PESTS, DISEASES AND DISORDERS

G S Ridley; M A Dick & J Bain – Forest Research, Rotorua

Forest pests, diseases and disorders cause either suboptimal growth or premature death. At any time, trees are subject to stresses, which can come from a variety of sources and in varying combinations, and these will have an effect on their state of health. Often a stress factor may enhance the effect of others. For example, a minor frost injury, which is harmless by itself, can be aggravated by a pathogen entering the damaged tissue and consequently a limb may die. Trees debilitated by frequent defoliation caused by a leaf pathogen or insect can have their resistance lowered to the stage where the tree is killed by a root fungus that normally would have little, or no, effect.

INSECT PESTS

This section describes insects that harm trees, forests or forest products, whilst noting that many other insects play a beneficial role in the forest.

Insect behaviour and characteristics, along with the relationship with their hosts, are key areas that require careful study in order that insect activities and numbers can be manipulated or regulated. Insect control can be achieved using tactics such as silviculture, species selection, biological methods or chemicals.

Relatively few insects are capable of killing healthy trees. Most pest species either reduce tree growth, cause malformation or degrade timber. Notable exceptions are the aggressive bark beetles of the northern hemisphere coniferous forests, none of which are found in New Zealand, and the introduced wood wasp Sirex, which is found here (and is capable of killing apparently healthy pine trees). Repeated defoliation by insects can cause tree death, but this is the exception rather than the rule. Defoliators, root feeders and sapsuckers are important because they reduce tree growth.

Forest insects can be divided into categories depending on the type of damage they do. The most generally recognised categories are listed below:

- Seed Feeders. These include the larvae (grubs) of various species of moths, beetles, wasps and flies.
- Root Feeders. The most common are the larvae of various species of beetles such as grass grubs and weevils.
- Sapsuckers. These can be found on virtually all parts of the tree from the leaves or needles, to trunks and even the roots. Examples are aphids and scale insects.
- Defoliators. These generally chew the leaves or needles and are commonly species of caterpillars, although some are the larvae of wasps and beetles. This group includes insects that mine buds and leaves.
- Bark Borers. These are most commonly beetles that feed in the cambium and phloem region between the bark and the wood. Some species can attack and kill apparently healthy trees, while others are more innocuous in that they are confined to logs and stumps.
- Wood Borers. The majority of these do not attack living trees, although some can, particularly those which mine twigs and small branches. Most of them are pests of logs and other forest produce. Some species can infest seasoned wood and manufactured articles. Most common are the larvae of beetles, and termites.

These categories are not definitive or all-embracing. For example, insects that cause galls on the leaves of some trees could be included as defoliators, or be placed in a category of their own; and some insects fit into more than one category when, for example, an adult chews leaves and is classed as a defoliator, but its larva is a wood borer.

Most adult insects fly so they can spread easily, although there are some notable exceptions. Small, soft bodied insects such as aphids and mealy bugs can be blown considerable distances, as can some caterpillars. Numerous species of Australian moths are regularly blown across the Tasman Sea, and some of them have become established. Man also assists the spread of some insects, either intentionally or by chance, by transporting them on freight and vehicles. The

high number of insect interceptions at sea ports and airports shows how easy it is for them to cross international borders.

Indigenous Forest

The insect pest fauna of native forests is generally more complex than that of exotic forests, but is not as extensively studied. Under normal circumstances, a natural balance exists between native trees and their associated insects, and no introduced insects have yet caused serious problems. However, after major events such as earthquake, windthrow, and road works, tree mortality caused by insect pests can become important locally.

Insect-caused damage is more apparent in mono-specific canopies of beech forest than mixed forest. For example, periodic defoliation of mountain beech in some areas by the caterpillars of the mountain beech moth (Proteodes carnifex), and the beech leaf roller (Epichorista emphanes) has been recorded.

Mass attack on beech by native pinhole borers (Platypus spp.) can kill trees, but in normal circumstances not a great deal of mortality is seen. Mortality is more common in red beech and hard beech stands after a catastrophic event that weakens trees and provides extra material in which Platypus can breed in large numbers. Non-lethal Platypus attack is common in living trees and the pinhole defect causes considerable degrading of the timber.

The reaction tissue, or pathological wood produced by trees in response to Platypus attack, appears to be more susceptible to fungal breakdown than healthy tissue. The presence of pathological wood enables wood-rotting fungi to enter through the stubs of suppressed or broken branches or wounds so that concealed rot pockets are formed.

If beech forests were to be managed for timber production, it may be that all silvicultural operations (thinning and pruning) need to be carried out in pole stands before the trees become attractive or susceptible to Platypus attack.

The puriri moth (Aenetus virescens) exists only in the North Island, and is found in a wide range of indigenous beech and exotic hardwoods. Damage caused in beeches by the caterpillars of the puriri moth restrict their potential for production forestry in the North Island.

Nurseries

Nurseries must be kept practically insect-free because of the large investment of money and effort that is at risk from small populations of insects causing seedling damage or mortality. Many problem insects can be eliminated by removing weeds, and new nursery beds should be cultivated for a year before sowing to avoid soil insect problems. Some soil insects such as the Australian soldier fly (Inopus rubriceps) have failed to respond to insecticides, and cultivation appears to be the only satisfactory means of control.

Exotic Conifers

There are few serious insect pests in New Zealand's introduced conifers. Soil insects or insects originating from competing weeds can slow the growth of young planted stock. Young trees usually suffer little more than a temporary set-back, and often produce compensatory growth in the autumn after the insects' feeding stages are complete. The black pine beetle (Hylastes ater), which is often associated with dying pine seedlings, does not normally affect nursery stock that has been well handled, well planted, and has actively growing roots.

The most important pests of mature radiata pine are Sirex and the common forest looper (Pseudocoremia suavis), and of Douglas-fir, P. suavis and the brown headed leaf rollers, Ctenopseustis species. They appear to be serious only when the trees are growing under stress. The problems can be largely avoided by planting on suitable sites, and by maintaining vigour by timely silviculture. Rare outbreaks by a few other insects have occurred on various conifers, but have been short-lived and of little consequence. Examples are the bag moth (Liothula omnivora), the forest semilooper (Declana floccosa), and the lucerne looper (Zermizinga indocilisaria).

When the Monterey pine aphid (Essigella californica) was first found in New Zealand in 1998 there was concern that it might prove to be a pest of note but monitoring has shown that that it is an insignificant pest here.

Some insects will attack and bore directly into logs in stockpiles. They include a native pinhole borer (Platypus apicalis),

particularly in Douglas-fir; a native scolytid beetle (Pachycotes peregrinus), often encountered in seasoning posts, and an introduced keyhole ambrosia beetle, (Xyleborinus saxeseni). This problem can be avoided by rapid removal of produce from the forest during the insects' summer flight periods. If temporary stockpiles must be formed during the summer, attacks can be dramatically reduced by piling logs off the ground on skids. This prevents soil contact and high moisture levels, which favour the insects.

Exotic Hardwoods

Poplars are little troubled by insect pests in New Zealand. The most important problems are the girdling of stools in nurseries by the lemon tree borer (Oemona hirta), and in the North Island only, puriri moth attack on the main stems where poplars have been planted adjacent to native forest.

The willow sawfly (Nematus oligospilus) which was first found in New Zealand in 1997 can, in some years, cause significant defoliation of willows (Salix spp.). Although it has been present here for only eight years it has spread throughout nearly the entire country.

Eucalypts and acacias are affected by a wide range of insects originating from Australia which commonly cause defoliation. It is still possible to select Eucalyptus species that have desirable growth rates and wood properties and which are unaffected by the insects so far established, although the choice is becoming more and more restricted. Sometimes the choice widens as a result of successful biological control of a major pest such as the eucalyptus tortoise beetle (Paropsis charybdis). A serious pest is the leaf gall eulophid (Ophelimus spp.), which can kill young Eucalyptus saligna and E. botryoides.

The eucalyptus leaf mining sawfly (Phylacteophaga froggatti), which it was thought could cause severe damage to some commercial species of eucalypts in nurseries and during plantation establishment, is now well controlled biologically.

In recent years several Australian eucalypt feeding insects have become established in New Zealand. The brown basket lerp (Cardiaspina fiscella) has caused noticeable foliage discolouration and defoliation of Eucalyptus saligna and E. botryoides although it is generally well controlled by a self-introduced parasitoid (Psyllaephagus gemitus). Another lerp-forming psyllid, Creiis liturata, is a serious pest of plantation eucalypts in Australia but its effect in New Zealand has not been evaluated yet. It was first found here in 2002. The blackbutt leaf-miner (Acrocercops laciniella) has been found on quite a range of eucalypts including Eucalyptus pilularis, E. nitens and E. globulus and has the potential to be a serious pest. The gum leaf skeletoniser (Uraba lugens) is another relatively recent import and is very widespread in Auckland were it is present in high numbers. Its potential to be a serious pest in eucalypt plantations has prompted research into biological control.

The blackwood tortoise beetle (Dicranosterna semipunctata) can cause defoliation of Acacia melanoxylon which could have a significant influence on tree form. The painted apple moth (Teia anartoides) is a significant defoliator of acacias and other trees.

Dutch elm disease was discovered in elms in Auckland in December 1989. The small elm bark beetle (Scolytus multistriatus) infects trees with the fungus Ophiostoma novo-ulmi, which blocks water conducting tissues to branches and causes rapid tree death. Another pest of urban trees is the sap sucker, Calophya rubra, which can cause die back on the pepper tree (Schinus molle). The banksia leafminer (Stegommata sulfuratella) can cause severe damage to Banksia spp.; tips on the lower half of infested trees are completely browned off.

Control of Insect Pests

Although insecticidal sprays were used to prevent defoliation of radiata pine in Canterbury in the early 1950s, and Douglas-fir in Kaingaroa Forest in the 1970s, this method of control is only a stop-gap emergency measure to prevent widespread tree mortality. The best, and in the long-term, cheapest approach to deal with pests is biological control. This includes the use of resistant crop species (or provenances), improving stand health through silviculture and better forest hygiene, and introducing biological agents such as parasitoidal and predatory insects, pathogenic fungi, bacteria and viruses.

A number of notable successes have been achieved in the biological control of forest pests in New Zealand:

- Sirex populations are regulated by the parasitoidal insects Megarhyssa nortoni, Rhyssa persuasoria, R. lineolata, and Ibalia leucospoides, and the sterilising nematode Beddingia siricidicola.
- The establishment of the ladybird Rhizobius ventralis and the predatory caterpillar Stathmopoda melanochra to control the gum-tree scale (Eriococcus coriaceus).
- The mymarid egg-parasite (Patasson nitens) controls the gum-tree weevil (Gonipterus scutellatus).
- The pteromalid egg parasitoid (Enoggera nassaui) controls Paropsis charybdis.
- Using the braconid parasitoid Bracon phylacteophaga against Phylacteophaga froggatti has reduced the effect of this insect on eucalypts.
- The pine woolly aphid (Pineus sp.) is well controlled by the predatory larvae of the fly Leucopis tapiae.
- The leaf miner of oak, Phyllonorycter messaniella is well controlled by the introduced parasites Apanteles circumscriptus, Achrysocharoides splendens and Pnigalio pectinicornis.

Eradication of a newly discovered pest is extremely difficult. Usually it is well established before it is detected. There are still continuing attempts to eradicate Dutch elm disease from Auckland following its discovery there in 1989. A very notable success however was the eradication of the whitespotted tussock moth (Orgyia thyellina) in Auckland. This species was found there in 1996 and after a major effort involving aerial and ground spraying was declared eradicated in 1998. It has not been seen since that time.

Some major problems with insects have been avoided rather than solved. For instance, spruces (which can be severely defoliated by the spruce aphid (Elatobium abietinum) and the spruce mite (Oligonychus ununguis)) are not considered suitable for large-scale planting. The same technique was used to prevent defoliation of Eucalyptus nitens by the eucalyptus tortoise beetle. Now that this pest has been controlled biologically, E. nitens is considered suitable for large-scale planting.

FOREST DISEASES AND DISORDERS

Trees diseases are caused by biotic agents, such as, fungi, bacteria, viruses, phytoplasmas, and nematodes, while disorders are caused by abiotic agents, including frost, drought, flood, lightning, salt scorch, nutrient deficiency, herbicides, machinery and animal damage, and poor planting practice. It may not always be possible to avoid diseases and disorders although their effect can often be minimised through good forest management. Damage attributable to abiotic agents is generally limited to very localised areas whereas damage caused by biotic agents is usually much more extensive. In New Zealand fungi are by far the most significant cause of disease in plantation forestry.

Abiotic Agents

Water is fundamental to tree health. Permanent wilting can result from both drought, through lack of water, and flooding, through a lack of oxygen. Out-of-season frost can cause significant damage when ice crystals form in unhardened plant tissue. In coastal areas salt burn is very common and can occur, especially after storms, many kilometres from the sea.

Storms and cyclones can cause severe local damage. Trees can be uprooted, and stems and branches broken by high winds. Lightning strike can range from a simple scar on a single tree to the death of trees in patches covering several hectares.

Adequate mineral nutrients are needed for normal healthy growth. Areas with low organic soil content, e.g. coastal sand dune country, are often low in nitrogen, and many New Zealand soils are low in phosphorus. In the short term mineral deficiency can be compensated for only through the application of fertilisers. However, long term tree breeding programmes can select for lines that can cope with some mineral deficiencies, e.g. magnesium.

Biotic Agents

Trees live in a complex relationship with micro-organisms, many of which live within tree tissue without causing disease. In fact many are beneficial if not essential (as in the case of mycorrhizal fungi) for healthy and normal tree growth. In the

example it is the tree root tips that are colonised by fungi thereby increasing the ability to take up mineral nutrients in exchange for complex carbohydrates that the fungus cannot produce itself.

Viruses cause diseases in many hardwood trees, e.g. birch, elm, maple, oak, poplar and walnut, but to date there are no known viral diseases of conifers. Bacteria also cause some significant diseases overseas but there is none of importance in New Zealand which affects plantation or amenity trees. In recent times a new class of organism, phytoplasmas, has been recognised as causing a number of hardwood tree diseases overseas, and they have also been implicated in the sudden decline of the New Zealand cabbage tree (Cordyline australis).

Fungi are the main cause of tree disease and disease symptoms can be confusingly similar to the inexpert eye. Pathogenic fungi attacking feeder roots can cause the development of chlorosis, followed by the fading of the canopy over a period of time, whereas attack of the major conductive roots can result in sudden death of the tree. If the fungus penetrates the woody tissue of the stem or branches, often through wounds, the result can be the death of the crown immediately above the infection site, or the roots immediately below. Some pathogens attack healthy bark tissue and the cambium, creating dead, sunken patches or cankers, where no new bark or wood will be formed. If such infections spread to girdle the infected stem all stem and leaf tissue above the infection site will die.

Some pathogens produce substances that mimic plant hormones and can induce abnormal growth such as galls or witches brooms. When leaves and needles are infected rapid death can result in the foliage being retained and is referred to as a "blight", whereas the slow death of foliage usually results in the leaves or needles falling prematurely and this is called a "cast".

Fungi reproduce by spores, which can be dispersed by either wind, rain, or insects. Wind dispersed spores can be blown long distances, for example the spores of poplar rust were blown across the Tasman Sea from Australia in the 1970s. Spores that are rain-splashed are generally dispersed short distances although it is possible for water droplets to be picked up by the wind and carried for long distances. A number of important tree diseases are dispersed by insects. Typically there is a close relationship between the fungus and its insect vector to the point that the insect has evolved specific structures to carry fungal propagules. Increasingly people have become dispersal agents by intentionally transporting infected plants, seeds and timber around the world, but also unintentionally in and on their clothing. A national biosecurity strategy has become a high government goal in an attempt to stem the tide of new incursions.

Indigenous Forests

New Zealand indigenous trees have evolved alongside their pathogens and have reached a natural balance. Fungi such as the leaf parasite Corynelia tropica on totara, the rust Caeomoa peltatum on tanekaha, and the gall-forming fungi, Cyttaria spp. on silver beech are common, but cause little damage.

For New Zealand the source of potentially devastating tree pathogens will be from the remnants of Gondwanaland: Australia, South America, Africa, and possibly India. The Earth's flora is distinctly different between the Northern and Southern hemispheres and because pathogens generally show a preference for specific hosts they must move east or west in either hemisphere before they encounter similar but non-resistant hosts. Any movement north-south across the equator is very likely to be unsuccessful owing to the lack of closely related susceptible hosts.

Exotic Conifers

Radiata pine, Douglas-fir and macrocarpa are natives of North America and their transportation to New Zealand has been relatively disease free. Only six diseases are considered of any significant impact nationally. These are needle infections caused by Dothistroma pini and Cyclaneusma species, and a variety of diseases caused by Sphaeropsis sapinea affecting radiata pine, Swiss needle cast affecting Douglas-fir, two species of Armillaria which cause root and collar rots in both species, and cypress canker caused by Seiridium species.

The needle blight caused by Dothistroma pini was first recognised in the USA in 1941 where it caused only minor damage. No one at that time would have predicted that by the 1960s this insignificant disease would be the major disease of radiata pine in many parts of the world. This needle blight was first found in New Zealand in 1962 in the

central North Island. It is a typical rain splash disease and as a result spreads very slowly. Its spread was further retarded by internal quarantine and the use of chemical control measures. As a result it was not until the late 1990s that the fungus was considered to have spread completely throughout the country.

Losses in growth attributable to needle blight caused by Dothistroma pini are directly proportional to the amount of the crown that is infected. Optimal conditions for the growth of Dothistroma pini are a mild, humid climate, and high rainfall during the warmer months of October to March. The fungus is therefore a serious problem in areas where the rainfall exceeds 800 mm over that period. Radiata pine develops disease resistance at about 15 years of age, and can be effectively managed in most locations with the application of a copper fungicide. Dothistroma pini is currently considered to cost New Zealand $24 million a year in lost growth, and $1 million a year in the cost of aerial spraying.

Another important needle blight of radiata pine is caused by Cyclaneusma spp. It is likely that these fungi have been present in New Zealand for a long time. Mild, wet autumn and winter periods favour infection with needle cast occurring in spring. This needle cast affects only needles that are one or more years old and susceptibility varies greatly from tree to tree. The disease is most commonly found in 11-20 year old trees, although four years or older can be affected. Currently Cyclaneusma spp. cost New Zealand $51 million a year in lost growth.

Sphaeropsis sapinea can cause several diseases. In warm, humid microsites S. sapinea causes shoot dieback of radiata pine. The pathogen can gain entry into stem tissue through wounds created by storm, hail and animal damage. The fungus also causes whorl cankers when trees are pruned too severely, for example, with the removal of more than 50% of the crown in one lift. The fungus may be contained within the stem causing degrade in log quality or may colonise the entire cross section of the stem causing death of the crown above that point. Prolonged periods of dry weather which place the trees under moisture stress are strongly conducive to fungal development within the stem.

Swiss needle-cast of Douglas-fir, caused by Phaeocryptopus gaeumannii, was first recorded in 1959 in the central North Island and is now found throughout New Zealand. It is a chronic disease, but infected trees rarely die. However, needle retention is reduced, causing a loss in growth.

The Seiridium spp which cause cankers on branches and stems of macrocarpa threaten its viability as a plantation species. Branch infections lead to branch death and dieback, and this can continue to occur throughout the life of a plantation. Stem cankers are common on trees under 10 years-old and considerable mortality can occur from such infections especially on one to three year-old trees. Other cypressus are also affected but generally to a less significant degree.

Radiata pine, as well as many other species of conifers and hardwoods, is affected by root and collar rot caused by two native fungi, Armillaria novae-zelandiae and A. limonea. This problem became apparent when first-rotation radiata pine plantations were established on cut-over native forest sites where up to 50% of trees under five years old could be killed. With canopy closure mortality decreases although the fungus persists as a chronic infection. In this latter state death usually occurs only as the result of other stress events such as drought or flooding. However, chronic infection reduces growth and makes trees prone to wind-throw. Armillaria species also persist from rotation to rotation and are capable of colonising plantations established on sites where there was no previous forest cover. Currently root and butt rot caused by Armillaria spp. costs New Zealand $37 million a year in lost growth.

Exotic Hardwoods

Eucalypts are the only hardwood species grown in any significant quantity in New Zealand. Leaf spot diseases of eucalypts can cause significant defoliation with a consequent profound loss of increment. These diseases have been a major factor in the decline of interest in many eucalypt species by the forest industry. The fungi responsible for the most debilitating diseases include two species of Mycosphaerella (M. cryptica and M. nubilosa) which between them affect a wide range of hosts, Phaeophleospora eucalypti which can totally defoliate young E. nitens (juvenile foliage) and Aulographina eucalypti which also has a very wide host range. Aulographina eucalypti is a major contributor to the “Barron Rd syndrome” of E. regnans in which a complex of fungi is responsible for leaf loss that eventually leads to mortality on disease-conducive sites.

Nurseries

Forest nurseries annually grow in excess of 45 million radiata pine plants. Diseases such as needle blight, caused by Dothistroma pini, and terminal crook, caused by Colletotrichum acutatum f. sp. pineum, are capable of causing substantial losses but can be controlled by regular application of fungicides. A range of fungi causes damping-off and root rots, and is often more difficult to control with a chemical regime. Poor soil drainage is a major factor in the root diseases caused by pythiaceous fungi and control measures are aimed at improving soil structure and drainage.

Over 90% of forest nursery production is radiata pine; the remainder is made up of a number of coniferous and hardwood species. Cypress canker can be both a serious nursery disease, and act as a source of further infection when established in plantations. Removal and destruction of infected plants is recommended plus application of a protective fungicide. Eucalypt leaf infections can be controlled chemically.

REFERENCES

CHAPMAN, S. 1998: Field Guide to Common Pests, Diseases, and Other Disorders of Radiata Pine in New Zealand. Forest Research Bulletin 207.
RIDLEY, G.S. 2003: Exotic Pests and Diseases of Pine Not Wanted in New Zealand. Forest Research Bulletin 227.
RIDLEY, G.S.; BAIN, J.; BULMAN, L.S.; DICK, M.A.; KAY, M.K. 2000: Threats to New Zealand's Indigenous Forests from Exotic Pathogens and Pests. Department of Conservation, Science for Conservation No. 142.
RIDLEY, G.S.; DICK, M.A. 2001: An Introduction to the Diseases of Forest and Amenity Trees in New Zealand. Forest Research Bulletin No. 220.