Alien Forest Pests

Context for the Canadian Forest Service's Science Program

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Contents

Introduction

The spread of non-indigenous or alien[1] forest pests is a growing threat to Canada's forests, its international trade in forest and other products, and Canadians and communities dependent on healthy forests and a competitive forest sector. The spread of invasive organisms, including alien pests, is increasingly recognized by parties to international agreements and other fora in which Canada participates as an issue that has wide implications for biodiversity, ecosystem health, human health, natural resource industries, and international trade.

The discovery in 1917 that white pine blister rust had become established in Ontario and Quebec helped trigger forest insect and disease monitoring and research in the early days of the Canadian Forest Service (CFS) (Conners 1972, p. 63; Johnstone 1991, p. 46, 50). As the primary federal agency on which other departments and the forest sector depend for forest science and policy expertise, the CFS will continue to be called upon, possibly in a growing capacity, to provide advice, information, and technology to combat this threat to Canada's forests and to related industries and jobs.


White pine blister rust on western white pine

This paper is the third in a series of context papers intended as guides to the current and future directions of the CFS's science program. This paper defines alien forest pests and describes why the CFS, in cooperation with its wide range of partners, addresses alien forest pests and related issues through research, monitoring, and assessment activities.

What Are Alien Forest Pests?

Any species, subspecies, variety, or race occurring in an area or ecosystem to which it is not native may be classified as an alien species. When they cause changes in ecosystems, displacing native organisms by predation or parasitism, by competition for space and nutrients or food, or by alteration of habitat, alien species are considered to be invasive. When their impacts are beyond acceptable levels, resulting in environmental damage and economic and social losses, alien species become known as pests.

Mixed island systems, ecosystems in humid environments or in southern continental regions, and ecosystems disturbed by human activities or with low biological diversity are susceptible to invasion by alien species. Other characteristics of vulnerable ecosystems include simple ecological structure, lack of predators, herbivores, or competitors, and climatic and soil/sediment similarities to the native habitat of the alien species. North American forests are particularly vulnerable to invasions of European and Asian insects (Niemelä and Mattson 1996), which often out-compete their North American counterparts, especially in disturbed and fragmented forests. Many endemic Asian or European pathogens have evolved along with their hosts. Related North American host species lack this parallel evolution and thus are extremely susceptible to non-native pathogens.

Boreal forests, mainly because of their relatively limited species complements, are considered particularly susceptible to alien species invasions, and even more so when disturbed. Over 300 species of tree-feeding insects from Europe have successfully invaded North America, compared with only 34 that have made the reverse journey (Niemelä and Mattson 1996). What most of these invasive species share, besides not having natural checks to their survival and spread, is that they are generalists: they reproduce quickly, disperse widely when given the chance, tolerate a fairly broad range of habitat conditions, and resist eradication once they are established.[2]

Established Alien Forest Pests

In the past century, alien pests have become established in Canada with devastating effects on forest health, biodiversity, and timber and other forest resource values (Table 1). Examples include chestnut blight, Dutch elm

Table 1. Significant forest pests introduced into Canada (E=eastern Canada; W=western Canada).

Alien forest pest	Primary hosts	Year detected
INSECTS		
Larch sawfly, *Pristiphora erichsonii* (Htg.)	Larches, *Larix* spp.	1882
Browntail moth, *Euproctis chrysorrhoea* (L.)	All deciduous species	1902
Poplar sawfly, *Trichiocampus viminalis* (Fall.)	Trembling aspen, *Populus tremuloides* Michx; largetooth aspen, *P. grandidentata* Michx.; balsam poplar, *P. balsamifera* L.	1904
Larch casebearer, *Coleophora laricella* (Hbn.)	Larches, *Larix* spp.	1905
Late birch leaf edgeminer, *Heterarthrus nemoratus* (Fall.)	Birches, *Betula* spp.	1905
Balsam woolly adelgid, *Adelges piceae* (Ratz.)	Balsam fir, *Abies balsamea* (L.) Mill.; grand fir, *A. grandis* (Dougl. ex D. Don) Lindl.; subalpine fir, *A. lasiocarpa* (Hook.) Nutt.; amabilis fir, *A. amabilis* (Dougl. ex Loud.) Dougl. ex J. Forbes	1908 E 1950 W
Satin moth, *Leucoma salicis* (L.)	Poplars, *Populus* spp.	1920
Winter moth, *Operophtera brumata* (L.)	Oaks,*Quercus* spp.; maples, *Ace*r spp.; willows, *Salix* spp.	1920 E 1970 W
European spruce sawfly, *Gilpinia hercyniae* (Htg.)	Spruces, *Picea* spp.	1922
Gypsy moth (European race), *Lymantria dispar* (L.)	Oaks, *Quercus* spp.; birches, *Betula* spp.; larches, *Larix* spp.; willows, *Salix* spp.; basswood, *Tilia americana* L.; Manitoba maple, *Acer negundo* L.	1924
European pine shoot moth, *Rhyacionia buoliana* (Denis & Schiff.)	Red pine, *Pinus resinosa* Ait.; jack pine, *P. banksiana* Lamb.; Scots pine, *P. sylvestris* L.	1925
Mountain-ash sawfly, *Pristiphora geniculata* (Htg.)	Mountain-ash, *Sorbus* spp.	1926
Birch leafminer, *Fenusa pusilla* (Lep.)	Birches, *Betula* spp.	1929
Introduced pine sawfly, *Diprion similis* (Htg.)	Pines, *Pinus* spp.	1931
Birch casebearer, *Coleophora serratella* (L.)	Birches, *Betula* spp.	1933
European pine sawfly, *Neodiprion sertifer* (Geoff.)	Red pine, *Pinus resinosa* Ait.; Scots pine, *P. sylvestris* L.	1939
Elm leaf beetle, *Pyrrhalta luteola* (Müll.)	Elms, *Ulmus* spp.	1945
Smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.)	Elms, *Ulmus* spp. (vector for Dutch elm disease)	1946
Ambermarked birch leafminer, *Profenusa thomsoni* (Konow)	Birches, *Betula* spp.	1948
Apple ermine moth, *Yponomeuta malinella* Zell.	Apples, crab apples, *Malus* spp.	1957
Pine false webworm, *Acantholyda erythrocephala* (L.)	Pines, *Pinus* spp.	1961
European pine needle midge, *Contarinia baeri* (Prell)	Red pine, *Pinus resinosa* Ait.; Scots pine, *P. sylvestris* L.	1964
Early birch leaf edgeminer, *Messa nana* (Klug)	Birches, *Betula* spp.	1967
Pear thrips, *Taeniothrips inconsequens* (Uzel)	Sugar maple, *Acer saccharum* Marsh.; red maple, *A. rubrum* L.	1989

(Continued…)

Table 1. Significant forest pests introduced into Canada. *(Continued)*

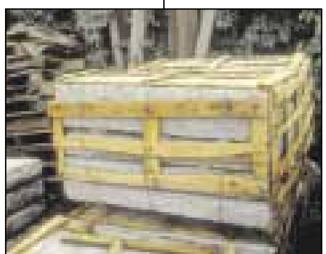
Alien forest pest	Primary hosts	Year detected
INSECTS *(cont.)*		
Pine shoot beetle, *Tomicus piniperda* (L.)	Eastern white pine, *Pinus strobus* L.; red pine, *P. resinosa* Ait.; Scots pine, *P. sylvestris* L.; spruces, *Picea* spp.	1993
Brown spruce longhorn beetle, *Tetropium fuscum* (Fabricius)	Red spruce, *Picea rubens* Sarg.; Norway spruce, *P. abies* (L.) Karst; black spruce, *P. mariana* (Mill.) BSP; white spruce, *P. glauca* (Moench) Voss	2000
DISEASES		
Beech bark disease, *Nectria coccinea* (Pers.:Fr.) F. var. *faginata* Lohm., Wats. & Ayers, with beech scale, *Cryptococcus fagisuga* Lind.	American beech, *Fagus grandifolia* Ehrh.	1890
Dothichiza canker, *Discosporium populeum* (Sacc.) B. Sutton	Poplars, *Populus* spp.	pre-1900
Chestnut blight, *Cryphonectria parasitica* (Murr.) Barr [syn. *Endothia parasitica* (Murr.) P.J. & H.W. Anderson]	American chestnut, *Castanea dentata* (Marsh.) Borkh.	post-1904
White pine blister rust, *Cronartium ribicola* J.C. Fisch.	Eastern white pine, *Pinus strobus* L.; whitebark pine, *P. albicaulis* Engelm.; western white pine, *P. monticola* Dougl. ex D. Don	1917
Willow scab, *Venturia saliciperda* Nüesch	Willows, *Salix* spp.	ca. 1925
Dutch elm disease, *Ophiostoma ulmi* (Buisman) Nannf.	Elms, *Ulmus* spp.	1944
Scleroderris canker (European race), *Gremmeniella abietina* (Lagerb.) Morelet	Red pine, *Pinus resinosa* Ait.; jack pine, *P. banksiana* Lamb.; Austrian pine, *P. nigra* Arnold; Scots pine, *P. sylvestris* L.	1978
European larch canker, *Lachnellula willkommii* (R. Hartig) Dennis	Larches, *Larix* spp.	1980
Butternut canker, *Sirococcus clavignenti-juglandacearum* Nair, Kostichka & Kuntz	Butternut, *Juglans cinerea* L.	1991

Source: Campbell (1998); Hendrickson (1998); Myren (1994); Martineau (1984); Lachance (1979); Conners (1972); Davidson (1964).

disease, beech bark disease, balsam woolly adelgid, and white pine blister rust. Chestnut blight and Dutch elm disease have had such a devastating effect that the host species, American chestnut and American elm, respectively, have ceased to be a significant part of the deciduous forests of southeastern Canada. They exist only as "ghost" trees, and ecosystems in the region now contain a different mixture of species (Hall et al. 1996, p. 11). Beech bark disease and balsam woolly adelgid reduce the value of the wood in infected trees. White pine blister rust, along with the native white pine weevil, *Pissodes strobi* (Peck), has greatly reduced the commercial value of planting white pine and threatens ecologically important species such whitebark pine (Campbell 1998).[3]

When the pest does not damage the host tree species in its country of origin (often in the same genus it attacks in Canada), scientists here have little information with which to begin their search for controls. The balsam woolly adelgid has caused extensive damage to balsam fir stands in eastern Canada, yet it does not harm firs in its native Europe (Hall et al. 1998, p. 12, 13). No effective controls have been found for blights or adelgids.

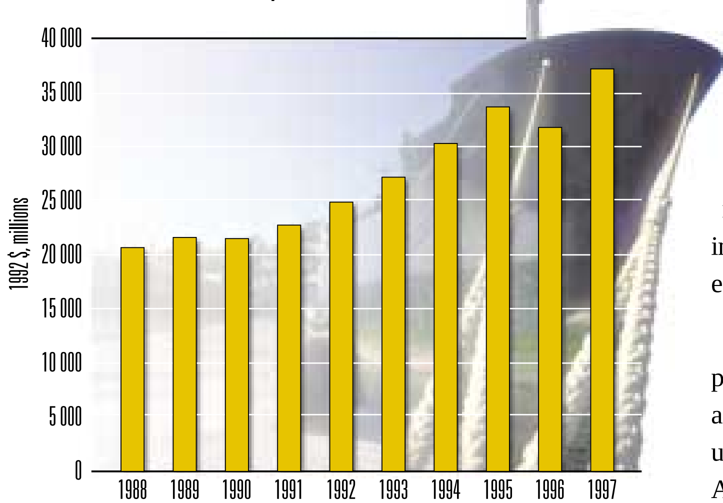
In Quebec, almost 600 vascular plant species have been introduced since early settlement, and among these, 275 species were introduced accidentally (Rousseau 1968). Many of these introduced plants are considered weeds. Purple loosestrife, *Lythrum salicaria* L., threatens natural ecosystems in eastern Canada, and Tatarian honeysuckle, *Lonicera tatarica* L. (Leysser.), has invaded woodlots in central Ontario (Environment Canada 1999). Common along both the Atlantic and Pacific coasts of North America, two related invasive weeds, Scotch broom, *Cytisus scoparius* (L.) Link and gorse, *Ulex europaeus* L., are hindering the regeneration of commercial forest tree species such as Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*, and encroaching on stands of Garry oak, *Quercus garryana* Dougl., in British Columbia (Peterson and Prasad 1998).


Some pests arrive in dunnage, such as this crate of granite

New Arrivals and Expanding Ranges

Despite detection efforts at Canada's ports of entry, the frequency of introductions and the number of alien species are increasing. This trend results mainly from the use of shipping containers, direct point-to-point delivery of shipments, the increase in the volume of trade, and a broadening of trading partners, especially with the Pacific Rim and Asia. Trade volume is so large that on average only 1% to 2% of shipments are inspected. Rates of inspection are higher for targeted shipments, such as regulated commodities and shipments from certain countries of origin. Other countries achieve similar inspection rates.

Canadian imports from Asia and the Pacific Rim countries, 1988–1997



Source: Statistics Canada (1998, table 1).

One new arrival causing concern is the Asian long-horned beetle, *Anoplophora glabripennis* (Mots.). Transported in shipments from China, this wood-boring beetle could spread to Canadian forests (CFIA 1998; Allen 1998; Humble et al. 1998a; OMNR 1998). The beetle has already been the target of control campaigns in New York and Chicago, where millions of dollars have been spent to cut down thousands of infected city trees. This destructive beetle tunnels into healthy trunks and branches, eventually killing the tree. It mainly attacks broadleaf trees, including maples. The sugar maple is Canada's national tree and a stylized version of its leaf is the central feature of the Canadian flag. It is also the principal source of sap for a maple syrup and sugar industry worth $100 million annually or 80% of the world market. Like many other introduced insects, the Asian long-horned beetle has no known natural predators in Canada or in its native range. In China, foresters attempt to protect the poplar plantations from this pest by interplanting with maple, its favored host. This beetle has been intercepted numerous times in Canada.

Scientists and quarantine officials warn that the entry into Canada of the Asian long-horned beetle and other destructive pests is imminent. Six alien species of bark and wood-boring beetles (from the Scolytidae and Cerambycidae families) have become established in urban forests and parks in the greater Vancouver area since 1995 (Humble et al. 1998b). Some of these recent introductions, as well as other previously introduced species, have dispersed into and are established in industrial forest lands in southwestern British Columbia. In some urban forests in British Columbia, alien ambrosia beetles are more abundant than the native ones. CFS scientists are currently assessing the impact alien ambrosia beetles would have on rural forest ecosystems.

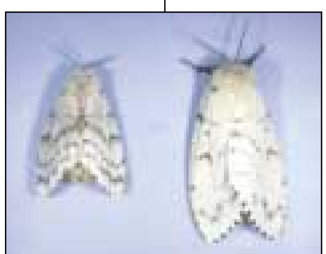
Many of these insects have been detected in wooden packing materials including wire spools, crates, pallets, and props, referred to as dunnage, in shipments of products such as wire rope, machinery, and stone. The North America Plant Protection Organization (NAPPO) has introduced standards for dunnage to reduce the risk of

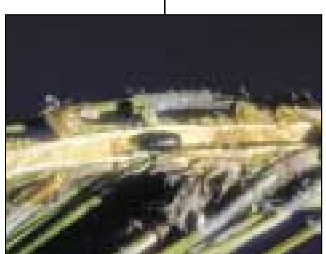
Asian long-horned beetles entering North America. As of 4 January1999, all solid wood cargo crating from China must be heat- or chemically treated (CFIA 1998), and from all other countries by October 2000. Under the Montreal Protocol, an international agreement on ozone-depleting substances, the use of methyl bromide as a pesticide by developed countries must be phased out by 2005. Methyl bromide may still be used for quarantine purposes but pressure could mount as this date approaches to discontinue its use even as a fumigant. Replacement products would then be needed to reduce the risk of alien pest introductions.

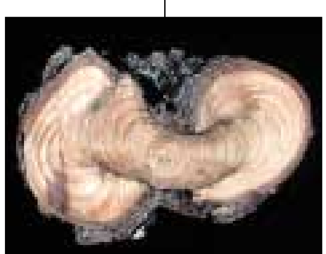
Other potentially destructive alien insects threatening Canadian forests include the Asian race of gypsy moth, pine shoot beetle, and an Eurasian spruce bark beetle, *Ips typographus* L. (Humble and Stewart 1994; Humphreys and Allen 1998). The Eurasian spruce bark beetle, which is a carrier of a tree-killing bluestain fungus, is continually intercepted on wood and wood packing from Europe and Asia. If established in Canada, it would affect spruce and other conifers of the boreal forest. Although technically not a new arrival, the pine shoot beetle has recently spread from pine plantations, where it was first found and managed satisfactorily, to established surrounding forest stands. This has spawned fears that the beetle could become established in the boreal forest.

Tree diseases are less obvious but also serious threats to Canada's forests. Two that have been expanding their ranges are butternut canker and European larch canker. Butternut canker has been known to be present in southern Ontario and the lower St. Lawrence portions of Quebec since 1991, having been introduced from the eastern United States. In 1998, it was detected in New Brunswick (Harrison and Hurley 1998). The European larch canker appears to have been successfully limited through quarantine to coastal parts of mainland Nova Scotia and New Brunswick (CFS 1998a). There is usually a lag of several years between the introduction of tree canker diseases and their detection in the forest.


Asian long-horned beetles


Female European (*L*) and Asian (*R*) gypsy moths


Pine shoot beetle "mining" a shoot


Cross section of a larch stem damaged by European larch canker

Why Is Information on Alien Forest Pests Needed?

Canada's forests are central to its economic, environmental, and social well-being, as well as to the very identity of Canadians. Forests filter the air we breathe and the water we drink and provide habitat for countless species of plants and animals. They also offer a multitude of spiritual and recreational values. Some 800 Aboriginal communities exist within the forest environment. In addition, the forest supports an economic sector that contributes substantially to the wealth of almost every part of the country, providing jobs for 880 000 Canadians, mostly in rural communities. Canada is the world's largest forest products exporter and forest products have been critical to Canada's ability to maintain a positive trade balance. In 1997, forest products contributed $31.7 billion to Canada's surplus balance of trade.

Forest resource management is primarily the responsibility of the provincial and territorial governments[4]; the federal government's role in forestry focuses on trade and investment, national statistics, science and technology, Aboriginal affairs, environmental regulations, and international relations. The levels of government share responsibilities for and cooperate on S&T, industrial and regional development, the environment, and other forestry matters.

The CFS, Natural Resources Canada, is the principal federal forest research organization in Canada. It addresses the issue of alien forest pests by providing provincial and territorial forest agencies, private sector forest managers, other federal departments and agencies, Aboriginal forest organizations, non-governmental organizations, and the interested public with

- compilations and syntheses of fundamental ecological information on potential alien forest pests and methods for detection, identification, and monitoring;
- assessments of the potential for the establishment and spread of alien forest pests in Canadian forests and of their impacts on Canada's forest ecosystems, economy, and communities;
- systems for predicting the establishment and spread of alien pests;
- mitigative and preventive measures, including silvicultural options, natural control products, and decision-support systems.

The CFS works cooperatively with other federal departments and agencies, including those with responsibilities for forested land and with regulatory mandates affecting the forest sector. The Pest Management Regulatory Agency, Health Canada, is responsible for providing safe access to pest management tools, while minimizing risks to human and environmental health.[5] Decisions to apply approved pesticides reside with provincial governments. Environment Canada also participates in the regulation of pest control products.

The Canadian Food Inspection Agency (CFIA) provides all federally mandated food inspection and quarantine services. The CFS collaborates with the CFIA in the detection, identification, and assessment of known and potential alien forest pests. Developing detection methods and creating risk scenarios to determine the likelihood of alien species becoming established in Canada is crucial for effective regulatory and pest management strategies (Harrison and Smith 1997; Humble and Allen 1997). In July 1998, Natural Resources Canada and the CFIA signed a Memorandum of Understanding to define the roles of the CFS and the Plant Health and Production Division, CFIA, in the management of plant quarantine pests affecting forests and forest products.

Impacts of Alien Forest Pests

Organisms that spread naturally, in response to changing environmental conditions or because they are transported by wind, water, or animals, into habitats in which they have not previously occurred usually do not make a great impact on ecosystems or their inhabitants. Most alien pests are accidentally introduced into Canada on imported goods, by travelers, or on vehicles; sometimes they are deliberately imported as ornamental plants, pets, and so on, and escape. Although most introduced organisms fail to survive and do not become established in this country, history has shown that the potential for damage is large if they do.[6] Furthermore, a comprehensive analysis in the United States concluded that the number of established alien species and their environmental, economic, and social impacts are chronically underestimated, especially for species that do not directly damage specific industries such as agriculture and forestry or human health (US Congress 1993, p. 5).

Ecological Implications

Forest Health

"A healthy forest is one that maintains and sustains desirable ecosystem functions and processes" (CFS 1999). Healthy forests are essential for environmental health, wealth generation, and job creation. Forest ecosystems are healthy when their underlying ecological processes operate within a natural range of variability, so that on any temporal or spatial scale they are dynamic and resilient to disturbance (Kimmins 1997; AFMSC 1997; Lacky 1998). Long before European settlement, Canada's vast forests evolved in response to recurrent and often profound, but inherent, influences, including wildfire, wind, ice storms, floods, drought, insects, diseases, and climate change. Human activities have disrupted the natural range of variation in structure, composition, and landscape patterns of Canadian forests. These activities include harvesting, fire protection, and the introduction of insects, diseases, and other foreign organisms. Forest management practices, such as intensification of timber production, may alter patterns of forest succession and host–pest dynamics and may increase the susceptibility of Canada's forests to alien invasive organisms.

Biological Diversity

The United Nations' Convention on Biological Diversity defines "biological diversity" as "the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems."[7] More simply, biodiversity means the "variety of life." It can be addressed in terms of genes, species, ecosystems, and landscapes and therefore through the scientific disciplines of genetics, taxonomy, and ecology. Biologically diverse ecosystems tend to be more resilient and can recover more readily from perturbations (Tilman and Downing 1994).

The negative effects of invasive organisms on biodiversity were recognized as early as 1958 (Elton 1958, cited in Heywood 1995, p.757). Invasive alien species are now regarded as second only to habitat loss as a leading threat to biodiversity (Wilcove et al.1998). Introduced species arrive without their natural parasites and predators. They deteriorate the habitat conditions needed to support native species; they prey on native species, displace them or hybridize with them. Globally, about 20% of the vertebrates that are thought to be in danger of extinction are threatened by invasive species (UNEP 1999). Listings by the Canadian Committee on the Status of Endangered Wildlife in Canada for 1998 suggest that about 25% of endangered, 31% of threatened, and 16% of vulnerable species in Canada are in some way at risk because of alien species.

Economic and Social Consequences

Changes in ecosystem functioning precipitated by invasive species can jeopardize the provision of services and goods by those ecosystems. Economic and social consequences include loss of income, costs for recovery actions, termination of certain activities in some instances when recovery is not possible, protection costs, monitoring costs, and costs for pest control (as opposed to control by natural enemies).[8] Cornell University ecologists have estimated that the 50 000 alien species in the United States cost US$138 billion a year in economic losses, with a list that runs from alien weeds (US$35.5 billion) and introduced insects (US$20 billion) to human disease-causing organisms (US$6.5 billion) and even the mongoose (US$50 million) (Pimentel et al. 1999).

Timber Losses

From 1981 to 1995, insects and disease, both native and exotic, affected over six million hectares of Canada's forest area, about one-half of that harvested, and damaged approximately one billion cubic metres of timber (CFS 1998b, p. 36-37). Because quantification of damage and control costs is difficult, Canada has no estimate of timber losses caused by alien pests alone. Losses due to alien forest pests in the United States are estimated to be about US$4 billion per year (Pimentel et al. 1999).

Pest Control Costs

Restoring ecosystems to their original condition by the eradication of invasive species can be very expensive or even impossible with currently available techniques. The use of many available control agents, especially chemical pesticides and some biological agents such as *Bacillus thuringiensis*, or *B.t.*, is resisted by the public. As mentioned previously, methyl bromide, regularly used to eradicate pests in ship holds and containers and on docks, is also an ozone-depleting compound; its continued use as a fumigant is uncertain.

Alternative control products are slow in becoming available. The cost of finding and introducing biological control agents can be high because the safety of native species must be considered. New control products generally have to be pest-specific and thus have limited application. Their low profitability, coupled with regulatory requirements, tends to discourage the pesticide industry from developing such products. In the United States, large pesticide companies are interested in developing products that can generate annual sales in the order of $50 million. Small companies are satisfied with annual sales of at least $5 million, but usually experience difficulty in financing the startup costs, especially the registration, of producing a new pesticide. To date, every company that has attempted to manufacture a gypsy moth virus product has failed to bring it to market (Podgwaite 1999). However, research continues to find new natural control agents, as well as silvicultural treatments and genetically resistant seedlings, to include in the arsenal against forest pests.

Risk Assessment

Prediction and prevention measures may be the most cost effective and efficient means to battle alien forest pests. This would involve determining which alien pests are most likely to become established and spread in Canadian forests; under what environmental conditions, including those projected for climate change, they would most likely flourish; and which of the growing number of pests will cause the greatest social and economic impacts. With this information, scientific effort could be better directed. Regulatory and other preventive measures, including, if needed, pest management ones, could be initiated. Efforts to contain the damage wreaked by a surprise entry of a new destructive pest would be avoided. Decision-makers, shippers, and the general public would be more aware of the risk presented by the entry of those organisms identified in the assessment process.

Impacts on Urban Forests

Urban areas near ports of entry and receiving points for international shipments are often where alien pests first become established. The trees in these areas are valued far beyond what they would be worth as raw material for forest products. For example, according to one estimate, the nearly 700 000 elm trees in Canadian cities and towns have been valued at $2.5 billion (Hubbes 1999). Therefore, the general public's perception of the threats to forest health from non-indigenous pests could have graver political consequences than just the loss of trade or timber supplies. The millions spent on destroying trees infected by the Asian long-horned beetle in Chicago and New York testify to this. If these beetles become established in Canadian parks, boulevards, and yards, Canadians could also face the cutting and removal of stately trees from their neighborhoods. Such an invasion could also see the CFS being pressed into dealing with pests on non-timber trees in Canadian cities.

Trade Implications

Quarantine pests are the subject of the International Plant Protection Convention (IPPC), an international agreement between 106 countries, under the United Nations Food and Agriculture Organization (FAO) and the North American Plant Protection Organization (NAPPO), a regional FAO body. IPPC is recognized in the Agreement on the Application of Sanitary and Phytosanitary Measures of the World Trade Organization (WTO) as the international reference point for the development and harmonization of phytosanitary standards, guidelines, and recommendations. Similarly, NAPPO is recognized as the authority on phytosanitary issues under the North America Free Trade Agreement (NAFTA).

The signatories to IPPC agree, among other things, to provide:

- reports on the existence, outbreak, and spread of economically important non-native pests of plants and plant products that may be of immediate or potential danger, and
- information on effective management methods for pests of alien plants and plant products.

In addition, importing countries can ask that restrictions be imposed on regions that they suspect have pests posing a threat to their crops and livestock. Non-tariff barriers to trade can and have been mounted under this agreement. Countries have recourse through the WTO to resolve disputes involving phytosanitary regulations.

Canada's heavy reliance on exporting natural resource products makes it vulnerable to trade disputes and susceptible to the consequences of the introductions of quarantine forest pests. If a quarantine forest pest is believed to be established in Canada, importing countries can refuse entry to Canadian goods unless they have been certified free of these organisms. Two examples of forest pest that have caused problems for the export of Canadian forest products are pinewood nematode and gypsy moth.

The pinewood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle, is a microscopic organism that causes pine wilt disease resulting in economic damage to pines in Japan and China. The organism is also present in North America, where it does not cause any economic damage to the native conifer forest (Evans et al. 1993). European Community countries imposed plant health regulations on shipments of green lumber from Canada even though there was no proof that the presence of pinewood nematode on Canadian lumber shipments would lead to pine mortality in European forests.

A European race of the gypsy moth is considered a serious forest pest. It was first introduced into the eastern United States in 1868 and later into Ontario and Quebec. Though not established in British Columbia, repeated introductions in the province over the past 20 years have required continued monitoring, eradication programs, and public awareness (Humble and Stewart 1994). In 1998, partly because of concern from the neighboring US states over the spread of this pest, and its more dangerous relative, the Asian gypsy moth, southern Vancouver Island was included in a quarantine zone. This involved certification and inspection of shipments and all vehicular traffic from this region. These measures, combined with eradication programs, may contain the moth in this area and possibly eliminate it. It is in the interest of Canada and its forest sector to detect, prevent, and, if necessary, control the spread of such quarantine organisms in order to protect its forests and access to markets.

Invasive Organisms: An International Issue

The impact of the spread of invasive organisms is increasingly recognized as a global change issue. The scope of the issue is beyond the capacity of any one country to manage. It requires a collective expertise in botany, zoology, and microbiology that can only be attained through global cooperation.

Invasive organisms are on the agenda of many countries. In February 1999 a United States Presidential Executive Order featured an incremental budget of US$29 million annually and the development of a national strategy for invasive organisms, including plants and animals. The United States has allocated about $US2.3 million per year to the study of the Asian longhorned beetle pest. New Zealand, recognizing its vulnerability as an island state to invasion by alien species, views breaches of its borders by these organisms as a biological threat to its national economic, environmental, and social security (Penman 1998).

The spread of alien organisms is being acknowledged as a global concern in several international fora. Canada, as a signatory to the United Nations Convention on Biological Diversity, is committed to managing and using its natural resources in a sustainable manner, to conserving its biodiversity, and hence to maintaining the productivity and resilience of its forests. Specifically, Article 8h of the convention prescribes that signatories should, as far as possible, prevent impacts of alien species and develop national strategies, plans, or programs to this end. The issue of invasive alien organisms is also on the agenda of the parties of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In addition, the North American Forestry Commission, of which Canada is a member, is developing a database for the management of exotic forest pests introduced to North America.[9] In 1997, a working group of 12 countries spanning five continents, known as the Montreal Process Working Group, developed a framework of internationally agreed-upon criteria and indicators for the conservation and sustainable management of temperate and boreal forests; the framework developed by the group contains an indicator that addresses alien forest pests (Montreal Process Working Group, 1997a,b).

No global strategy yet exists to address the invasive species problem. To rectify this, the Conference of the Parties of the Convention on Biological Diversity fostered an initiative to establish the Global Invasive Species Program (GISP),[10] a component of an international program on the science of biodiversity, DIVERSITAS. GISP will draw together the best management approaches for pest prevention and control and make these readily accessible to all nations; it will lay the groundwork for new tools in science, information management, education, and policy that must be developed through collaborative international action. In addition, this program will assess the current status of the science dealing with invasive species.

Emerging Issues

The introduction, establishment, and spread of alien species will continue. Unfortunately, there are no easy solutions. In the short term, we need to prevent entry and spread, using eradication techniques when necessary; set up early-detection systems; and conduct timely and reliable risk assessments. In the longer term, we must address their effects on forest ecosystems–on the composition, processes, and resiliency–and on timber losses. Issues that will likely affect the forest sector include the following:

- international cooperation in the research and sharing of information on the biology and impact of current and potential alien invasive species;
- restrictions by trading partners on Canadian forest products because of the potential, perceived, or real threat of quarantine pests from Canada;
- increased entry of alien pests into Canada, their establishment and spread, under current and projected forest management practices and environmental conditions, including the effects of global change; and
- lack of alternatives to the currently available, permitted pest control agents

Notes

1. From a biodiversity and ecological perspective, the terms “alien species” and “non-indigenous species” are commonly used. Regulatory and related agencies tend to employ the terms “exotic” and “foreign” species.

2. For a disturbing view of what may happen if current trends in biodiversty loss continue, see David Quammen’s article in *Harper’s Magazine* (October 1998) entitled “Planet of Weeds: Tallying the Loss of Earth’s Animals and Plants.” See also, Holmes (1998), Lövel (1997), and Bright (1998) for further perspectives on the issue.

3. A summary of Campbell’s M.S. thesis, “The Status of Whitebark Pine in British Columbia,” is published in *Nutcrackernotes: A Research and Management Newsletter about Whitebark Pine Ecosystems*, 11 Dec. 1999, No.10. <http://www.mesc.usgs.gov/glacier/number 10.htm>.

4. The transfer of resource management to the Yukon Territory is currently being negotiated.

5. For an overview of requirements for the commercial importation of pest control products, visit Health Canada’s Web site for the Pest Management Regulatory Agency <http://www.hc-sc.gc.ca/pmra-arla/qforms-e.html>.

6. A comprehensive assessment of the ecological impact of alien species can be found in the United Nations Environment Programme publication *Global Biodiversity Assessment* (Heywood 1995).

7. The United Nations presented the Convention on Biological Diversity at its Conference on the Environment and Development in Rio de Janeiro, Brazil, June 1992. The convention grew out of recognition by the world community of the threat posed by the degradation of ecosystems and loss of species and genetic diversity. On 4 December 1992, with the support of the provinces and territories, Canada became the first industrialized country to ratify the convention. See Environment Canada (1995).

8. See “Invasive Pests (‘Biological Pollutants’) and US Forests: Whose Problem, Who Pays?” (Wallner 1996) for an excellent discussion about damages from the spread of invasive pests; see also “Importing Pacific Rim Wood: Pest Risks to Domestic Resources” (Filip and Morrell 1996) for a description of the rapid increase in log exports into the US from Russia, Chile, New Zealand, and other countries, and with them, the introduction of forest pests.

9. Visit the North American Forestry Commission’s database Exotic Forest Pest Information System for North America: <http://www.exoticforestpests.org/>.

10. The Global Invasive Species Program (GISP) is coordinated by the Scientific Committee on Problems of the Environment, in conjunction with the World Conservation Union, the United Nations Environment Program (UNEP), and CAB International, with financial support from the Global Environmental Facility, UNEP, the International Council for Science (ICSU), and the National Aeronautics and Space Administration (NASA). For more on the GISP, visit its Web site: <http: //www.icsu.org/DIVERSITAS/Plan/gisp.html>.

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