitrogen (van Wilgen *et al*., 2001). They have also decreased water supplies for nearby communities and increased fire hazards.