

North America

A variety of indigenous and introduced insect pests and diseases are known to negatively affect North American forests. No countries were profiled in this region, but the following is a brief discussion of some of the major pests impacting Canada and the United States.

INDIGENOUS INSECTS

Three species of Coleoptera (the southern pine beetle, mountain pine beetle and white pine weevil) are known pests of pines in the region. The southern pine beetle (*Dendroctonus frontalis**) is a very destructive pest of pines in the southern United States as well as Mexico and Central America (Billings *et al.*, 2004). Populations can build rapidly to outbreak proportions and kill large numbers of trees. This beetle kills trees by a combination of girdling during construction of egg galleries and the introduction of blue stain fungi of the genus *Ophiostoma* (Billings *et al.*, 2004).

The mountain pine beetle (*Dendroctonus ponderosae**) is the most destructive pest of mature lodgepole pine (*Pinus contorta*) forests in North America. In the western United States, outbreaks have been increasing in area after several years of drought (Tkacz, Moody and Villa Castillo, 2007). A major epidemic of this pest has been ongoing in western Canada (British Columbia and, more recently, Alberta) for several years and even with large-scale efforts to mitigate the impacts of the pest, millions of trees have been killed. The problem has been exacerbated by local climatic changes and increased winter temperatures which reduce mortality of overwintering stages. A record 10 million hectares of pines were recorded as infested during 2007 aerial overview surveys in British Columbia, with more than 860 000 ha of this located in provincial parks and protected areas (Westfall and Ebata, 2008). In January 2007, the Government of Canada announced the Mountain Pine Beetle Program, a three-year programme aimed primarily at slowing the eastward spread of the mountain pine beetle infestation, but also at recovering economic value from damaged forests and protecting forest resources and communities.

The white pine weevil (*Pissodes strobi*) is the most serious and economically important insect pest of spruce and pine species, primarily eastern white pine (*Pinus strobus*), in Canada and the United States (PFC and LFC, 2007). The weevil is also known to attack Norway spruce (*Picea abies*) and jack pine (*Pinus banksiana*) and, to a lesser extent, pitch pine (*P. rigida*), red pine (*P. resinosa*), Scots pine (*P. sylvestris*) and red spruce (*Picea rubens*).

Important indigenous lepidopteran defoliators in the region include the hemlock looper, forest tent caterpillar, large aspen tortrix, spruce budworm and western spruce budworm. Larvae of the hemlock looper (*Lambdina fiscellaria*) can be extremely destructive to hemlock (*Tsuga* spp.), balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*). It feeds on eastern hemlock (*T. canadensis*) in western areas of its distribution and on balsam fir in the east; during periodic outbreaks it will feed on other conifers and hardwoods.

The forest tent caterpillar (*Malacosoma disstria*) is a serious defoliator of trembling aspen (*Populus tremuloides*) and other hardwood tree species in Canada and the United States. Outbreaks occur periodically over wide areas of the eastern half of North America, resulting in inhibited growth and dieback. However, trees are seldom killed unless they sustain three or more successive years of complete defoliation (Cerezke, 1991).

The large aspen tortrix (*Choristoneura conflictana*) is an early summer defoliator of trembling aspen (*P. tremuloides*). While it does not generally affect tree survival, outbreaks may sometimes last for more than three years and can kill trees, particularly

if trees are stressed by other factors such as drought (CFS, 2006a). Outbreaks of the pest occur periodically, impacting hundreds of square kilometres of aspen forests, often in association with infestations of the forest tent caterpillar (Cerezke, 1992).

Spruce budworm (*Choristoneura fumiferana*) and the western spruce budworm (*Choristoneura occidentalis*) are widespread destructive pests of spruce and fir species in many northern coniferous forests (CFS, 2006a). During years of peak infestation, over 20 million hectares of forest in Canada have been affected by *C. fumiferana* annually (Tkacz, Moody and Villa Castillo, 2007). Damage caused by *C. occidentalis* in British Columbia has increased steadily from over 120 000 ha of forests in 2001 to over 600 000 ha in 2004 (CFS, 2006a).

The hymenopteran balsam fir sawfly (*Neodiprion abietis*) is a common and destructive native defoliator that feeds mainly on balsam fir (*Abies balsamea*) and occasionally on white spruce (*Picea glauca*) and black spruce (*P. mariana*) (CFS, 2006a). Outbreaks occur occasionally and may cause growth loss or limited tree mortality.

Some indigenous pests may not have significant impacts on the region's forest resources but concerns about introductions into other nations can have serious effects on the forest sector through international trade restrictions. An example is the pine wilt nematode, *Bursaphelenchus xylophilus**, the causal agent of pine wilt disease, which is spread through insect vectors, pine sawyer beetles (*Monochamus* spp.). The pine wilt nematode is native to North America, where it is widespread in natural coniferous forests, but significant losses have not been recorded and it is not considered a serious pest (EPPO/CABI, 1997). While the nematode has been associated with the death of some pines in the United States, in general losses are most often confined to non-native tree species (primarily *Pinus sylvestris*) in artificial forest ecosystems such as ornamental conifer plantings, windbreaks and Christmas tree plantations (EPPO/CABI, 1997; Liebhold *et al.*, 1995).

While not a serious problem in North America, pine wilt disease is a major threat to Asian and European pine forests and has resulted in extensive tree mortality in countries such as China, Japan, Republic of Korea and Portugal (Shi, 2005). It was apparently introduced to Japan on North American timber imports in the early 1900s and since then it has caused major epidemics of pine wilt disease (Krcmar-Nozic, Wilson and Arthur, 2000). The pest was intercepted in shipments of wood chips to Finland and Sweden. As a result, *B. xylophilus* is listed as an A1 quarantine pest by EPPO and regulations have been imposed on Canadian and United States shipments of unprocessed coniferous wood products since the early 1990s (EPPO/CABI, 1997). Such regulations have resulted in significant economic losses to Canada and the United States, as decreased exports of coniferous wood and wood products to Europe has cost both countries hundreds of millions of dollars (FAO, 2000; Allen and Humble, 2002).

INTRODUCED INSECTS

A number of destructive forest pests have been introduced into North America. Coleopteran species include the Asian longhorned beetle, emerald ash borer, banded elm bark beetle, pine shoot beetle and the brown spruce longhorn beetle. Discovered in 2002 in Michigan (United States) and Ontario (Canada), the emerald ash borer (*Agrilus planipennis**) is threatening ash trees (*Fraxinus* spp.) in North American forests, urban plantings and shelterbelts (Thomas, 2005). In June 2008 it was also reported from the province of Quebec, Canada (CFIA, 2008a). This native of Asia kills trees by feeding under the bark and disrupting the flow of nutrients and water throughout the tree (CFS, 2006a). It is responsible for the death and decline of millions of trees in the region and as a result it is considered a major pest problem; many believe the potential for damage to ash trees and overall biodiversity could rival the devastation caused by Dutch elm disease and chestnut blight. The emerald ash borer could also become a major threat to other countries.

The Asian longhorned beetle (*Anoplophora glabripennis**) was first discovered in the United States in Amityville, New York in 1996 followed by three separate infestations in Chicago, Illinois in 1998 and one in Jersey City, New Jersey in 2002. A very aggressive quarantine and eradication programme was implemented by the USDA Animal and Plant Health Inspection Service (APHIS) at all sites after detection. In September 2003, the beetle was discovered in Toronto, Ontario, Canada. The area was immediately quarantined by the Canadian Food Inspection Agency (CFIA) and an eradication programme was initiated involving the removal of infested trees, which has contained the spread of the beetle. This insect attacks many hardwood species in North America including maple, elm, birch, horse chestnut, willow and sycamore (CFIA, 2008b).

The pine shoot beetle (*Tomicus piniperda*), a European species, was discovered in North America in 1992. As of December 2002, twelve states in the United States (Illinois, Indiana, Maine, Maryland, Michigan, New Hampshire, New York, Ohio, Pennsylvania, Vermont, West Virginia and Wisconsin) and two Canadian provinces (Ontario and Quebec) were known to have infestations of *Tomicus piniperda* (Haack and Poland, 2001). Pines are the preferred hosts although the pest also attacks *Abies*, *Larix*, *Picea* and *Pseudotsuga* species.

Native to Europe, the brown spruce longhorn beetle (*Tetropium fuscum*) was found in dying red spruce (*Picea rubens*) trees in Halifax, Nova Scotia, Canada in 1999 (Hurley *et al.*, 2004). White spruce (*Picea glauca*) and black spruce (*P. mariana*) have also been attacked. The beetle is believed to have entered the region on wood packing materials or dunnage (Hurley *et al.*, 2004). Federal and provincial agencies are carrying out a survey and eradication programme.

Native to eastern Russian Federation, China, Democratic People's Republic of Korea, Kazakhstan, Kyrgyzstan, Mongolia, Republic of Korea, Tajikistan, Turkmenistan and Uzbekistan, the first specimens of the banded elm bark beetle (*Scolytus schevyrewi*) were trapped in Colorado and Utah, United States in 2003 although it is suspected that this insect had been present for several years (Thomas, 2005). This pest has been collected from *Ulmus americana*, *U. pumila*, *U. thomasi* and *U. procera* in the United States and is suspected to transmit Dutch elm disease (EPPO, 2008).

The gypsy moth, *Lymantria dispar**, is a significant pest of oaks, poplars, and maples, but is also capable of feeding on over 500 different plant and tree species. Two strains of gypsy moth have been recovered in North America: the Asian strain (not established), of which the female is capable of flight; and the European strain, of which the female is flightless (Brandt, 1994). The Asian strain was introduced into western North America on several occasions but in each case it was eradicated. While the pest has been prevented from establishing in the region, the costs associated with eradicating the Asian gypsy moth have been enormous, estimated at US\$34 million for two introductions (Pacific Northwest, North and South Carolina) in the United States alone (Krcmar-Nozic, Wilson and Arthur, 2000). Coupled with the costs of border vigilance and monitoring, the economic losses are enormous. The European strain was introduced into the northeastern United States in 1869 and is now found primarily in eastern Canada and the United States. In Canada, this strain of gypsy moth was found first in Quebec in 1924 and then in New Brunswick in 1936; both of these infestations were eradicated (Brandt, 1994). In the last 20 years, however, Quebec, Ontario, New Brunswick and Nova Scotia have all been infested with the European strain (Brandt, 1994). The European gypsy moth is considered the most costly of introduced forest insect pests. In the United States, annual expenditures for control have exceeded US\$35 million since 1980 (Wallner 1996, 1997). In addition, timber losses have been estimated at over US\$291 million (Krcmar-Nozic, Wilson and Arthur, 2000).

A new pest in eastern Canada and the United States is the European woodwasp, *Sirex noctilio**. Native to Asia, northern Africa and Europe, this insect has been introduced into many countries in the southern hemisphere where it has caused significant damage to conifer trees, pines in particular. The woodwasp was discovered in the United States

(New York) in 2004 and in Canada (Ontario) in 2005 (Haugen and Hoebeke, 2005; CFS, 2006a). Since these initial introductions, the pest has spread throughout various counties in the Canadian province of Ontario and also to parts of the United States including Michigan, Pennsylvania and Vermont (P. de Groot, personal communication). Monterey (*Pinus radiata*), lodgepole (*P. contorta*), ponderosa (*P. ponderosa*), jack (*P. banksiana*), and most species of southern pines are known hosts; the susceptibility of other North American conifers is not known (Tkacz, Moody and Villa Castillo, 2007). Based on its behaviour in other countries, it is expected that, without adequate control measures, sirex will spread rapidly throughout the region. It is thus considered a serious pest in the region.

At least five species of adelgids have been introduced into North America (Blackman and Eastop, 1984). Two species have caused extensive tree mortality: the balsam woolly adelgid (*Adelges piceae*) and the hemlock woolly adelgid (*Adelges tsugae*). The balsam woolly adelgid is a major pest of true firs and the greatest cause of balsam fir (*Abies balsamea*) mortality in North America. It was accidentally introduced into Canada and the United States from Europe in the early part of the twentieth century (CFS, 2006b). Native to China and Japan, the hemlock woolly adelgid was first reported in western Canada (British Columbia) in the 1920s and in the United States (Virginia) in the 1950s (Thomas, 2005). This pest attacks spruce and hemlock trees. In the eastern United States, eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliniana*) are susceptible to infestations; in western Canada, damage to western hemlock (*T. heterophylla*) has been minor.

INTRODUCED DISEASES

Many of the major diseases impacting North American forests are introduced species. Dutch elm disease (*Ophiostoma ulmi*) is the most destructive disease of wild and planted elm trees (*Ulmus* spp.) in North America (Ip, 1992). It was first found in Ohio in 1930 and has since spread throughout almost the entire North American range of elms. In Manitoba, the disease was found for the first time in 1975, and in 1981 it appeared in Saskatchewan. Over 35 million elms in the United States and millions of elms in eastern Canada have been killed by this disease resulting in significant landscape destruction (Ip, 1992).

White pine blister rust (*Cronartium ribicola*), an introduced fungus from Asia, has decimated several species of native white pines across the western United States and Canada (Thomas, 2005). It entered North America through the east and west coasts on European nursery stock around 1910.

Sudden oak death, *Phytophthora ramorum**, causes a serious disease of tanoak and oaks, resulting in crown dieback, stem bark lesions and basal cankers (Thomas, 2005). It attacks a variety of tree species including coast live oak (*Quercus agrifolia*), California black oak (*Q. kelloggii*), shreve oak (*Q. parvula* var. *shrevei*), tanoak (*Lithocarpus densiflorus*) and madrone (*Arbutus* spp.), and also infects several other plant species (Thomas, 2005). Infected trees die relatively quickly once crown symptoms develop although the severity of damage varies considerably between sites.

Beech bark disease, caused by the fungus *Nectria coccinea* var. *faginata*, causes significant damage or mortality in American beech (*Fagus grandifolia*). The disease results when bark that is attacked and altered by the beech scale (*Cryptococcus fagisuga*) is invaded and killed by fungi, primarily *Nectria coccinea* var. *faginata* and sometimes *N. galligena*. It was introduced to North America at Halifax, Nova Scotia in the 1890s and it killed entire stands of American beech as it spread north and west throughout the Canadian Maritime Provinces and in localized areas of eastern and south-central Maine (Houston and O'Brien, 1983).

Butternut canker (*Sirococcus clavignenti-juglandacearum*) is a significant pest of *Juglans* species, primarily butternut, *J. cinerea*. The natural range of butternut extends throughout the northern and eastern United States and southern portion of eastern

Canada. The fungus was first reported in Wisconsin in 1967, but the causal agent was not isolated and described until 1979. It is not known how long it has existed in North American hardwood forests or if it was native or introduced, but there is evidence that it was introduced into the United States in the 1960s or earlier (EPPO, 2005). The pathogen spread rapidly across the United States and is now present in the entire native distribution area of *J. cinerea*. It was detected in Canada for the first time in Quebec in 1990 and in Ontario in 1991 (EPPO, 2005). The canker is currently known to exist throughout the range of butternut in Canada.

CAPACITY FOR FOREST HEALTH PROTECTION

The capacity for forest health protection in the region is high. Both Canada and the United States are very active in the area of forest health and protection. They have clear and comprehensive pest management programmes at both national and provincial/state levels, efficient monitoring and detection activities and sophisticated systems for data management. There is significant high quality information publicly available on specific pests with alerts for particularly noxious pests.

REGIONAL PEST MANAGEMENT EFFORTS

North America has several mechanisms for promoting regional cooperation on forest health issues. The working group for forest insects and disease of the North American Forest Commission (NAFC) was established over 40 years ago and was recently amended to include invasive plant species. In addition, the North American Plant Protection Organization (NAPPO), recognized under the IPPC, offers mechanisms for regional coordination on phytosanitary matters, including those for reporting on pests and activating alerts, as well as providing fact sheets.