Invasive Plants of Natural Habitats in Canada

An Integrated Review of Wetland and Upland Species and Legislation Governing their Control

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Introduction

The problem of plants invading natural areas in North America, especially species originating in Eurasia, dates back to the earliest days of European settlement. Purple loosestrife (*Lythrum salicaria*) arrived very early and was so well established along the eastern seaboard that early American botanists considered the plant to be native to North America (Thompson, 1991; Thompson *et al*., 1987). As time passed, more and more plants became invasive in the steadily shrinking area of natural landscape. In Canada, as elsewhere, the greatest impact tends to occur in areas that have experienced the greatest landscape modification. Southern Ontario and southern British Columbia appear to be experiencing the greatest problem with plants invading natural areas. In a 1985 Ontario survey of readers of *The Plant Press*, 13 species of upland and wetland habitats were regarded as invasive in southern Ontario. None, however, were identified as being invasive in northern Ontario (Kaiser, 1986). A number of "near-natural" ravines in the Toronto area were studied in 1977 to determine the density of alien trees in the vegetation relative to the distance from the urban core (Kaiser, 1986). As expected, the ravines closest to the heart of Toronto had the highest density of alien trees, whereas those areas furthest from the core had the lowest density of aliens.

In this report, the term **invasive** indicates a plant that has moved into a habitat and reproduced so aggressively that it has displaced some of the original components of the vegetative community. The term **natural area** indicates an area that is in a largely undisturbed condition and supports primarily species that are native to the area. The term **alien** refers to a plant that did not originally occur in an area where it is now established but which arrived as a direct or indirect result of human activity. Such a plant might have come from Eurasia, such as purple loosestrife, and is considered to be alien to North America, or it may have come from another part of North America, such as Manitoba maple (*Acer negundo*), which is native to the Prairies but mostly alien in southern Ontario. The usage of scientific names follows that accepted in Kartesz and Kartesz (1980).

Invasive aliens have become introduced in Canada through a number of means: many, such as purple loosestrife, have arrived as contaminants with seed crops, livestock feed, or ballast dumped by ships from Eurasia; others, such as yellow flag (*Iris pseudacorus*), have spread from introductions of horticultural material; and some, such as smooth brome grass (*Bromus inermis*), have been intentionally introduced for use as forage crops or for revegetating roadsides, etc.

Both native and alien plants can be invasive in natural areas. There are a number of native plants that many consider to be invasive in some situations, such as cattail (*Typha* spp.); however, most botanists do not consider native invasive plants to be a 'problem' because they are native and their increase is probably part of the dynamic nature of the ecosystem (DeLoach, 1991; botanist survey). Due to the fact that there have been very few long-term vegetation studies, it is simply not known how normal it is for species compositions to vary greatly from time to time in some habitats. Plant communities are very dynamic and it may be quite natural to see frequent population swings in many species (DeLoach, 1991). Added to this dynamic nature of the natural ecosystem, much of the landscape across the country has been and continues to be modified to a greater or lesser extent. Hence we should expect a constantly changing

vegetational pattern, as species, each with its own microclimatic preferences and reproductive abilities, fights for survival under constantly changing conditions.

The Problem of Invasive Aliens

There are many alien plants in Canada. Kaiser (1983) reported that approximately 700 species (27% of the total flora) growing in Ontario are alien. Alien plants may not always be invasive-the vast majority of alien species consist of ephemeral garden escapes, dooryard weeds, and scarcely persisting seed mixture contaminants that do not pose a problem in natural areas because they are restricted to urban areas, agricultural fields, and other highly disturbed sites. Other alien species, such as dandelion (*Taraxacum officinale*) or the helleborine orchid (*Epipactis helleborine*), do grow in natural areas but they occur in small numbers and do not appear to displace or significantly compete with the native flora. Finally, there is a small group of primarily alien species that has the ability not only to grow in natural areas but to thrive in them and to do so at the expense of the original native flora. It is these species that are a cause for concern and the subject of the present report.

Invasive aliens can have a number of impacts upon a natural area (Bratton, 1982; DeLoach, 1991; Harty, 1986; Hester, 1991). These impacts can be on the natural area itself or they can be on the human use or enjoyment of this area. When an invasive alien, such as purple loosestrife, becomes established in a natural area, it displaces some of the existing native plants. In extreme infestations, there may be a loss of most of the original vegetation (Balogh and Bookhout, 1989; Hanna, 1989). This original vegetation would have supported a complex suite of animals that fed upon or reproduced within this plant community. When the community is taken over by purple loosestrife, many of the animals are displaced along with their host plants, since purple loosestrife appears to have few consumers among North American fauna-muskrat cannot use purple loosestrife for food, and many birds, such as grebes and terns, will not nest in it (Hemphill, 1991). The species displaced may include rare native flora and fauna that could be seriously threatened by purple loosestrife invasion (Moore and Keddy, 1988; Thompson *et al*., 1987).

There are other plants, such as reed canary grass (*Phalaris arundinacea*), that are native but have been introduced for forage as commercial cultivars from Eurasia and have spread widely from these introductions (Apfelbaum and Sams, 1987). Because reed canary grass is both native and introduced, the spread of alien stock has aroused little concern. The establishment and spread of the Eurasian cultivars could genetically 'swamp' the native populations and ultimately eliminate the native genotype in many areas.

The alien white mulberry (*Morus alba*) is a threat to the native and nationally threatened red mulberry (*Morus rubra*) because they hybridize, and this 'genetic swamping' could eliminate the native red mulberry (Ambrose, 1987).

Infestations of alien plants can also have direct impacts on human use of a natural area (Bratton, 1982). Eurasian watermilfoil (*Myriophyllum spicatum*) has aggressively taken over many lake shorelines and slow-moving rivers in Ontario and southern British Columbia (Aiken *et al*., 1979; Newroth, 1985). Human use and enjoyment of these areas for recreation, travel, and drinking water has been severely affected. Dense colonies of the plant create a safety risk for swimmers (Newroth, 1985). In the United States, dense stands of this plant pose a public health risk because they create a multitude of protected 'pools' that provide ideal breeding conditions for a mosquito (*Anopheles quadrimaculatus*)-a known vector for malaria and encephalitis (Bates *et al*., 1985).

There are many reasons why there are considerable problems with invasive species in natural areas and why such problems appear to be increasing rather than decreasing. Most alien species are adapted to habitats that have been disturbed in some way. This disturbance for a wetland could be in the form of changes in the regime of water level fluctuations as a result of flood control measures, for an upland forest it could be encroaching clearing of adjacent lands that changes the local microclimate, or for a prairie it could be long-term fire suppression necessary to protect private property. Whatever the disturbance, the effect is to create an instability in the forces and conditions operating on a dynamic community that leaves the habitat under stress and prone to colonization by opportunistic plants, be they native or alien. Native species may be declining in these areas due to the spread of the invasive aliens or they could be declining because of the same disturbance factors that were favouring the spread of the aliens. It should be expected that such problems will only increase as new aliens, now here in only small numbers, adapt to local conditions with time and become invasive. In addition, due to the extensive world-wide exchange of goods, one must expect a steady stream of new arrivals, some of which will ultimately join the ranks of invasive aliens in natural areas.

Control of Invasive Aliens

In addressing the problem of invasive aliens in natural areas, there are many aspects to consider. Clearly, control efforts must balance improvement of the community against the damage caused by the management methods (Heidorn, 1991). To accomplish this, Thomas (1986) considers it necessary to monitor and survey both the exotic and its associated species in order to document the results of any management or control methods. Management should first be done on trial plots that are set up to allow statistical and biological analysis of the methods to ensure that they provide effective control with minimum environmental damage (Thomas, 1979; Thomas, 1986).

Some would argue that in the long run it is futile to try to control invasive species because: (1) they are for the most part well established; (2) the use of chemical herbicides in natural areas may have greater negative impacts on the natural area than the presence of the invasive species; (3) the successful removal of an established invasive species from an area might be more disruptive to the habitat than the *status quo* (Hanna, 1984; Whelan and Dilger, 1992); and (4) given time, some species may decline without human intervention (Crowder, 1991a; Hanna, 1984) as native diseases and predators respond to the new species and populations of the invasive plant decline to acceptable levels.

Natural areas that are most affected by invasive species are often under stress from disturbances such as air and water pollution, and habitat fragmentation (botanist survey comments). Programs that reduce these disturbances might be more effective in the long run in re-establishing natural conditions in an area than attempting to remove aliens that are more of a symptom than the basic problem. Of course, trying to reduce disturbances to natural areas, especially in areas of extensive landscape modification, such as southern Ontario or southern British Columbia, could be a very long and extremely difficult process. Short-term programs, which simply remove the offending aliens, could 'buy time' for the longer term solutions to be put in place. A community that has been invaded by an alien plant may require habitat restoration after the exotic has been removed to favour native species and prevent re-establishment of the alien or the establishment of another exotic (Thomas, 1986).

Another consideration is which species should receive highest priority if control programs are desirable? Well-established species, such as purple loosestrife, are having the greatest impact on natural areas; however, it may be impossible to eradicate them. Control programs for such well-

established species would have to be large and widespread to have a significant impact. Species that are presently limited in impact or distribution could be controlled with less effort; however, it may be very difficult to determine which of these species are destined to become major problems and which are simply additional members of the flora. Another aspect to consider is on which populations of an invasive species to concentrate control efforts. Moody and Mack (1988) show that where there is a large colony of an alien in an area (the main focus) and a number of small satellite colonies, it is more critical to vigorously suppress these small satellite colonies than the main focus.

A high priority might be to attempt to prevent future invasions of alien plants by instituting more effective programs to better keep out aliens. As well, rather than focusing on particular species that require control, it might be more effective to concentrate on certain habitats or rare species that are at greatest risk from invasive aliens.

A ranking system was developed for alien plants in Indiana (Hiebert and Klick, 1988). This system was used to set control and management priorities, and it evaluated alien species on their: significance of impact (highly ranked species occur in high quality natural areas or have large populations that invade and replace natural communities), innate ability to be a pest (highly ranked species are highly fecund, have specialized dispersal abilities, and germinate in a wide range of environmental conditions), and feasibility of control (highly ranked species are widely distributed, have extensive seed banks, and require high levels of mechanical or chemical control) (Hiebert and Klick, 1988). Point Pelee, in southern Ontario, has been invaded by a number of invasive aliens. Dunster (1990) developed a set of criteria to assess the priority for removal of these invasive plants. The criteria included: aggressiveness, reproductive success, ability to hybridize with native plants, showiness, extent of populations, and location in sensitive habitats.

The goal of a control program could be to eradicate completely a plant everywhere, it could be to eradicate it only in a specific area, or it could be to reduce its population to a level that did not significantly displace native flora and fauna.

Careful consideration must be given to the potential impact caused by the removal of an exotic species from a natural area. Whelan and Dilger (1992) report on a study of a woodland in Illinois that is infested with several exotic shrubs, including Tatarian honeysuckle (*Lonicera tatarica*) and common buckthorn (*Rhamnus cathartica*). Over a period of time, these shrubs have displaced the native shrubs, such as hazelnut (*Corylus* spp.), and some nesting birds have been forced to use the exotic shrubs as alternatives. If these aliens were now removed quickly without at the same time planting native shrubs, some songbirds could be extirpated from the area (Whelan and Dilger, 1992). Thomas (1986) cites examples of management practices that were used to combat one invasive alien that resulted in stand disturbance sufficient to allow a second alien to become established that had a greater negative impact on the habitat than the impact caused by the initial infestation.

In order to be successful, a control program against an invasive plant must take into account a wide range of extensive life history information about that plant. An effective control program for a species such as Eurasian watermilfoil, which spreads by vegetative reproduction, would be vastly different from a program designed to control a species that reproduces by seed production, such as purple loosestrife. A program to eradicate a newly established invasive species could be highly concentrated and intensive. For an established species, such a program would be too costly and might entail environmental damage over an unacceptably wide area.

There has been pressure from a number of groups for governments to declare invasive aliens, especially the most widespread and aggressive species such as purple loosestrife, to be 'noxious

weeds'. This would have the effect of requiring municipal and other levels of government to control or eradicate the species in their jurisdiction.

It is not clear, however, what is to be gained by declaring species to be noxious weeds in advance of the development of effective methods of control. If municipalities were required to control or eliminate extensive stands of purple loosestrife using the current tools available (herbicide application and physical removal), there could be widespread negative environmental effects while achieving very limited long-term control.

Natural area managers in Canada are realizing that policies and action plans must be developed to deal with the problem of invasive aliens of natural areas if these natural areas are to fulfil one of their primary objectives, i.e., to protect and preserve examples of Canada's natural heritage. Recent amendments to the *National Parks Act* make the "maintenance of ecological integrity [of the natural resources of National Parks]" a first priority. Canadian Parks Service Policy emphasizes "the perpetuation of a natural environment essentially unaltered by human activity" and states that efforts will be made to remove non-native species from National Parks (Achuff *et al*., 1990; Geomatics, 1992).

Control Program Alternatives

There are five principal control methods: the use of chemical herbicide, physical removal, the use of biological agents, prescribed burning, and ecological or integrated pest management. In judging which method is most appropriate, consideration must be given to the short-term and long-term effectiveness against the target species, possible side effects on the native flora and fauna of the area, and possible short-term and long-term effects on human use of the area, such as contamination of drinking water supplies.

In evaluating possible control programs, a prime consideration must be the degree of control that is possible or appropriate for a particular species at a particular site. Purple loosestrife, for example, is so well-established, so widespread, and so prolific, that it would be impossible to totally eliminate it from North America. It might be possible, however, to either reduce its impact in large areas with an effective biological control program, or to eliminate it from small, highly significant or sensitive areas, or areas where it was not well-established (Thompson *et al*., 1987). For such a species, effective control might consist of elimination from highly significant sites with a low population of purple loosestrife present, to simple containment of the species in large sites with an extensive population (Thompson *et al*., 1987; Keddy, 1990). For a species that is much more limited in distribution, such as European birch (*Betula pendula*), it might be possible, with a vigorous and concentrated effort, to eliminate the species before it becomes widespread and beyond total control.

Herbicide control, involving the application of toxic chemicals to invasive aliens, has been used extensively in the past against a number of species with mixed results. Herbicides can be quite effective against species such as Eurasian watermilfoil which spreads vegetatively and overwinters as buds that can probably last only one season (Bates *et al*., 1985; Newroth, 1985; Truelson, 1985). During the growing season such a species has all of its potential propagules growing and hence is vulnerable to herbicide. Unfortunately, the species was well-established in many areas before control methods were tried and it was impossible to treat all infested sites. Thus, areas treated with herbicide were subsequently re-infested from non-treated areas (Bates *et al*., 1985; Newroth, 1985). Herbicides have also been tried against species such as purple loosestrife that spreads by profuse seed production. These seeds are relatively long-lived and germinate sporadically, and hence the seed bank of an established population of such a plant is

at little risk since it is not affected by a control program that removes only the current year's standing crop of growing plants. Growing concern regarding the environmental and human safety of using herbicides have greatly curtailed their use for controlling invasive aliens (Hanna, 1989; Newroth, 1985). In natural areas, herbicide use may result in the loss of native species and produce a questionable net benefit (Steuter, 1983). One of the most effective ways of removing some shrubs and trees is to cut them down and apply herbicide to the cut stump. This method eliminates most shoot and root sprouting, and if done carefully at the right time of year, will have very little effect on associated native species (Chapman, 1983; Dunster, 1990; Heidorn, 1991; Kline, 1983). The use of herbicides in National Parks is recommended only as a last resort under strict conditions (Achuff *et al*., 1990).

Physical control methods have been used against a number of species with at least short-term success. These methods involve a range of devices from harvesters and tillers to dredges (Bates *et al*., 1985; Newroth, 1985; Truelson, 1985). Also included in this category is flooding and de-watering (Bates *et al*., 1985) and 'hand weeding', which can be effective in limited areas (Darbyshire, 1985; Fuller and Barbe, 1985; Dunster, 1990). Most mechanical devices cut or dislodge the plant and often remove from the habitat most harvested material. Eurasian watermilfoil has been extensively harvested and tilled, especially in southern British Columbia (Newroth, 1985; Truelson, 1985). Unfortunately, this species spreads by vegetative growth of plant fragments and these harvesters typically produce large amounts of viable fragments that can either re-infest the harvested area or spread to new sites. In addition, many such methods cause gross environmental disturbance that might be worse than the disturbance caused by the presence of the invasive species.

Prescribed burning involves the use of fire to kill unwanted species. Timing of the fire is very critical in order to control the unwanted alien and at the same time leave the desired native species unharmed. Fire is most effective against shrubs or young trees that are invading open habitats, such as prairies, alvars, or savannas. It is also an option for the control of garlic mustard (*Alliaria petiolata*) in woods (Nuzzo *et al*., 1991). Fire would not be a recommended control option near built-up areas because of the risk to life and property.

Biological control methods involve introducing living organisms, such as insect herbivores or disease organisms, into populations of an invasive species in order to reduce the invasive species' vigour, reproductive capacity, or density (DeLoach, 1991; Harris, 1989). These agents are generally found in the natural range of the invasive species and help keep its population in check (Drea, 1991). Often, one of the primary reasons an alien species has been able to reach invasive proportions is because it was introduced into its new area without its normal control agents (DeLoach, 1991; Drea, 1991). If the new area did not support 'generalist' insect herbivores or disease organisms that could take the place of the alien's natural predators, the alien was often able to increase its population dramatically and become invasive (Drea, 1991). Early efforts to control invasive aliens with biological agents have seen mixed success (DeLoach, 1991). In some cases, the control agent was not able to survive in the new area in sufficient numbers to have the desired effect. In other cases, the control agent found native species more to its liking and itself became invasive. To be effective a biological control agent must meet a number of conditions that relate to host specificity, degree of damage inflicted, timing of damage to occur at a vulnerable stage in the host's life cycle, degree of fecundity of the agent, degree of immunity of the agent to attack by native predators, and compatibility with other established or potential control agents (Harris, 1973). Carefully chosen, host specific control agents offer perhaps the best promise for lasting and economical control of some of our invasive aliens (DeLoach, 1991). In addition, biological control methods are much less intrusive on natural areas than chemical or mechanical control methods (DeLoach, 1991).

Rigorous screening tests are performed on all candidate biocontrol agents to make sure they will

not attack plant species other than the targeted weed. This is done before they are released (usually by the International Institute of Biological Control in Europe). Canada has an excellent record in this process. Out of 59 insect agents imported and released on 21 different weed species in Canada since the 1950s, none have 'moved' onto other plant species or have become troublesome (R. DeClerck-Floate, pers. com., 1992).

Generally, biological control methods are not capable of exterminating the host species; rather they tend to reach an ecological balance with their host that ideally will limit the effects of the invasive alien to an acceptably low level (Drea, 1991; Hight and Drea, 1991). Biological control programs will probably concentrate, for the foreseeable future, on invasive species that are having a significant effect on agricultural production due to the very high cost and length of time needed to develop such programs (Peschken, 1979). Although economic crops will be the main focus of biological control programs, such programs may prove more effective in natural areas than in agricultural land because many insects and plant pathogens survive the dormant season in plant residue that is normally removed or destroyed by cultural practices in field crops (Mortensen, 1986).

There are a number of aliens that are invasive in natural areas that are also forage crops, such as smooth brome grass. Because of their agricultural value it is unlikely that invasive agricultural species could be candidates for biological control programs.

Phytotoxins are another approach that can be used. Phytotoxins are compounds produced by microorganisms that are toxic to plant pests. The toxic compounds could be produced by maintaining laboratory colonies of the microbe and extracting the compound; or the compounds could be synthesized (Strobel, 1991). The obvious advantage of this approach is that no living organism is introduced into the environment that could later prove harmful to other plants, be they native or economic. The disadvantage is that there is no living organism that could become established and spread widely to effect control with no further intervention after initial release. The approach of using phytotoxins to control weeds is in an early stage of development although one compound that is specific to the invasive alien spotted knapweed (*Centaurea maculosa*) has already been identified and synthesized (Strobel, 1991).

Ecological or Integrated Pest Management involves combining elements of the above four methods with preventative measures, increased knowledge of the target species biology and ecology, and restoration of the biotic and abiotic components of a habitat before or concomitant with the removal of the invasive exotic (Achuff *et al*., 1990; Thomas, 1986; Thomas, 1991). Invasion of a community by an alien plant usually occurs because that community has been disturbed, either in terms of its vegetation structure, composition, or its topography (Thomas, 1986). For an exotic to be successfully removed from a community, the disturbance factor that allowed the alien to invade in the first place must be removed and the habitat restored to as near to its original condition as possible (Thomas, 1986). This habitat restoration can involve restoring the native dominants, filling vacant niches with natives, restoring natural densities, restoring age and class structures, and correcting any disturbed physical conditions (Thomas, 1986). If these steps are not taken, the removal of an exotic species may be followed by either reinvasion or establishment of another exotic (Thomas, 1986). Integrated pest management is the approach recommended for use against invasive aliens in Canada's National Parks system (Achuff *et al*., 1990).

Methodology

The present study was undertaken in order to research and document the occurrence of invasive species of natural habitats in Canada. The study consisted of a review of relevant literature and the soliciting of opinions from a wide range of botanists across Canada.

Literature Review

The computer database search facilities of the Canadian Museum of Nature were utilized to locate relevant literature, through the database BIOSIS, on the problem of invasive species in general and on a number of invasive plants in particular. A number of more local journals, such as *The Plant Press*, *Restoration and Management Notes*, and *Seasons*, were reviewed for relevant information. Additional articles were brought to our attention by respondents to the survey. A range of floras and monographic treatments supplemented the above literature.

In 1985, an Ontario journal, *The Plant Press*, solicited opinions from its readership on which species were invasive aliens in their region of the province. Between 50 and 60 readers replied to the survey (J. Kaiser, pers. com., 1992). Thirteen species of upland and wetland habitats were identified by at least 10% of the respondents and the list of these species, along with the region affected, was published in Kaiser (1986). This survey provided useful information on the problem of invasive aliens in Ontario.

Botanist Survey

In the early stages of the present study, a survey form was prepared to help assess the impact and extent of a number of potential invasive species-both native and introduced (Table 1). This preliminary list of invasive species, from both wetland and upland habitats, was developed from a preliminary survey of recent literature and the authors' previous field experience. Since the list was sent to fellow botanists, the plant names were arranged alphabetically by scientific name. In order to satisfy a more general reader, the plant names throughout this report are arranged alphabetically by common name.

Table 1: Survey Form for Invasive Species

INVASIVE SPECIES	HABITAT AFFECTED	DEGREE OF IMPACT	EXTENT OF IMPACT	STATUS

	Wetland	Upland Forest	Alvar/Prairie	Severe	Moderate	Limited	Widespread	Local	Spreading	Stable
Absinth (*Artemisia absinthium*)	0	0	0	0	0	0	0	0	0	0
Black locust (*Robinia pseudo-acacia*)	0	0	0	0	0	0	0	0	0	0
Canada thistle (*Cirsium arvense*)	0	0	0	0	0	0	0	0	0	0
Cattail (*Typha latifolia*)	0	0	0	0	0	0	0	0	0	0
Celandine (*Chelidonium majus*)	0	0	0	0	0	0	0	0	0	0
Common buckthorn (*Rhamnus cathartica*)	0	0	0	0	0	0	0	0	0	0
Dame's rocket (*Hesperis matronalis*)	0	0	0	0	0	0	0	0	0	0
Dog-strangling vine (*Cynanchum spp.*)	0	0	0	0	0	0	0	0	0	0
Eurasian Watermilfoil (*Myriophyllum spicatum*)	0	0	0	0	0	0	0	0	0	0
European birch (*Betula pendula*)	0	0	0	0	0	0	0	0	0	0
European Frog-bit (*Hydrocharis morsus-ranae*)	0	0	0	0	0	0	0	0	0	0
Flowering-rush (*Butomus umbellatus*)	0	0	0	0	0	0	0	0	0	0
Garlic mustard (*Alliaria petiolata*)	0	0	0	0	0	0	0	0	0	0
Glossy buckthorn (*Rhamnus frangula*)	0	0	0	0	0	0	0	0	0	0
Goutweed (*Aegopodium podagraria*)	0	0	0	0	0	0	0	0	0	0
Hawthorn (*Crataegus spp.*)	0	0	0	0	0	0	0	0	0	0
Hoary-alyssum (*Berteroa incana*)	0	0	0	0	0	0	0	0	0	0
Leafy spurge (*Euphorbia esula*)	0	0	0	0	0	0	0	0	0	0
Lilac (*Syringa vulgaris*)	0	0	0	0	0	0	0	0	0	0
Manitoba maple (*Acer negundo*)	0	0	0	0	0	0	0	0	0	0
Moneywort (*Lysimachia nummularia*)	0	0	0	0	0	0	0	0	0	0
Mullein (*Verbascum thapsus*)	0	0	0	0	0	0	0	0	0	0
Multiflora rose (*Rosa multiflora*)	0	0	0	0	0	0	0	0	0	0
Norway maple (*Acer platanoides*)	0	0	0	0	0	0	0	0	0	0
Periwinkle (*Vinca minor*)	0	0	0	0	0	0	0	0	0	0
Purple loosestrife (*Lythrum salicaria*)	0	0	0	0	0	0	0	0	0	0
Ragweed (*Ambrosia artemisiifolia*)	0	0	0	0	0	0	0	0	0	0
Red cedar (*Juniperus virginiana*)	0	0	0	0	0	0	0	0	0	0
Reed canary grass (*Phalaris arundinacea*)	0	0	0	0	0	0	0	0	0	0
Reed grass (*Phragmites australis*)	0	0	0	0	0	0	0	0	0	0
Scots pine (*Pinus sylvestris*)	0	0	0	0	0	0	0	0	0	0
Scouring-rush (*Equisetum hyemale*)	0	0	0	0	0	0	0	0	0	0
St. John's-wort (*Hypericum perforatum*)	0	0	0	0	0	0	0	0	0	0
Sweet-clover (*Melilotus spp.*)	0	0	0	0	0	0	0	0	0	0
Tatarian honeysuckle (*Lonicera tatarica*)	0	0	0	0	0	0	0	0	0	0
Teasel (*Dipsacus spp.*)	0	0	0	0	0	0	0	0	0	0
White poplar (*Populus alba*)	0	0	0	0	0	0	0	0	0	0

The survey form was sent out to 42 botanists across Canada. Recipients of the form were requested to: evaluate the impact in their area of the listed potentially invasive species, to add any species to the list that they felt were also invasive, and to add any additional information or comments that they felt were relevant. Responses were received from 35 botanists.

It must be pointed out that the survey is in no way a scientifically-based opinion poll from which could be drawn quantitative data on the current impact of invasive species. The botanists chosen to receive the questionnaire were selected from those known by the authors. Although requests were sent out to botanists across Canada, no attempt was made to ensure 'equal regional representation'. It may be that a disproportionate number were sent to Ontario botanists. In addition, the field experience, knowledge, and perceptions of the respondents differ widely. Nonetheless, the survey data represent a large amount of up-to-date field experience across a wide range of natural areas in Canada. If the data are interpreted cautiously, valuable information can be gleaned from the survey results.

Table 2 presents a compilation of the survey responses for wetland species. Table 3 presents the responses for upland species. The second column of the tables lists the number of responses from people who either didn't know a particular species; didn't feel it was invasive in their area; didn't feel it was invasive in wetlands-in the case of Table 2, or uplands-in the case of Table 3; or lived in an area where the species did not occur. For some species, some respondents only completed part of the impact, thus the number of entries in a section does not always add up to the total number of returned survey forms.

Table 2: Survey Responses for Invasive Wetland Species

INVASIVE WETLAND SPECIES	IMPACT EVIDENT							
		Degree			Extent		Status	
	IMPACT NONE OR UNKNOWN	Severe	Moderate	Limited	Widespread	Local	Spreading	Stable
European birch * (*Betula pendula*)	14	9	9	3	12	7	14	5
European Frog-bit (*Hydrocharis morsus-ranae*)	26	1	3	5	-	7	5	3
Flowering-rush (*Butomus umbellatus*)	17	7	9	2	8	8	15	2
Glossy buckthorn * (*Rhamnus frangula*)	16	10	7	2	11	8	17	1
Moneywort (*Lysimachia nummularia*)	13	1	8	13	8	15	12	10
Purple loosestrife (*Lythrum salicaria*)	-	23	9	3	27	5	27	5
Reed canary grass (*Phalaris arundinacea*)	11	7	11	6	15	8	10	11
Scots pine * (*Pinus sylvestris*)	32	1	2	-	-	3	3	-

** These scores relate to species impact on **wetland** habitats only - see Table 3 for it's impact on uplands.*

Table 3: Survey Responses for Invasive Upland Species

INVASIVE WETLAND SPECIES	IMPACT EVIDENT		
	Degree	Extent	Status

	IMPACT NONE OR UNKNOWN	Severe	Moderate	Limited	Widespread	Local	Spreading	Stable
Absinth (*Artemisia absinthium*)	24	1	-	10	1	8	3	8
Black locust (*Robinia pseudo-acacia*)	14	3	4	14	3	17	6	13
Canada thistle (*Cirsium arvense*)	16	1	13	5	17	2	15	4
Celandine (*Chelidonium majus*)	13	1	3	18	6	15	6	13
Common buckthorn (*Rhamnus cathartica*)	11	10	6	8	9	15	18	4
Dame's rocket (*Hesperis matronalis*)	13	1	9	12	10	12	12	8
Dog-strangling vine (*Cynanchum spp.*)	23	9	-	3	1	8	10	2
European birch * (*Betula pendula*)	30	-	-	5	-	5	2	3
Garlic mustard (*Alliaria petiolata*)	15	13	4	3	12	7	17	3
Glossy buckthorn * (*Rhamnus frangula*)	21	5	5	4	9	8	14	2
Goutweed (*Aegopodium podagraria*)	15	2	-	18	-	18	8	6
Hoary-alyssum (*Berteroa incana*)	22	-	4	9	2	9	6	6
Leafy spurge (*Euphorbia esula*)	24	3	4	4	5	6	6	6
Lilac (*Syringa vulgaris*)	16	-	6	13	2	16	2	15
Manitoba maple (*Acer negundo*)	12	-	9	14	10	16	12	12
Mullein (*Verbascum thapsus*)	15	-	6	14	10	8	2	17
Multiflora rose (*Rosa multiflora*)	22	-	7	6	4	10	7	6
Norway maple (*Acer platanoides*)	24	3	3	5	1	9	8	2
Periwinkle (*Vinca minor*)	13	3	4	15	-	20	6	13
Ragweed (*Ambrosia artemisiifolia*)	17	1	8	9	14	3	6	11
Scots pine * (*Pinus sylvestris*)	20	1	5	9	3	12	6	8
St. John's-wort (*Hypericum perforatum*)	17	1	9	8	14	3	8	9
Sweet-clover (*Melilotus spp.*)	12	3	13	7	20	3	11	20
Tatarian honeysuckle (*Lonicera tatarica*)	12	-	14	9	9	12	12	9
Teasel (*Dipsacus spp.*)	26	-	3	6	5	6	1	9
White poplar (*Populus alba*)	21	1	3	10	2	12	8	6

** These scores relate to species impact on **upland** habitats only - see Table 2 for it's impact on wetlands.*

Although one should not try to read too much into the data in Tables 2 and 3, there are a number of interesting comparisons that can be made. For example, the perceived impact of moneywort compared to that of purple loosestrife in Table 2 is very different: the latter was rated primarily as having a severe to moderate, widespread impact that is continuing to spread; the former was ranked as having only a limited to moderate impact, that was rated evenly as having a widespread versus local extent and whose population is mostly stable.

The survey also included several native species that are known to be invasive. Although many of these native species do displace other native plants, some of which may be rare already, most survey respondents felt that invasive native species did not constitute a problem because they were part of the natural order and that they were simply being successful.

General Contact Us from Survey

As well as filling in the survey table, many respondents also included additional comments on a range of items from species that should be added to the list of invasive plants to considerations of the general problem of invasive plants and to what degree they pose a threat to native species in natural areas. Contact Us by respondents from different parts of a species' range often reflected very different perspectives of the invasiveness of that species.

The following is a summary of relevant comments. Wetland species that were suggested by respondents as additions to the list are dealt with in the Minor Invasive Aliens section. Upland species that were suggested as additions to the list are dealt with in the Moderate Invasive Aliens and Minor Invasive Aliens sections.

- most who commented, felt that invasive **native** plants are not a problem because they are native and their increases are part of the natural 'boom and bust' cycle of a natural system.

- some who commented, felt that most invasive aliens, with the exception of purple loosestrife, were having a limited effect on native species. Others felt that it wasn't clear to what extent most exotic species were actually significantly displacing native species. In many cases, the successful exotics may be simply adding to the number of species present. Still others felt that invasive aliens were a great problem in natural areas and action was urgently needed.

- an invasive alien with a wide range might be affecting native species in only a portion of that range.

- natural areas that were truly **natural** and essentially undisturbed had few problems with invasive aliens. The greatest problems occurred in natural areas that were located close to urban centres and hence were being disturbed by a number of human-induced factors, including the proximity to seed sources of a range of exotic species.

- some invasive aliens might ultimately be brought under control without human intervention by existing native plant consumers and diseases responding or adapting to the new 'food source' and increasing their populations to match those of the alien.

- control measures need to address the problem of why many aliens are becoming invasive; i.e., human disturbance to the environment. Reducing this disturbance would go a long way toward reducing the populations and effects of invasive aliens that are simply taking advantage of an unnatural situation.

- aquatic and semi-aquatic habitats may be at greatest risk from invasive aliens since natural disturbances, like yearly spring flooding, summer drawdown, and ice-push damage, may be enough of a disturbance to enable many aliens to successfully colonize a natural area. Upland areas are most affected by invasive aliens when there has been some human-induced disturbance.

- with the exception of purple loosestrife, few alien species are presenting a serious threat to the plant communities of natural habitats. The problem with invasive aliens is primarily the result of human disturbance of habitats that creates a niche that can be exploited.

- many invasive species are only a problem because man has limited the natural controls (normal water level fluctuations, wildfire, etc.) that would periodically check their spread.

- most natural communities are too well balanced, and their species too well adapted to the conditions in these communities, to be seriously affected by new arrivals. The exception to this is habitats that are naturally disturbed, such as shorelines.

- the problem of invasive species is caused by the human altering of habitat and the maintenance of the disturbed habitat. Spending energy and resources trying to control well-established species, such as purple loosestrife, is both futile and wasteful.

Mapping

Maps were compiled from information in published manuals and floras, and to a lesser extent from specimens at the Canadian Museum of Nature, Central Experimental Farm of Agriculture Canada, and various university collections. Maps in this publication are based on originals prepared by Erich Haber on a desktop computer mapping system.

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Canada

Wetland Species Accounts

The wetland invasive species have been divided into two levels of invasiveness-principal and minor. Principal Invasive Aliens contains the species of wetland habitats that are considered to pose the greatest threat to natural areas. Minor Invasive Aliens contains the species that are considered to be only minor problems. Both groups are listed below.

Minor Invasive Aliens

The following section presents a summary of relevant information on a number of alien species that appear at present to pose only a minor or local threat to wetland natural areas. Some of these species were listed in the botanist summary table, however, many were additional species suggested by respondents as constituting a problem in their area.

Among the additional plants suggested as potentially invasive aliens of wetlands by respondents of the botanist survey, were bouncing bet (*Saponaria officinalis*) and sow-thistle (*Sonchusarvensis*). These two aliens, however, are generally regarded as weeds of urban and agricultural land and are not discussed further in this report.

Angelica (*Angelica sylvestris* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in New Brunswick wetlands. It has long been

known from Cape Breton County, Nova Scotia and may also occur in Quebec (Scoggan, 1978-79).

Black alder (*Alnus glutinosa* (L.) Gaertner) was not on the list for botanist survey as sent out, however, several respondents reported it as being a problem in a number of southwestern Ontario wetlands. It has recently been recorded in southeastern Ontario (Garwood, 1986). It also occurs in Nova Scotia and Newfoundland (Scoggan, 1978-79).

Curly pondweed (*Potamogeton crispus* L.) was not on the list for botanist survey as sent out, however, several respondents reported it as being a problem in a number of southwestern Ontario wetlands. It occurs across southern Ontario as well as at the southern end of Lake Superior (Montgomery, 1956).

European birch (*Betula pendula* Roth) was reported in the survey by most respondents as not being a problem in wetlands. Those who did regard it as a problem considered it to be a limited problem of a local nature that is spreading. Contact Us included European birch being a problem only in southwestern Ontario and in British Columbia wetlands. Riley (1989) describes its invasion of the Wainfleet bog in southwestern Ontario where it is displacing most of the existing native flora. Mosquin and Whiting (1992) regard European birch to be one of five invasive alien plants that have had a major impact on natural ecosystems in Canada. It also occurs in Manitoba, Prince Edward Island, and Nova Scotia (Scoggan, 1978-79).

Floating heart (*Nymphoides peltatum* (S.G. Gmelin) Kuntze) was not on the list for botanist survey as sent out, however, one respondent reported it as being a potential problem in that it is growing in a pond connected to the Rideau River very close to the original site of the introduction of European frog-bit. Floating heart has become established in a number of locations in the eastern United States (Gleason, 1968).

Great manna grass (*Glyceria maxima* (Hartman) Holmberg) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in a number of southern Ontario wetlands. Great manna grass occurs in southern Ontario with a concentration in the southeastern part of the province (Montgomery, 1956; Dore and McNeill, 1980). It also occurs in Alberta and Newfoundland (Scoggan, 1978-79).

Marsh cress (*Rorippa amphibia* (L.) Besser) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in a number of Quebec wetlands. Marsh cress occurs in southeastern Ontario and southwest Quebec (Scoggan, 1978-79).

Moneywort (*Lysimachia nummularia* L.) occurs across eastern Canada (Ray, 1956), however, the majority of the respondents to the survey rated it as a limited problem of a local nature. Opinion was divided as to whether it is spreading or stable. Contact Us included: Moneywort is generally uncommon and does not form the dense monocultures typical of purple loosestrife. Moneywort was listed in *The Plant Press* survey as a problem in southwestern Ontario (Kaiser, 1986). It also occurs in Nova Scotia and Newfoundland (Scoggan, 1978-79). It is considered to be a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). In the United States the plant is not considered to be a problem in high quality natural areas (Kennay and Fell, 1992). In more disturbed natural areas, burning in spring or fall, hand pulling, flooding, and use of herbicides are possible control methods (Kennay and Fell, 1992).

Scots pine (*Pinus sylvestris* L.) has been widely planted in the past in Canada and has frequently escaped to old fields, roadsides, open bogs, and open woods. The majority of the respondents to the survey did not consider Scots pine to be a problem. Those who did consider

it to be a problem rated it as moderate, local, and spreading. Riley (1989) describes the invasion of two bogs by Scots pine: the Luther Bog and the Farlain Bog, both in southern Ontario. Scots pine was listed in *The Plant Press* survey as a problem in central Ontario (Kaiser, 1986), however, this may refer to upland habitats.

Yellow flag (*Iris pseudacorus* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in a number of southwestern Ontario wetlands. Harty (1986) and Thomas (1980) reported it to be a problem in Washington, D.C. Thomas (1980) discusses its impacts, ecology, and management options. In Canada it occurs in British Columbia and Manitoba to Newfoundland (Cody, 1961; Scoggan, 1978-79).

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Canada

Eurasian watermilfoil

(*Myriophyllum spicatum* L.)

Alternate Common Name

Spiked water-milfoil, Eurasian water-milfoil

Taxonomic Overview

Myriophyllum is a cosmopolitan genus of about 40 species belonging to the watermilfoil family (Haloragidaceae). The generic name is derived from the Greek *myrios*, numberless and *phyllon*, leaf-in reference to the innumerable divisions of the leaves. Eurasian watermilfoil was described by Linnaeus in 1753. In the past, some authors have considered the North American native *Myriophyllum exalbescens* to be a variety or subspecies of the European *Myriophyllum spicatum*, however, current taxonomic opinion is that they should be regarded as separate species (Aiken, 1981; Aiken *et al*., 1979; Couch and Nelson, 1985). Due to its close similarity to other members of the genus, Eurasian watermilfoil can be difficult to identify (Ceska and Ceska, 1985).

Distribution

Eurasian watermilfoil is native to Europe, Asia, and Northern Africa (Couch and Nelson, 1985). It was introduced into North America and now occurs in both Canada and the United States (Couch and Nelson, 1985). It is not clear exactly how and when Eurasian watermilfoil was introduced to North America, however, it seems most likely that it was introduced at several locations in or just prior to the 1940s (Couch and Nelson, 1985). Aiken *et al*. (1979) state that the plant was introduced in the late nineteenth century in the Chesapeake Bay area, possibly in shipping ballast and that it was considered a weed species by the late 1930s, however, Couch and Nelson (1985) report that the first North American specimen was collected near Washington D.C. in 1942. The Chesapeake Bay reports are based on specimens that are presently unavailable for examination but probably contain the native *Myriophyllum exalbescens* (Couch and Nelson, 1985).

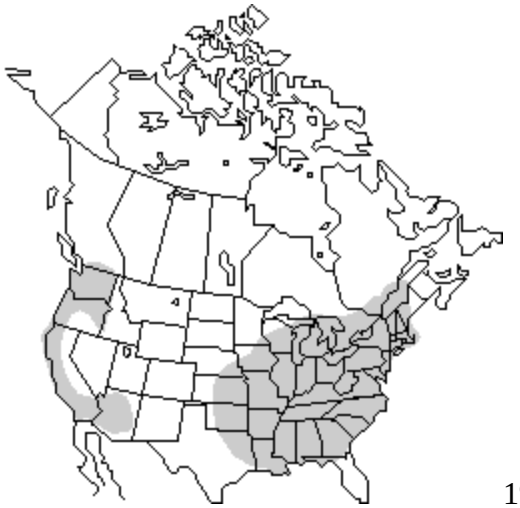
Between 1942 and 1949 the plant was collected in California and Arizona, near Washington D.C. (the earliest known North American collection), and near Lake Erie in Ohio. In Washington, it was apparently cultivated "in a pool in front of the Interior Building" (Couch and Nelson, 1985). Other sites of introduction may relate to the aquarium trade (Bates *et al*., 1985) as the species has been considered to be a useful aquarium plant (Couch and Nelson, 1985). From the initial points of introduction, Eurasian watermilfoil spread quickly by a number of agents including fishermen, boaters, and waterfowl. Within 20-30 years the plant had begun to

be regarded in many areas as a weed problem (Couch and Nelson, 1985).

In Canada, the plant was discovered in Ontario and Quebec in the 1960s, with the first Canadian collection apparently from Rondeau Provincial Park in 1961 (Aiken *et al*., 1979). It is believed to have moved into British Columbia between 1968 and 1970 (Aiken *et al*., 1979; Newroth, 1985; Warrington, 1985). By the early 1970s, the plant had become a troublesome weed in several places in Ontario and Quebec (Aiken *et al*., 1979). By 1985 the plant had become a major weed problem in parts of all three provinces (Couch and Nelson, 1985).

1950

1965



1985

Range expansion of Eurasian watermilfoil (*Myriophyllum spicatum*) in North America (after Aiken *et al*. (1979) and Couch and Nelson (1985)). Solid circles represent individual or local occurrences.

Biology

Eurasian watermilfoil is a submersed aquatic perennial herb that reproduces primarily by vegetative fragmentation (Aiken *et al*., 1979). These fragments are produced during much of the year with roots often developing on a fragment before it is 'released' by the plant (Aiken *et al*., 1979). Plants may grow in water from 0.5 to 10 m deep, however, most plants appear to grow in water 0.5 to 3.5 m deep (Aiken *et al*., 1979). Eurasian watermilfoil is rooted to the bottom and grows toward the surface. When the surface is reached, the plant branches profusely to form a dense canopy (Aiken *et al*., 1979). Flowering and seed production are common, however, the seeds exhibit prolonged dormancy and their germination is erratic (Aiken *et al*., 1979). Even in areas where the plant is common, no seedlings have been found (Bates *et al*., 1985). Vegetative reproduction is the principal means of spread (Aiken *et al*., 1979).

Ecology

Eurasian watermilfoil can quickly recolonize areas that have been cleared of the species because of the viability of even small fragments. Studies in New Jersey that involved denuding quadrats in heavily infested areas in a lake and noting the results, showed that the plant quickly recolonized the quadrats and that one year later the quadrats were indistinguishable from the controls (Aiken *et al*., 1979). Eurasian watermilfoil grows so densely that it tends to displace all other species. In the above study, no other plant colonized the denuded areas even though there were 17 other aquatic species present in the lake. When Eurasian watermilfoil colonizes an area it displaces virtually all other aquatic macrophytes (Aiken *et al*., 1979; Miller and Trout, 1985; Hanna, 1984).

One infestation of Eurasian watermilfoil in Ontario at Rondeau Bay displaced luxurious beds of native submerged aquatics in the 1960s (Hanna, 1984). The watermilfoil mysteriously died out in 1977 and left the habitat unsuitable for the recolonization by any submerged aquatics due to increased wave effect that caused erosion and prevented settling of the sediment load entering the bay (Hanna, 1984). The loss of the submerged vegetation also resulted in a significant reduction in the warm-water fishery (Hanna, 1984). Although this die-off appeared to have been caused by unknown natural causes, the effect of the collapse of the habitat and its subsequent lack of suitability for the original native species clearly have implications for control programs and their possible environmental effects.

Present Status and Potential Threat

Eurasian watermilfoil occurs in parts of British Columbia, Ontario, and Quebec and will probably continue to expand its range in Canada. The plant not only has an impact on existing native plants by largely displacing them, and possibly on fish populations by interfering with spawning (Newroth, 1985), but also on human use of the habitats, for recreational use, for water transportation, or for water reservoir use.

Infestations of the plant may create public safety problems when swimmers become entangled in dense stands of the plant, or they may create public health problems associated with increases in some mosquito populations, such as *Anopheles quadrimaculatus*, which can serve as disease vectors for malaria and encephalitis (Bates *et al*., 1985; Newroth, 1985). Mosquin and Whiting (1992) regard Eurasian watermilfoil to be one of five invasive alien plants that have had a major impact on natural ecosystems in Canada. In *The Plant Press* survey it was regarded as a problem in central and eastern Ontario (Kaiser, 1986).

Control Measures

Many methods have been tried in the United States and Canada to contain or eliminate Eurasian watermilfoil. Most of these methods have had, at best, limited success due to the plant's inherent capacity of rapid vegetative spread (Rawson, 1985). The control methods can be classified as chemical or physical. Biological control methods are still in the research and development stage.

Chemical control methods have been based primarily on the use of 2,4-D because the plant is highly susceptible to it. Regrowth can be controlled for as little as six weeks to as long as one year (Aiken *et al*., 1979). Many factors, such as water movement, type of herbicide formulation,

water temperature, timing of the application, and calcium level, affect the success of the application (Aiken *et al*., 1979; Miller and Trout, 1985). There may also be adverse effects upon the environment, such as fish kills, increased algal growth, or contamination of public water supply.

Physical control has involved the use of mechanical harvesters, underwater rototillers and cultivators, diver-operated dredges, water drawdown to allow desiccation or freezing of the plant, and the use of fragment barriers to prevent spread (Bates *et al*., 1985; Newroth, 1985).

Mechanical harvesters offer relatively fast reduction in Eurasian watermilfoil biomass, however, the plant quickly regrows and the artificial creation of a large number of fragments can enhance the spread of the plant (Aiken *et al*., 1979; Bates *et al*., 1985; Newroth, 1985). Mechanical harvesters cut and remove most of the plant and deposit the debris on land. Three or four harvests per year may be necessary to keep the plant 'under control' and it quickly grows back when harvesting is stopped (Truelson, 1985). In Ontario, Painter and Waltho (1985) reported that the timing of the harvests was very important and that two 'cuts' were adequate for short-term control if they were carefully timed during the growing season. Harvest costs are high and harvesting is hampered by the existence of debris and manmade structures (Truelson, 1985).

Underwater tilling and cultivating uproot the plants and allow them to float away which is more effective in clearing a site of Eurasian watermilfoil than harvesting (Maxnuk, 1985). It is, however, a slow and costly operation that frees a large number of plant fragments that are then able to spread to new sites (Truelson, 1985). Diver-operated dredges operate like underwater vacuum cleaners to remove plants etc. from the bottom. Such devices are also slow and costly to operate and hence only suitable for limited infestations (Newroth, 1985; Truelson, 1985).

Water level manipulation, such as drawdown or overwatering, has been used effectively in Tennessee reservoirs and found to be one of the most useful tools in the control of Eurasian watermilfoil (Bates *et al*., 1985). Drawdown in winter exposes the plants to below freezing temperatures. One study reported that only 96 hours of such exposure was required to kill Eurasian watermilfoil (Aiken *et al*., 1979). Such drawdowns in Ontario are thought to be of limited usefulness because of the potential for fish kills, damage to docks and boathouses, and the rapid re-infestation from adjacent areas (Aiken *et al*., 1979).

Fragment or bottom barriers are physical 'covers' (of window screen, polyethylene etc.) placed over the colony to prevent fragmentation spread. It has been found useful for small infestations but is expensive and requires regular maintenance (Newroth, 1985).

Quarantine programs that attempt to prevent boaters and fishermen from transporting Eurasian watermilfoil from infested to non-infested areas have been tried in British Columbia but they appear only to delay the inevitable (Newroth, 1985).

A promising new approach, still in the testing stage in 1985, involves the use of high intensity ultrasound to kill the plants in situ. This creates limited environmental disruption compared to many other methods (Soar, 1985).

Biological control programs are being studied that include a range of organisms from diseases to herbivorous fish (Aiken *et al*., 1979; Bates *et al*., 1985). The grass carp (*Ctenopharyngodon idella*) may be one of the most promising biological agents (Bates *et al*., 1985).

Survey Summary and Contact Us

The majority of the respondents to the survey rated Eurasian watermilfoil to be a moderate to severe problem of a widespread nature that is still spreading. One respondent felt that it has stabilized in many Ontario wetlands.

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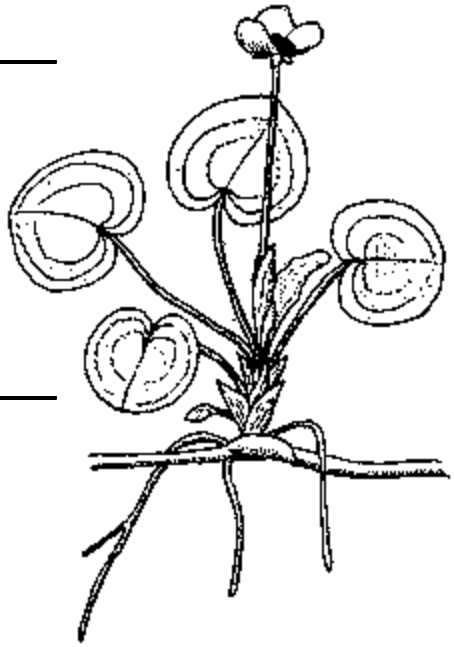
Canada

European frog-bit

(*Hydrocharis morsus-ranae* L.)

Alternate Common Name

Frog-bit, frog's-bit, frogs-bit



Taxonomic Overview

The genus consists of three to six species and belongs to the frog-bit family (Hydrocharitaceae). European frog-bit was described by Linnaeus in 1753.

Distribution

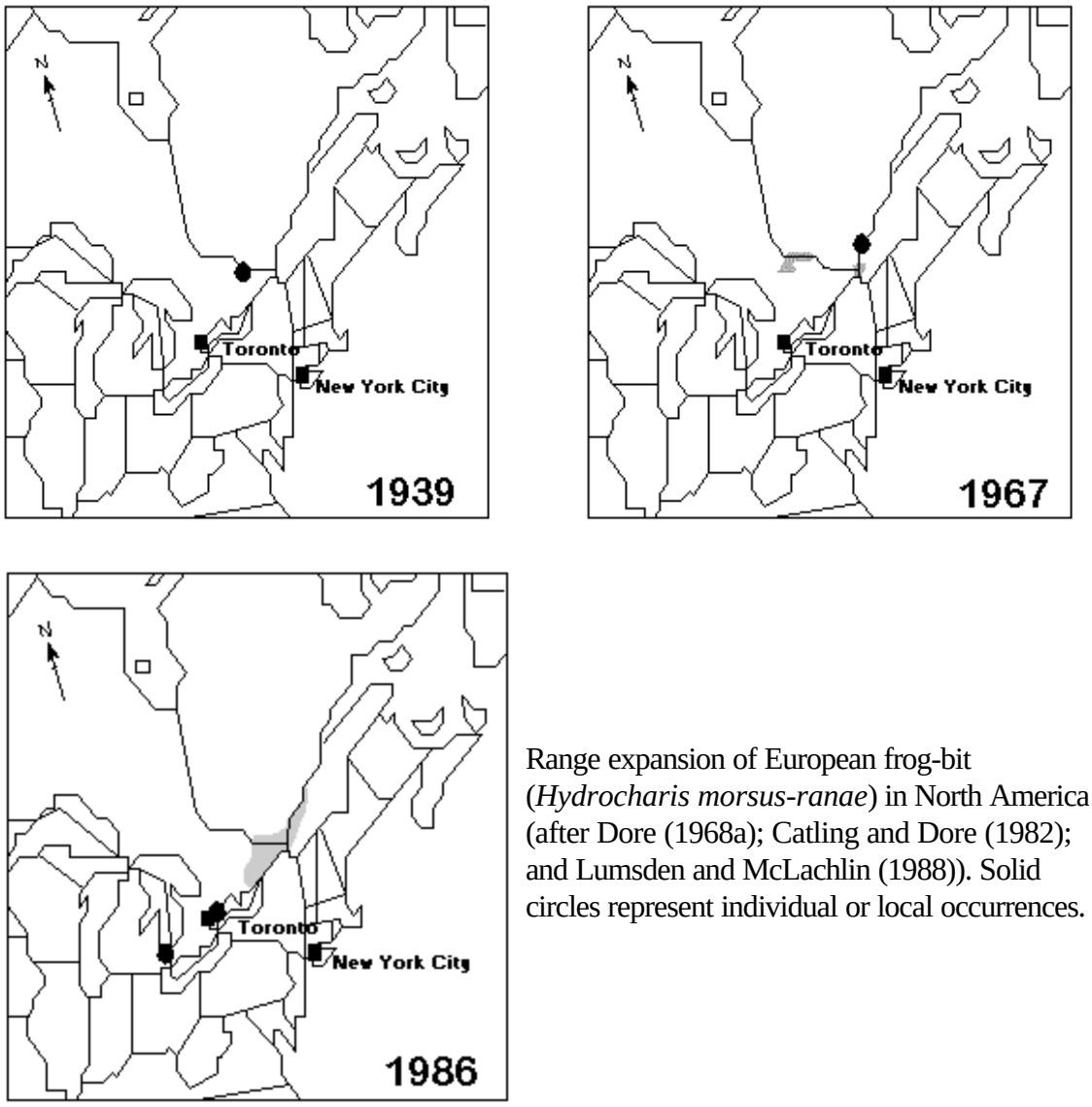
European frog-bit occurs in much of Europe and parts of Asia. In North America, it is known primarily from southeastern Ontario. It also occurs in adjacent western Quebec and to a limited extent in northern New York State. The introduction of this plant in Canada and its subsequent spread from cultivation have been well documented (Minshall, 1940; Dore, 1954; Dore, 1968a; Dore, 1968b; Catling and Dore, 1982; and Lumsden and McLachlin, 1988) and the story highlights the perils of cultivating exotic plants.

In 1932 European frog-bit was intentionally introduced for horticultural purposes to a trench or aquatic pond in the Arboretum of the Central Experimental Farm in Ottawa. The original plants, or perhaps seeds, came from the Zürich garden in Switzerland. European frog-bit grew in the original site apparently without incident until 1939 when Harold Minshall noticed that they had spread to nearby sections of the Rideau Canal and Brown's Inlet, a nearby artificial pond with underwater connections to the Canal (Minshall, 1940). By 1952 the plant had been collected in the Ottawa River at Montreal Island. This latter site may have been due to the plant travelling downstream from the Ottawa colonies or it may have been the result of a separate escape from material cultivated at the Montreal Botanic Garden (Dore, 1968a; Catling and Dore, 1982). In 1953 European frog-bit had been found at the Rideau Canal exit and along the shore of the Ottawa River. In 1957 *Hydrocharis* had been found in the main channel of the Rideau River. By 1960 European frog-bit had been discovered in various locations in the Ottawa River around Montreal and much farther downstream at Lake St. Peter. By 1967 the plant had moved upstream on the Rideau River to at least Merrickville (Dore, 1968a).

European frog-bit continued spreading along the Rideau and Ottawa Rivers as well as into connected tributaries and intervening, often isolated, wetlands (Reddoch, 1976). By 1982, it had

spread along the shore of Lake Ontario to Belleville, along the St. Lawrence River to the province of Quebec and beyond, and up the Ottawa River to near Pembroke (Catling and Dore, 1982). A disjunct station on Lake Erie at Rondeau Park was also recorded then (Lumsden and McLachlin, 1988). Intervening stations along the shore of Lake Ontario in the vicinity of Toronto had been recorded by 1986.

Although its initial spread was confined to the Rideau and Ottawa River systems, it soon found its way into many isolated and unconnected wetlands and waterways. Field work by D. White in 1985, 1986, 1989, and 1991 in many wetlands within the current range of *Hydrocharis* found European frog-bit to be commonly established and often dominant in a large number and wide range of wetland communities.



Range expansion of European frog-bit (*Hydrocharis morsus-ranae*) in North America (after Dore (1968a); Catling and Dore (1982); and Lumsden and McLachlin (1988)). Solid circles represent individual or local occurrences.

Biology

European frog-bit is a free-floating aquatic plant of open-water marshes and the standing water pools of swamps. It has small white unisexual flowers that open just above the water surface. The flowers have three white petals and attract a range of insect pollinators, however, pollination and subsequent fruit-set appears to be poor in many populations (Scribailo and Posluszny, 1984; Dore, 1968a). Most plants are dioecious in that male and female flowers are found on separate plants (Scribailo and Posluszny, 1984). In addition, many populations are totally or almost totally of one sex and thus little fruit set occurs (Scribailo and Posluszny, 1984; Cook and

Luond, 1982). Those populations studied, which are of mixed sex, tend to have a high to very high male bias in the sex ratio (Scribailo and Posluszny, 1984), which of course would also limit the seed production of a population. Sexual reproduction is probably of limited importance for the spread of European frog-bit (Scribailo and Posluszny, 1984; Scribailo *et al*., 1984).

Hydrocharis reproduces primarily vegetatively by means of strong cord-like stolons and the production of winter buds (turions). In the fall, turions are formed along the stolons and these turions loosen, sink to the bottom, and remain dormant during the winter (Dore, 1968a). In spring these turions rise again to the surface and begin growing. From observations made in 1965, Dore (1968a) estimated that two plants produced about 300 turions that fall. Scribailo and Posluszny (1984) estimate that a plant could produce up to 100 turions. It is this great capacity for vegetative reproduction that has allowed European frog-bit to spread and proliferate so quickly in eastern North America (Scribailo and Posluszny, 1984).

There is a well-developed root system, however, the roots generally do not anchor the plant to the bottom, rather, they become tangled amongst other vegetation and themselves and thus help form dense masses that stabilize the colony (Dore, 1968a).

Ecology

Few studies have been conducted on the ecological impact of European frog-bit. Catling *et al*. (1988) studied the effects of *Hydrocharis* on native submerged aquatic vascular plants in Ontario and New York State. Because of the dense floating mat of vegetation produced by European frog-bit, available light, dissolved gases, and nutrients were restricted to submerged aquatics attempting to grow beneath this mat. Very dramatic declines in the cover value of native submerged aquatics were noted under mats of European frog-bit (Catling *et al*., 1988).

Present Status and Potential Threat

European frog-bit presently occurs in a limited portion of Canada-primarily eastern Ontario and adjacent western Quebec. Within that range, however, the plant is very common and is often a dominant species in the wetlands within which it occurs (Dore, 1968a; White, 1985; White, 1989; White and Sparling, 1986). By dominating wetlands with its thick mats there can be little doubt that *Hydrocharis* is displacing native flora and perhaps impacting also the fauna. Detailed ecological studies need to be conducted to assess this impact. European frog-bit often occurs in wetlands with purple loosestrife (*Lythrum salicaria*). With European frog-bit dominating the open water portions of a wetland and purple loosestrife dominating the relatively drier portions, such wetlands are receiving a double blow that could dramatically reduce their original biodiversity. Mosquin and Whiting (1992) regard European frog-bit to be one of five invasive alien plants that have had a major impact on natural ecosystems in Canada. It is considered to be a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990).

Control Measures

So far as is known no control measures have been reported for European frog-bit.

Survey Summary and Contact Us

The majority of the respondents to the survey rated European frog-bit as a moderate problem which is spreading. It was about evenly ranked as widespread versus local in extent. Several respondents commented that European frog-bit is a problem in eastern Ontario where it is a major dominant along the St. Lawrence River and is spreading into isolated beaver ponds.

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Wildlife Habitat Conversation, Canadian Wildlife Service
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http://www.cws-scf.ec.gc.ca/habitat/inv/p2_e.html

Canada

Flowering-rush

(*Butomus umbellatus* L.)

Alternate Common Name

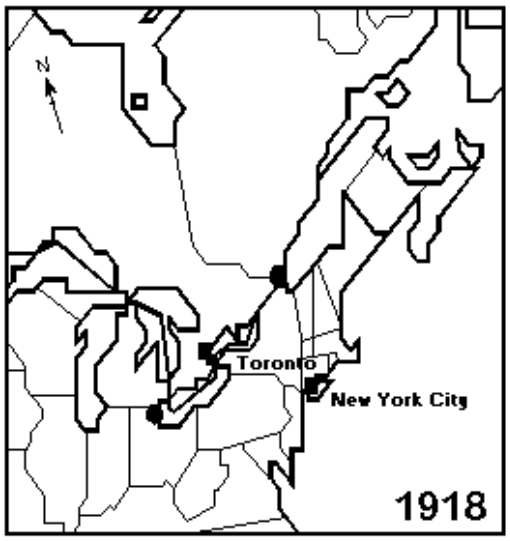
Flowering rush

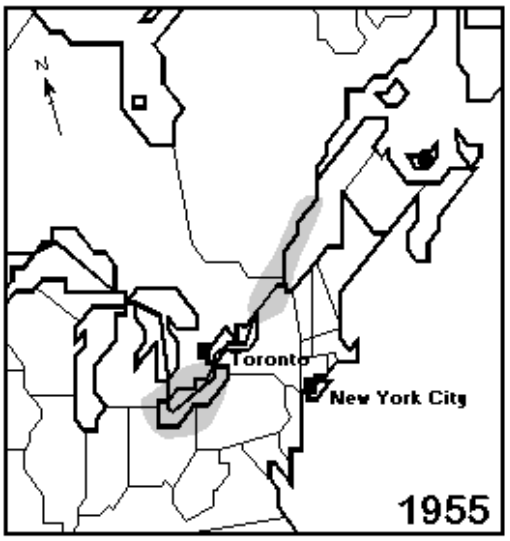
Taxonomic Overview

The genus Butomus consists of a single species. The name is derived from the Greek *bous*, cow and *temno*, to cut, in reference to the sword-like leaves. Flowering-rush was described by Linnaeus in 1753. Some botanists place the plant in the family Alismaceae, however, most consider the plant to belong in its own family, Butomaceae (Core, 1941).

Distribution

Flowering-rush is native to Eurasia. In North America it was first discovered about 1897 along the St. Lawrence River in Quebec (Fletcher, 1908; Core, 1941). Marie-Victorin in Quebec suggested that the plant had spread from that initial area to as far as Michigan where it was found about 1918 (Anderson *et al*., 1974). Stuckey (1968) and Anderson *et al*. (1974), however, argued that flowering-rush was probably introduced separately to Michigan because of taxonomic differences between the Quebec and Michigan populations and because the Michigan populations were well-established by 1918 and no intervening stations were known then (Stuckey, 1968). Since those early discoveries, flowering-rush has spread considerably. By 1955 the plant had spread along the St. Lawrence River and into eastern Ontario and expanded its range in southwestern Ontario and adjacent Michigan (Knowlton, 1923; Montgomery, 1956; Staniforth and Frego, 1980). By 1991, flowering-rush had been found in mainland Nova Scotia, Manitoba, Alberta, and British Columbia, in Canada; and South Dakota, North Dakota, Montana, Minnesota, Idaho, and Ohio in the United States (Godfread and Barker, 1975; Scotter, 1991; Roberts, 1972). Many reports of its discovery in a new area also mention the plant's occurrence as large or extensive populations (Roberts, 1972; Stuckey, 1968; Staniforth and Frego, 1980; Gaiser, 1949; Anderson *et al*., 1974).





Range expansion of flowering-rush (*Butomus umbellatus*) in North America (after Anderson *et al*. (1974; Scotter (1991); Staniforth and frego (1980); and Stuckey (1968)). Solid circles represent individual or local occurrences.

Biology

Flowering-rush reproduces by seed production and vegetative spread of its rootstocks especially with the production of bulblets (Core, 1941). Both the seeds and the bulb-lets can be moved by water currents (Stuckey, 1968). The seeds are quite long-lived which also enhances their ability to disperse (Staniforth and Frego, 1980).

Ecology

No known studies have been conducted on the effects of this introduced plant on its new wetland environment though there have been recommendations to do so (Roberts, 1972).

Present Status and Potential Threat

Flowering-rush is actively expanding its range in North America. In the last 35 years the plant has spread from a limited area around the Great Lakes and St. Lawrence River to cover, in a sporadic manner, the northern United States and southern Canada. Its distribution in central and

western North America is mostly sporadic (Staniforth and Frego, 1980; Scotter, 1991). With the plant's great reproductive potential (Roberts, 1972) this situation could change quickly. There have been no studies to determine the effect on native vegetation of the colonization of wetlands by flowering-rush, however, Staniforth and Frego (1980) consider that the plant is capable of aggressively displacing native vegetation. Anderson *et al*. (1974) documented a site in Idaho and between 1956 and 1973 flowering-rush had spread and "appeared to be out-competing the willows and cattails".

Control Measures

So far as is known there have been no attempts made to control or eradicate flowering-rush in either Canada or the United States.

Survey Summary and Contact Us

The majority of the respondents to the survey rated flowering-rush as a moderate to limited problem that is spreading. Opinion was about evenly divided between it being widespread versus local in extent. One respondent in Quebec commented that it is not forming the same dense monospecific stands as has purple loosestrife.

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Glossy buckthorn

(*Rhamnus frangula* L.)

Alternate Common Name

Black buckthorn, European alder buckthorn

Taxonomic Overview

The genus belongs to the buckthorn family (Rhamnaceae) and consists of about 100 species, primarily of north temperate regions. Many are purgative. The generic name is based on the Greek name *Rhamnos* used for some of the species. Glossy buckthorn was described by Linnaeus in 1753. It has also been known under the synonym *Frangula alnus* Miller.

Distribution

Glossy buckthorn, a native of Europe, was introduced to northeastern North America (Soper and Heimburger, 1982; Howell and Blackwell, 1977). In Canada, it is known mainly from southern Ontario but also occurs in Nova Scotia, Quebec, and Manitoba. In Ontario it is found primarily in the vicinity of the larger cities (Soper and Heimburger, 1982).

Generalized distribution of glossy buckthorn (*Rhamnus frangula*) in North America based on floras and herbarium specimens. Solid circles represent individual or local occurrences.

Biology

Glossy buckthorn is a shrub or small tree that produces small dark fruits, each containing two to three seeds. The berrylike drupes occur singly or in small groups in leaf axils (Soper and Heimburger, 1982). The fruit contains a poisonous substance (Kingsbury, 1964) that probably deters many potential consumers, however, European Starlings can apparently eat the fruit with impunity and they have been suggested as the primary agent responsible for the spread of glossy buckthorn in Ohio (Howell and Blackwell, 1977). Glossy buckthorn occurs in a range of wetland communities including fens, marshes, and bogs. Although the plant has a preference for wetlands, it also occurs in some upland habitats, such as forests, fencerows, wood edges, prairies, and old fields (Heidorn, 1991; Howell and Blackwell, 1977; botanist survey comments).

Ecology

When glossy buckthorn invades a natural area it displaces the native species by the dense shade produced by the stand (Taft and Solecki, 1990; botanist survey comments).

Present Status and Potential Threat

Glossy buckthorn presently occurs in a limited portion of Canada and appears to be seriously invasive in only part of its limited range. Its rapid spread, however, coupled with its ability to quickly invade natural areas (Howell and Blackwell, 1977; Taft and Solecki, 1990) suggest that it will become a greater problem in the future. In *The Plant Press* survey it was regarded as a problem in southwestern Ontario (Kaiser, 1986).

Control Measures

Several methods have been used to control glossy buckthorn in natural areas including fire, herbicide application, flooding, and girdling (Heidorn, 1991; Taft and Solecki, 1990). Most methods have produced at least some positive results, however, all methods require follow-up treatment (Heidorn, 1991).

Fire has been used to control glossy buckthorn, however, annual or biennial burns may be needed for five or six years or more (Heidorn, 1991). Burning kills most seedlings and older stems of glossy buckthorn but seeds and seedlings growing in saturated soil are unaffected, top-killed plants can resprout, and all can quickly recolonize the area (Heidorn, 1991; Post and Klick, 1988; Post *et al*., 1989; Taft and Solecki, 1990). Fire may be inappropriate for some natural areas due to damage to native species (Heidorn, 1991).

Stem-cutting or girdling, in combination with later sprout removal or the application of herbicide to the cut stem can be effective if there is adequate follow-up treatment or monitoring (Heidorn, 1991). This method is of course very labour-intensive and probably suitable only for small and highly significant sites. Seeds and seedlings are unaffected by this method and can quickly recolonize the site (Taft and Solecki, 1990). Herbicide application must be done with extreme care to prevent damage to native species (Heidorn, 1991).

Survey Summary and Contact Us

The majority of the respondents to the survey rated glossy buckthorn as a severe to moderate problem of a local nature which is spreading. Contact Us included: Glossy buckthorn is a major problem in southern and eastern Ontario. In Quebec it is mostly a problem in floodplain forests where it may hinder the regeneration of trees and affect the diversity of herbs. Glossy buckthorn is one of the most invasive species in the Ottawa area and it is having a severe impact in a provincially significant fen south of Leitrim. In the Ottawa area it is aggressively spreading and is probably supplanting native species. In Ontario glossy buckthorn is one of the most aggressive aliens.

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Purple loosestrife

(*Lythrum salicaria* L.)

Alternate Common Name

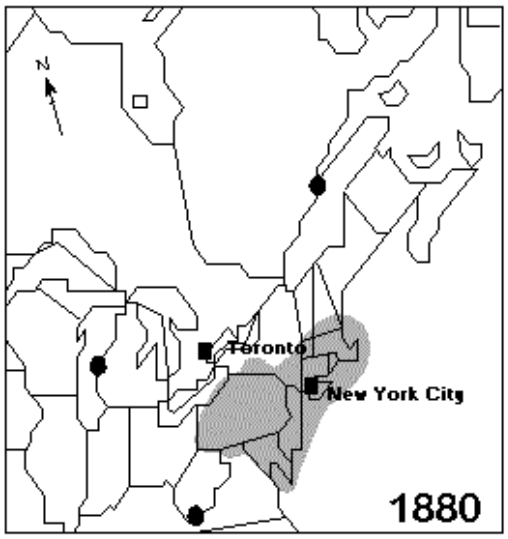
Spiked loosestrife, swamp loosestrife

Taxonomic Overview

The genus belongs to the loosestrife family (Lythraceae) and consists of about 30 species mostly of north temperate regions. The generic name comes from the Greek *luthron*, blood, possibly in reference to the colour of the flowers or to one of its herbal uses, as an astringent to stop the flow of blood. Purple loosestrife was described by Linnaeus in 1753.

Distribution

Purple loosestrife is native to Eurasia. It was probably introduced to North America in ship ballast, on imported sheep, or in livestock feed and bedding in the early 1800s (Thompson *et al*., 1987; Hight and Drea, 1991). By 1830 purple loosestrife was well established along the New England seaboard (Thompson *et al*., 1987; Hight and Drea, 1991). In North America it now occurs in greatest concentrations primarily in northeastern United States and adjacent Canada where it is common to abundant. Keddy (1990) contains a detailed map of the distribution and abundance of purple loosestrife in Ontario. In lower densities it occurs across virtually the entire United States and the southern portion of Canada (Hight and Drea, 1991). Lee (1991) documents purple loosestrife in all Canadian provinces. A 1991 public survey extended the range as far northas The Pas, Manitoba (and in 1992 to Snow Lake, Manitoba), and confirmed its presence in salt marshes on both the Atlantic and Pacific coasts (G. Lee, pers. com., 1992). Although most of its spread in North America probably relates to the initial introductions from ship ballast etc., some populations may have spread from intentional introductions for herbal use of the plant, from home garden plantings, or from wildflower seed mixtures that often contain purple loosestrife seeds (Hanna, 1989; Thompson, 1991; Thompson *et al*., 1987).



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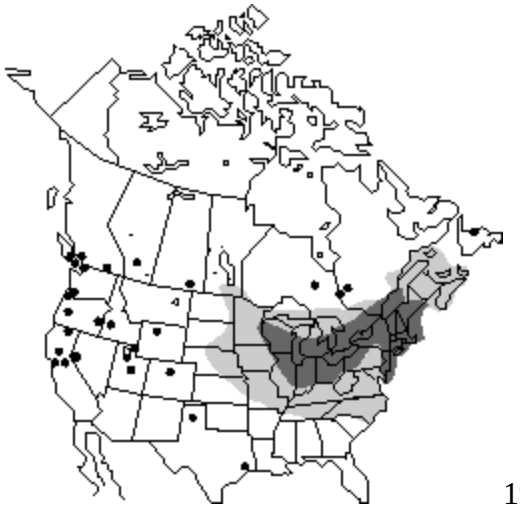

1992

Range expansion of purple loosestrife (*Lyythrum salicaria*) in North America (after Hight and Drea (1991) and Thompson *et al*., (1987)). Area with darker fill represents region with population of dense stands; solid circles represent individual or local occurrences; triangles represent recent updates.

Biology

Purple loosestrife is an herbaceous perennial. Its prolific seed production-up to 2.7 million per plant per year-enables the plant to establish dense stands within a few years (Hight and Drea, 1991; Thompson *et al*., 1987). It can also spread vegetatively by adventitious shoots and roots from clipped, trampled or buried stems (Thompson *et al*., 1987). As well, ornamental-grown 'seedless' cultivars have been shown to produce large quantities of viable seed when fertilized with pollen from naturalized populations (Ottenbreit, 1991). The resulting hybrids from this cross are themselves highly interfertile (Ottenbreit, 1991).

Ecology

The prolific seed production of purple loosestrife enables it to quickly develop a large seed bank at a site (Charvat and Stenlund, 1990). The seeds are able to live for several years and they can germinate across a wide range of environmental conditions (Welling and Becker, 1990). These factors have important implications for possible control of the species: removal of adult and/or seedling plants in an established population will have limited impact due to the ability of the population to re-establish itself from the seed bank.

The impact of purple loosestrife is seen in loss of native flora and fauna in infested wetlands, degradation of wetland pastures and wild hay meadows, clogging of irrigation systems, and the loss of natural habitats for recreational enjoyment (Hight and Drea, 1991). When purple loosestrife establishes dense stands it is able to displace native species (Thompson *et al*., 1987; Hanna, 1989; Balogh and Bookhout, 1989). Displaced species may include plants-rare or otherwise (Moore and Keddy, 1988), or they may include waterfowl and furbearers which are displaced because of loss of foodplants or changes in cover values of the wetland (Thompson *et al*., 1987; Balogh and Bookhout, 1989; Heidorn and Anderson, 1991).

Present Status and Potential Threat

At present, the area of greatest impact of purple loosestrife is the northeastern United States and adjacent Canada (Hight and Drea, 1991). Until recently, there has been only limited spread in central and western United States and Canada. In British Columbia, it is becoming increasingly invasive and is a fisheries concern (G. Lee, pers. com., 1992). In Alberta it is believed that there are only 15 locations (Ali, 1992). Infestations in prairie sloughs, which produce a large portion of many North American ducks, could have a major impact on waterfowl populations already under stress from other factors. Mosquin and Whiting (1992) regard purple loosestrife to be one of five invasive alien plants that have had a major impact on natural ecosystems in Canada. In *The Plant Press* survey it was regarded as a problem in southwestern, central, and eastern Ontario (Kaiser, 1986). It is considered to be a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990).

Control Measures

Because purple loosestrife is so well-established, so widespread, and so prolific, it should be clear that it would be impossible to totally eliminate it from North America. It might be possible in the long term, however, to reduce its impact in large areas with an effective biological control program. In the short term at least, it might be possible to eliminate it from highly significant or sensitive areas, or areas where it was not well-established, by the use of physical and/or chemical control (Thompson *et al*., 1987). A recent workshop on the impact, spread, and control of purple loosestrife in Canada felt that no single control method would be sufficient but that an integrated approach with consideration of the particular site involved must be taken to control this alien (Lunam, 1992).

Effective control might consist of the use of physical and/or chemical measures, on an interim basis: (1) to eliminate the species from highly significant sites with a low population present; (2) to eliminate the species in geographical areas where it is just becoming established; and (3) to contain the plant in large sites with an extensive population in order to slow its spread (Thompson *et al*., 1987; Keddy, 1990). Such a program could minimize damage caused by the species and 'buy time' while development proceeded on biological control efforts.

In Quebec, starting in 1941, Louis-Marie conducted a study to find suitable control methods (Thompson *et al*., 1987). The results suggested that repeated mowing with continuous grazing, and deep discing and harrowing were effective in agricultural land (Thompson *et al*., 1987). More recently in Ontario there has been some preliminary study to identify effective control measures for natural areas (Keddy, 1990).

In the United States, there has been considerable research into possible control methods involving physical, chemical, and biological control (Thompson, 1991; Hight and Drea, 1991). Physical control, such as mowing or flooding, appears to be of limited usefulness (Crowder, 1991; Hanna, 1989); control using herbicide is a yearly operation due to recruitment from the seed bank and is complicated by the need to control damage to other biota of the wetland (Crowder, 1991; Hanna, 1989); control using biological agents appears the most promising, however, research into this control method is still in the field stage for several of the likeliest candidates (Hight and Drea, 1991; Thompson, 1991).

Studies on the seed bank dynamics of purple loosestrife have shown that to be effective, a control program would have to operate on a continuing basis. One-time control measures would have only a temporary effect due to new plants being recruited from the extensive seed bank which a population quickly establishes in a site (Welling and Becker, 1990). There is also evidence that a minority of established plants can remain dormant above-ground for a year and then resume growth the next season (Thompson *et al*., 1987). Control measures would also have to take that unusual plant behaviour into account.

Physical control of purple loosestrife includes a range of options from hand pulling and shearing, to inundation, mowing, cultivating, fire (Thompson *et al*., 1987; Keddy, 1990; Hanna, 1989). Some of these, including mowing, cultivating, and probably inundation, are probably not suitable for control of purple loosestrife in many natural areas because of damage to native species. Hand pulling and shearing are suitable only for very limited infestations due to its labour-intensive nature (Keddy, 1990). Fire is ineffective because the root crown is well protected below the surface and little fuel accumulates on the surface to support the kind of hot fire which would be needed to affect the roots (Thompson *et al*., 1987). Flooding appears to take several years to have an appreciable effect in the reduction of purple loosestrife and the levels must be substantially higher than normal to be effective (Thompson *et al*., 1987). In many wetlands this flooding would probably have other profound effects on the native flora and fauna.

Chemical controls that have been used in the United States include 'Rodeo' and 'SEE 2,4-D' (Keddy, 1990; Hemphill, 1991). Some reports consider these chemicals to be useful (Hemphill, 1991), however, others consider their use to be of limited benefit (Thompson, 1991) due to high cost and temporary effectiveness (Hight and Drea, 1991). Rodeo is not licensed for use in Canada, however, Roundup, which is closely related to Rodeo, could possibly be allowed in terrestrial habitats by permit since it can be used on a broad range of plants (Keddy, 1990). SEE 2,4-D can also be used on purple loosestrife in terrestrial habitats, however, no chemicals are registered in Canada for use against purple loosestrife in aquatic habitats (Keddy, 1990). The problem of restricting the effects of the herbicide to the target plant, purple loosestrife, is one of the most difficult aspects of chemical control (Hanna, 1989; Keddy, 1990). Canadian herbicide trials are continuing in a number of provinces in search of formulations and applications that will satisfy Canadian environmental standards (G. Lee, pers. com., 1992).

Biological control agents for purple loosestrife were investigated initially by the International Institute of Biological Control (IIBC), Europe. The IIBC was contracted by the U.S.A. to do the initial survey for biocontrol agents in Europe and to conduct the screening tests on candidate organisms (R. DeClerck-Floate, pers. com., 1992). Biological control tests were also conducted in the United States for a number of years (Thompson, 1991; Hight and Drea, 1991). Three beetles were approved for release in the United States on June 26, 1992-*Hylobius transversovittatus* is a root-infesting weevil, and *Galerucella calmariensis* and *G. pusilla* are leaf-feeding beetles. Canada approved the release of these three insects on July 13, 1992. Feeding by these insects at high densities of attack resulted in defoliated mature plants, killed seedlings, and destruction of or prevention of formation of flower spikes (Hight and Drea,

1991). In addition to being effective, these insects are highly host-specific as has been confirmed during trials between 1988 and 1990. These trials involved the three insects and 50 plants that were either closely related to purple loosestrife, were commonly associated with purple loosestrife in its wetland habitat, or were important agricultural crops (Hight and Drea, 1991). Supplies of these insects were acquired during the summer of 1991, quarantined first in the United States and then in Canada, and are presently being winter hardened in anticipation of initial releases and further propagation in 1993 (G. Lee, pers. com., 1992). Several years of field trials will be necessary to determine whether these insects have real potential to effectively control purple loosestrife (Hight and Drea, 1991).

It seems clear that the only hope of achieving widespread and long-term control of purple loosestrife is with the development of an effective biological control program (Thompson *et al*., 1987). The plant is simply too well-established across too wide an area for physical or chemical control methods to do more than achieve temporary and local relief.

Survey Summary and Contact Us

The vast majority of the respondents to the survey rated purple loosestrife as a severe widespread problem that is spreading. Contact Us included: Purple loosestrife is the worst invasive alien of wetlands in Ontario. In British Columbia it is not yet very invasive. In Ontario it is perhaps the most invasive alien species. Along the Ottawa River in Quebec there has been a great increase in purple loosestrife in shoreline areas surveyed between 1979 and 1991. In Quebec it is the most aggressive competitor. One respondent felt that trying to control a well-established species like purple loosestrife is futile and wasteful. Purple loosestrife is one of the few alien species that presents a serious threat to the plant communities of natural habitats.

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Canada

Reed canary grass

(*Phalaris arundinacea* L.

Alternate Common Name

Reed canarygrass

Taxonomic Overview

Phalaris is a genus of about 20 species of the grass family (Poaceae) found in temperate America and Eurasia. The generic name is based on an ancient Greek name for a grass. Reed canary grass was described by Linnaeus in 1753. The species includes native plants as well as commercial cultivars that have originated from Europe (Dore and McNeill, 1980).

Distribution

Reed canary grass occurs across the northern hemisphere of both North America and Europe (Dore and McNeill, 1980). In addition to its native range in Canada, reed canary grass has been widely introduced in the form of European cultivars for hay and forage (Dore and McNeill, 1980). The native plants and the European cultivars are very similar and there are evidently no clear distinguishing characteristics to differentiate between the native and introduced plants and their respective Canadian distributions are unclear (Dore and McNeill, 1980). In Ontario, the distribution of the native genotype is thought to be primarily the shores of the northern Great Lakes and possibly the upper Ottawa and French Rivers (Dore and McNeill, 1980). The European genotype is well represented by dense stands inland from the Great Lakes, especially in the southern part of the province (Dore and McNeill, 1980). In the United States, reed canary grass is considered to be invasive in many natural wetlands (Apfelbaum and Sams, 1987).

Generalized distribution of reed canary grass (*Phalaris arundinacea*) in North America based on floras.

Biology

Reed canary grass is a perennial grass that can reproduce sexually by seed production or vegetatively by means of dense vigorous rhizome growth (Apfelbaum and Sams, 1987). The seeds can germinate immediately upon maturation or they can germinate after one year of alternating temperatures (Apfelbaum and Sams, 1987).

Ecology

Reed canary grass grows vigorously and is able to inhibit and eliminate competing species (Apfelbaum and Sams, 1987). Areas that have supported reed canary grass monocultures for extended periods may have seed banks that are devoid of other species (Apfelbaum and Sams, 1987). In Minnesota and Wisconsin it is described as an extremely aggressive species that often forms persistent, monotypic stands (Reed and Eggers, 1987).

Present Status and Potential Threat

Reed canary grass occurs widely across Canada as native populations and as introductions of the European cultivars. The introductions form dense monocultures that are able to displace native species (Apfelbaum and Sams, 1987). Because of the difficulty of distinguishing between the native and introduced plants (Dore and McNeill, 1980), it is not clear exactly how common the introduced cultivars are. Reed canary grass often occurs in wetlands with purple loosestrife. Since the latter is so much more showy and conspicuous, reed canary grass may be going largely unnoticed and its effects may be unrecognized.

Control Measures

No control measures have been undertaken in Canada, however, a number of different strategies have been used in the United States to attempt to control the plant (Apfelbaum and Sams, 1987; Gillespie and Murn, 1992; Henderson, 1990). The control methods tried include herbicide application, burning, covering the plants with plastic or paper, and mowing and/or mechanical disturbance.

A number of herbicides, including Glyphosate, Amitrol, Dalapon, and Paraquat, have been tried with some success (Apfelbaum and Sams, 1987). Maximum control depended on timing of application-some herbicides produced best results when used in the dormant season while other formulations were most effective with application at flowering time (Apfelbaum and Sams, 1987). At best, these herbicides provided control up to two years by which time reed canary grass would have re-colonized the area from adjacent stands or from seed bank recruitment.

Mechanical control has been tried using hand-pulling, mowing, mowing and covering with paper or black plastic, or clearing (Apfelbaum and Sams, 1987; Gillespie and Murn, 1992; Henderson, 1990). These methods produced only temporary control (Apfelbaum and Sams, 1987), however, Gillespie and Murn (1992) report that regular, twice-yearly, properly timed mowing at a site in Wisconsin has controlled reed canary grass and allowed a number of native wetland species to repopulate the area. Regular burning of a prairie in Illinois on a two to three year rotation apparently keeps reed canary grass out of the prairie (Apfelbaum and Sams, 1987). Henderson (1990) found that late spring burning, the most effective time for control of reed canary grass, harmed many native species in a savannah in Wisconsin. It remains to be seen whether burning could be conducted in many wetland habitats for the control of reed canary grass. Selective hand-pulling, if carried out two or three times a year for five years can be very effective (Henderson, 1990), however, it may only be practical for small highly significant sites.

To date, effective control methods for reed canary grass in natural areas have yet to be developed (Apfelbaum and Sams, 1987).

Survey Summary and Contact Us

The majority of the respondents to the survey rated reed canary grass as a moderate problem of a widespread nature. Opinion was divided as to whether it was stable or spreading. Contact Us included: Reed canary grass may be more of a problem than it first appears since it is green and is not as evident in a wetland as the much showier purple loosestrife. In British Columbia it is primarily native and not overly aggressive.

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Canada

Upland Species Accounts

The upland invasive species have been divided into three levels of invasiveness-principal, moderate, and minor. Principal Invasive Aliens contains the species of upland habitats that are considered to pose the greatest threat to natural areas. Moderate Invasive Aliens contains several species that are considered to be moderately invasive. Minor Invasive Aliens contains the species that are considered to be only minor problems. All three groups are listed below.

- Periwinkle (*Vinca minor*)
- Ragweed (*Ambrosia artemisiifolia*)
- Scotch broom (*Cytisus scoparius*)
- Scots pine (*Pinus sylvestris*) *
- Siberian peashrub (*Caragana arborescens*)
- Spotted knapweed (*Centaurea maculosa*)
- Teasel (*Dipsacus spp.*)
- White bedstraw (*Galium mollugo*)
- White mulberry (*Morus alba*)
- White poplar (*Populus alba*)
- Wild marjoram (*Origanum vulgare*)

** These species are also recognized as invasive in wetlands and their accounts are included with the wetland species*

Moderate Invasive Aliens

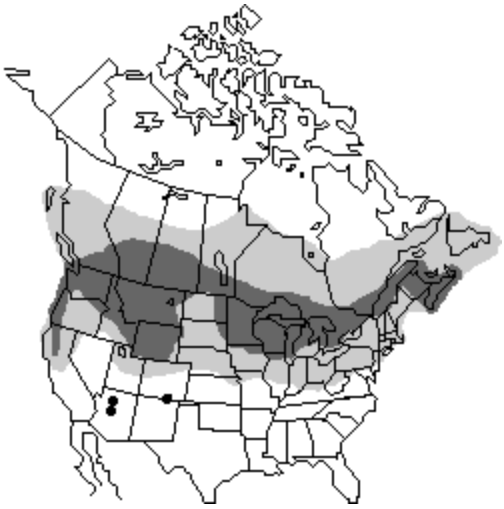
The following section presents information on invasive alien species of upland habitats that appear to constitute an intermediate level of threat to natural areas. Reference citations for these species are given after Part II.

Canada thistle

(*Cirsium arvense*) (L.) Scop.

Distribution andf Biology

Canada thistle belongs to the aster family (Asteraceae). It is native to Europe but was introduced to Canada probably in the 17th century (Moore, 1975). Although the plant's Canadian range is very wide, it is most common in the southern portions of this range (Moore, 1975). Canada thistle is found in agricultural land, roadsides, prairies, alvars, savannas, sand dunes, shorelines, and forest openings (Moore, 1975; Hutchison, 1992; botanist survey).



Generalized distribution of Canada thistle (*Cirsium arvense*) in North America (after Moore (1975) and floras). Darker fill represents region with populations of dense stands, solid circles represent individual or local occurrences.

Canada thistle is an herbaceous perennial that spreads by seed production and vegetatively by the production of rhizomes from its vigorous and wide-spreading root system (Moore, 1975).

Since the species is dioecious-male and female flowers are produced on separate plants-and primarily insect-pollinated, both sexes must be in reasonable proximity to one another for pollination and seed set to occur (Moore, 1975). The number of seeds produced per above-ground shoot may be as high as 5 300 but averages 1 500 (Moore, 1975). In a well-established infestation the shoot density can be over 175 per square metre and this can translate into a seed production per square metre for a female plant in the range of 250 000 (Moore, 1975). The seeds are long-lived with some remaining viable after 21 years of burial (Moore, 1975). Seeds are attached to a plumose pappus that aids its dispersal by wind-water transport may also be important (Hutchison, 1992; Moore, 1975).

Impact and Control

Although Canada thistle is widespread in Canada, its main impact is in agricultural land. The chief impact in natural areas occurs in prairies, alvars, and open meadows (Moore, 1975; botanist survey). Since the greatest impact by Canada thistle occurs in areas that have been disturbed or are undergoing restoration management, it is important to maintain and encourage healthy stands of native species to prevent the establishment or spread of Canada thistle (Hutchison, 1992). Canada thistle is capable of crowding out and replacing native grasses and forbs, decreasing the species diversity of an area, and changing the structure and composition of some habitats (Hutchison, 1992). Part of the negative impact of Canada thistle on an area may be due to the production of allelopathic substances, i.e., compounds that inhibit the growth or development of other nearby species (Hutchison, 1992).

Due to the negative impact of Canada thistle on agricultural crops and grazing land, much effort has been expended to control the plant. A number of herbicides have been found effective: 2,4-D kills the above-ground portion of the plant; picloram destroys the root system; glyphosate destroys the entire plant (Hutchison, 1992; Moore, 1975). Great care must be exercised when using herbicides in natural areas to avoid damage to native plants. Repeated mowing for several years can control the plant where the infestation is not severe (Moore, 1975). Cultivation must be very thorough and repeated often for it to be an effective control of Canada thistle-even small portions of the extensive root system are capable of starting a new plant (Moore, 1975). Repeated mowing and cultivating are likely to be unsuitable methods for most natural areas. Prescribed fire is effective if conducted annually in late spring for several years (Hutchison, 1992). Even a single burn in a native mixed grass prairie in North Dakota resulted in a reduction in Canada thistle populations for a number of years (Smith, 1985). Frequent and repeated hand removal of individual shoots will eventually eliminate Canada thistle in light to moderate infestations in smaller areas (Hutchison, 1992).

Considerable effort has been directed toward finding biological control agents that could be effective against Canada thistle. In Canada, there are over 80 species of insect that consume the plant (Maw, 1976) and there are a similar number in Europe (Moore, 1975). Given the fact that Canada thistle is a problem across the country, it would appear that the native Canadian consumers of Canada thistle are not effective enough on their own to keep the plant in check. A number of European insects have been tested as possible biological control agents, however, none have yet shown much impact on Canada thistle populations (Evans, 1984b). The insect agents tested so far have either failed to become established, have shown a capacity to attack other plants, or have had only limited impact on the survival or spread of Canada thistle (Evans, 1984b). Since Canada thistle is regarded to be a serious problem in its native European range (Peschken, 1971), it seems that the European insects are not capable of controlling the plant in its natural range and hence it may be that no control agent can be found that will have a major impact on Canada thistle populations. Recent work in China has identified a flea beetle-*Altica*

cirsicola-and a root boring beetle that have good potential as biocontrol agents for Canada thistle (Harris, pers. com., 1992).

There are species of rust, such as *Puccinia punctiformis*, that infect Canada thistle and they may be effective in controlling the plant in some situations (French and Lightfield, 1990).

It may be that Canada thistle will not be controlled across its wide North American range by a single agent (Evans, 1984b). A more realistic approach may be integrated pest management where a combination of treatments is brought to bear on the pest depending on the geography, habitat, and degree of infestation (Evans, 1984b).

In natural areas the most common combination of treatments is hand cutting, spot applications of herbicide, and prescribed fire (Evans, 1984b).

Survey Summary and Contact Us

The majority of the respondents rated Canada thistle to be a moderate problem of a widespread nature that is spreading. Many respondents considered its impact to be none or unknown. Contact Us included: Its presence indicates disturbed site conditions. It is primarily a species of disturbed communities. It is having no impact in natural areas.

St.John's-Wort

(*Hypericum perforatum L.*)

Distribution andf Biology

St. John's-wort, also called klamath weed, belongs to the St. John's-wort or mango-steen family (Hypericaceae or Clusiaceae). It is native to Europe but has been known in Eastern North America since 1793. The plant's spread to the west occurred much later-it may not have become an established weed in British Columbia until the 1940s (Crompton *et al*., 1988; Harris *et al*., 1969). Its spread in North America is probably due primarily to its inherent abilities as an aggressive alien, however, this spread has probably been aided by its past cultivation as a medicinal plant (Crompton *et al*., 1988). In Canada, it has a wide distribution with the greatest concentrations in the southern portions of British Columbia, Ontario, and Quebec (Crompton *et al*., 1988). St. John's-wort occurs in a variety of open habitats, such as meadows, alvars, forest openings, and agricultural lands (Crompton *et al*., 1988; botanist survey).

Generalized distribution of St.John's wort (*Hypericum perforatum*) in North America (after Crompton *et al*., (1988) and floras).

St. John's-wort is an herbaceous perennial that spreads primarily by seed production but also vegetatively by the production of rhizomes (Crompton *et al*., 1988). Seed production is prolific with up to 100 000 per plant annually (Crompton *et al*., 1988; Tisdale *et al*., 1959). The seeds are long-lived with only a 50% reduction in germination after 15 years of dry storage (Crompton *et al*., 1988). The seed is coated with a gelatinous layer that may aid in animal dispersal; wind dispersal also plays a role in local distribution (Crompton *et al*., 1988).

Impact and Control

Although St. John's-wort is relatively widespread in Canada, its main impact is in southern British Columbia where it forms large dense stands-in eastern Canada it is only a minor problem where it occurs as small infestations or as single plants (Crompton *et al*., 1988; botanist survey).

Due to the negative impact of St. John's-wort on pasture and rangeland in the west, there has been much effort expended to control the plant. Herbicides have been used, however, the small waxy leaves, the plant's tolerance to a number of chemical formulations, and the cost of treatment limits the usefulness of herbicides (Crompton *et al*., 1988). Fires appear to result in an increase of St. John's-wort stands, and physical methods, such as handpulling, digging, or mowing, are ineffective (Crompton *et al*., 1988). Regular tillage is effective (Crompton et al., 1988), however, it would not likely be suitable as a control method in natural areas.

In 1951, several potential biological control agents that contribute to the plant's control in its native European range were released in British Columbia and this has resulted in the effective control of the plant in many of its habitats in the province (Crompton *et al*., 1988; Harris *et al*., 1969). The prime agents responsible have been two leaf-feeding beetles-*Chrysolina quadrigemina* and *C. hyperici* (Crompton *et al*., 1988; Peschken, 1979). The former is active in drier sites and the latter is effective in wetter ones-both have been introduced and become established in southern Ontario and the latter has also been introduced in Nova Scotia (Crompton *et al*., 1988; Fields *et al*., 1988). In Nova Scotia, St. John's-wort is also attacked by at least one native fungus-*Colletotrichum gloeosporioides* (Hildebrand and Jensen, 1991). Other species of fungus have been identified on St. John's-wort in Ontario and Nova Scotia and they may also be contributing to controlling the species in eastern Canada (Crompton *et al*., 1988).

Survey Summary and Contact Us

Many respondents considered its impact to be either none or unknown. Of the respondents who felt it was having an impact, the majority rated St. John's-wort to be a limited or moderate problem of a widespread nature, however, the responses were equally divided as to whether the plant was spreading or stable. Contact Us included: Its presence indicates disturbed site conditions. It is not considered a threat in Quebec. It is not having an impact on natural areas in Quebec.

Smooth Brome Grass

(*Bromus inermis*) Leysser.

Distribution andf Biology

Smooth brome grass is a member of the grass family (Poaceae). It is native to southern Europe but has been introduced widely in Canada for forage production and erosion control beginning in the late 1800s (Romo and Grilz, 1990; Walton, 1983). Smooth brome grass occurs across Canada from Quebec to Alberta. It is found in prairies, natural meadows and savannas,as well as roadsides and agricultural land (Romo and Grilz, 1990; botanist survey).

Generalized distribution of smooth brome grass (*Bromus inermis*) in North America (after Dore and McNeill (1980); Newell (1973); and floras). Solid circles represent individual or local occurrences.

Smooth brome grass is a long-lived herbaceous perennial that spreads vegetatively by underground rhizomes as well as by seed production (Newell, 1973; Walton, 1983). Romo and Grilz (1990) describe its seed production as "prolific" and its vegetative spread as "rapid". Seed dispersal can involve wind and water as well as birds, livestock, and native ungulates. There is evidence that viable seeds may pass through animal digestive tracts unharmed and thus be spread widely across the landscape (Romo and Grilz, 1990).

Impact and Control

The greatest impact of smooth brome grass appears to be prairies and native grasslands of the Canadian prairies, however, the southern boreal forest and aspen parkland as well as portions of the mixed prairie may be at risk of invasion by this exotic grass (Romo and Grilz, 1990).

Little attention appears to have been directed to controlling smooth brome grass in natural areas. Control programs in place for other exotic aliens have relied heavily on experience gained trying to control the aliens where they are in direct conflict with agriculture. Because smooth brome grass is an important agricultural crop, few have turned their efforts to possible control strategies. There do not appear to be parasites and predators native to the Canadian prairies that attack smooth brome grass (Romo and Grilz, 1990). Since the species is used widely in agriculture, it is unlikely that a biological control program for natural areas could be developed.

Survey Summary and Contact Us

Smooth brome grass was not one of the original species included in the survey, however, it was suggested by a respondent from the prairies. That respondent regarded it as one of the worst invasive species in natural areas in that region.

Tatarian Honeysuckle

(*Lonicera tatarica L.*) Leysser.

Distribution andf Biology

Tatarian honeysuckle belongs to the honeysuckle family (Caprifoliaceae). It is a native of Eurasia that has been widely planted in North America as an ornamental and has escaped to open woods, thickets, shorelines, and roadsides (Soper and Heimburger, 1982; botanist survey).

Generalized distribution of Tatarian honeysuckle (*Lonicera tatarica*) in North America based on floras.

Tatarian honeysuckle is a large shrub that spreads by the production of seeds contained in small fleshy berries (Soper and Heimburger, 1982). The fruit of the related Amur honeysuckle (*Lonicera maackii*) are eaten and dispersed by birds (Williams *et al*., 1992). Tatarian honeysuckle fruit are probably also consumed and spread by birds. It is not known how long Tatarian honeysuckle seeds can survive in the soil seed bank, however, those of Amur honeysuckle are thought to be short-lived (Williams *et al*., 1992).

Impact and Control

The principal impact of Tatarian honeysuckle in natural areas occurs in open woods, ravines, and woodland edges (botanist survey). In *The Plant Press* survey it was regarded as a problem in central Ontario (Kaiser, 1986).

Amur honeysuckle (*Lonicera maackii*), the closely related Belle honeysuckle (*Lonicera* **x** *bella*)-a hybrid between *L. tatarica* and *L. morrowii*-and Japanese honeysuckle (*Lonicera*

japonica) are other invasive shrubs or vines that are well established in eastern and central United States (Evans, 1984a; Williams *et al*., 1992). These shrubs impact natural areas by displacing native understorey species and ground flora, changing vegetation structure, and impeding forest tree regeneration (Evans, 1984a; Evans, 1984b; Whelan and Dilger, 1992; Williams *et al*., 1992). It is likely that Tatarian honeysuckle is having similar impacts in natural areas, though to what degree is unknown.

There is no evidence that control of Tatarian honeysuckle has been attempted in North America. Other honeysuckles, such as those listed above, as well as unrelated shrubs of similar habit and site requirements, have been the subject of control programs and relevant information can be obtained from such programs. The most effective strategy reported with many shrubs is to cut them off near ground level and apply herbicide, such as glyphosate, to the freshly cut stem base (Chapman, 1983; Evans, 1983b; Henderson and Howell, 1981; Kline, 1981).

Voegtlin (1983) reports that a European aphid pest of the Tatarian honeysuckle complex, *Hyadaphis tataricae*, was found in the United States in 1976 and has been spreading rapidly since that time. This pest causes severe damage to the growing tips that can result in reduced vigour, low seed set, and possibly death in heavy infestations (Voegtlin, 1983). It is not known if this aphid has established itself in Canada.

Survey Summary and Contact Us

The majority of the respondents rated Tatarian honeysuckle to be a moderate or limited problem of more a local than widespread nature. The plant was regarded more as spreading than stable. Many respondents to the survey considered its impact to be either none or unknown. Contact Us included: It is having no impact on natural areas in Quebec. It is common and frequent in urban woodlots in Quebec and has the potential to interfere with native vegetation. In Ontario it is a species of high concern. It is one of the most aggressive aliens in eastern Ontario.

Yellow sweet-clover and White sweet-clover

(*M. officinalis L.*) and (*Melilotus alba L.*)

Distribution andf Biology

Yellow and white sweet-clovers belong to the bean family (Fabaceae). Both species are native to Eurasia and widely distributed in North America. In Canada, they occur from Newfoundland to British Columbia and north to southern Northwest Territories (Turkington *et al*., 1978). White sweet-clover is generally more common and occurs somewhat farther north than yellow sweet-clover. The sweet-clovers occur in prairies, savannas, alvars, meadows, as well as roadsides and agricultural land (Turkington *et al*., 1978; botanist survey).

Generalized distribution of yellow sweet-clover

(*Melilotus officinalis*) in North America (after Turkington *et al*., (1978) and floras).

Generalized distribution of white sweet-clover (*Melilotus alba*) in North America (after Turkington *et al*., (1978) and floras).

The sweet-clovers are herbaceous biennials or short-lived perennials that form a rosette of leaves in the first growing season after germination and normally produce a tall flowering stalk and set seeds the second year, after which time they die (Turkington *et al*., 1978). Plants that germinate very early in the spring in the southern part of the range, such as southwestern Ontario, can flower at the end of the first season (Turkington *et al*., 1978). Plants that are prevented from flowering in the second year by mowing or other clipping may survive into the third year (Turkington *et al*., 1978). Reproduction is by seed production only, the sweet-clovers cannot spread vegetatively (Turkington *et al*., 1978). Seed production varies widely from fewer than 100 per plant to 350 000 per plant (Turkington *et al*., 1978). The seeds are often dispersed by running water in the spring and many will germinate readily the first year, however, they can remain viable for at least 40 years (Turkington *et al*., 1978). Their common names indicate the most obvious distinction between the two sweet-clovers-yellow sweet-clover has yellow flowers; white sweet-clover has white flowers.

Impact and Control

Sweet-clovers have been in North America for a long time because they have long been cultivated as forage crops for cattle and, to a lesser degree, for honeybees (Turkington *et al*., 1978). Their principal impact occurs in prairies, alvars, natural meadows, and savannas (Cole, 1991b; botanist survey).

There are a number of methods that have been used to control sweet-clovers. Because they do not spread vegetatively but produce large number of long-lived seeds, control strategy must concentrate on the prevention of seed set (Cole, 1991b). Physical removal of first-year plants, either in the first fall or early the next spring, or cutting flowering plants near the ground before they flower can be effective if such methods continue long enough to deplete any soil seed bank present (Cole, 1991b). Prescribed burning can also be effective if the timing is right and if it is repeated in subsequent years (Cole, 1991b; Kline, 1983; Schwarzmeier, 1984). Although burning may kill second-year plants, it may also stimulate the germination of new plants that will

have to be dealt with by either a later repeat burn or the application of herbicide (Turkington *et al*., 1978). Fall burning appears to be most stimulative of spring germination of sweet-clovers (Schwegman and McClain, 1985). Herbicides, such as 2,4-D, can be effective against such seedlings as well as the overwintering rosettes when applied early in the spring before native vegetation emerges (Cole, 1991b; Schwegman and McClain, 1985). The native sweet-clover weevil (*Sitona cylindricollis*) can be an effective control agent if its populations are high enough, however, at least in the Canadian prairies, the natural population levels are rarely high enough for significant control to be achieved (Craig, 1978).

Survey Summary and Contact Us

Many respondents to the survey considered its impact to be either none or unknown. Of the respondents who felt it was having an impact, the majority rated the sweet-clovers as moderately invasive and widespread, however, the responses were equally divided as to whether they were spreading or stable. Contact Us included: No impact in natural areas. They are not problem species. Two of the nine worst species on the list. It is invading wet meadows at Presqu'Ile Provincial Park in Ontario that have seen some past disturbance. They are primarily species of disturbed sites-their impact on natural areas is limited. White sweet-clover is the greater problem, however, neither compete that well in natural areas.

Minor Invasive Aliens

The following section presents a summary of relevant information on a number of alien and one native species that appear at present to pose only a minor or local threat to upland natural areas. Some of these species were listed in the botanist summary table, however, many were additional species suggested by respondents as constituting a problem in their area.

Among the additional plants suggested as potentially invasive aliens of upland natural areas by respondents of the botanist survey, were the following species:

Amur honeysuckle (*Lonicera maackii*)
Amur maple (*Acer ginnala*)
Blueweed (*Echium vulgare*)
Bouncing bet (*Saponaria officinalis*)
Burnet-saxifrage (*Pimpinella saxifraga*)
Cat's-ear (*Hypochoeris radicata*)
Climbing euonymus (*Euonymus fortunei*)
Climbing nightshade (*Solanum dulcamara*)
Coltsfoot (*Tussilago farfara*)
Crown-vetch (*Coronilla varia*)
Cypress spurge (*Euphorbia cyparissias*)
English holly (*Ilex aquifolium*)
Eulalia (*Miscanthus sinensis*)
European mountain-ash (*Sorbus aucuparia*)
Field scabious (*Knautia arvensis*)
Foxglove (*Digitalis purpurea*)
Goat's-beard (*Tragopogon dubius*)
Great ragweed (*Ambrosia trifida*)
Hedge parsley (*Torilis japonica*)
Hemp-nettle (*Galeopsis tetrahit*)
Impatiens (*Impatiens glandulifera*)
Japanese barberry (*Berberis thunbergii*)
Japanese honeysuckle (*Lonicera japonica*)
Japanese knotweed (*Polygonum cuspidatum*)
Mossy stonecrop (*Sedum acre*)
Ox-eye daisy (*Leucanthemum vulgare*)
Sheep sorrel (*Rumex acetosella*)
Short-rayed aster (*Aster brachyactis*)
Siberian elm (*Ulmus pumila*)
Spurge-laurel (*Daphne laureola*)
Winged euonymus (*Euonymus alata*)
Winter cress (*Barbarea vulgaris*)

Since the above aliens are generally regarded as weeds of urban and agricultural land, they are not discussed further in this report.

Absinth (*Artemisia absinthium* L.) was reported in the survey by most respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a

limited invasive of a local nature that is stable. Contact Us include: Not a problem in natural areas in Quebec. Absinth is native to Eurasia and was introduced to North America in the mid to late 1800s because of its purported medicinal values (Maw *et al*., 1985). In Canada, it is largely a species of disturbed sites (Maw *et al*., 1985) and is found from British Columbia to Newfoundland. A number of control options are discussed in Evans (1982), Maw et al. (1985), and Steuter (1983).

Alfalfa (*Medicago sativa* L.) was not on the list for botanist survey as sent out, how-ever, one respondent reported it as being a problem in the Prairie provinces. Alfalfa is a Eurasian species that is commonly cultivated in North America; in Canada it occurs from the District of Mackenzie to Nova Scotia (Scoggan, 1978-79).

Black locust (*Robinia pseudo-acacia* L.) was reported in the survey by many respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature that is stable. Contact Us include: Very limited in impact. A significant problem in southern Ontario. In Nova Scotia it is found mainly near towns. Black locust was listed in *The Plant Press* survey as a problem in southwestern Ontario (Kaiser, 1986). It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). Black locust is native to the United States; in Canada, it is much planted and occasionally established in southern British Columbia, and from Nova Scotia to Ontario (Scoggan, 1978-79). A number of control options are discussed in Fleming *et al*. (1986), Liegel *et al*. (1984), Luken (1991), Luken *et al*. (1991), and Scheerer and Jackson (1989).

Canada blue grass (*Poa compressa* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in Ontario. This Eurasian species is naturalized in dry soils all across Canada (Scoggan, 1978-79).

Celandine (*Chelidonium majus* L.) was reported in the survey by many respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature that is stable. Contact Us include: Very limited in impact. Aggressive in eastern Ontario. Only a problem near urban areas in Quebec. A major weed in some southern Ontario floodplain forests. Celandine is a native of Europe that has become established in towns and rich damp soils of southwest British Columbia, and Ontario to Nova Scotia (Scoggan, 1978-79).

Crested wheat grass (*Agropyron pectiniforme* Roemer and Schultes = *A. cristatum* (L.) Gaertn.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in the Prairie provinces. Crested wheat grass was introduced into the Prairies from Siberia in 1915 for forage and has been widely planted in both the United States and Canada since that time (Looman, 1983; Redente *et al*., 1989). Although this plant has not spread substantially from the area where it was first introduced, it has remained the dominant species in most of these areas-some sites have remained virtual monocultures of crested wheat grass after having been seeded 50 years ago (Redente *et al*., 1989). Two sites, one in Alberta and one in Saskatchewan, of the endangered slender mouse-ear-cress (*Halimolobos virgata*), have been over-taken by crested wheat grass (Smith, 1991).

Dame's rocket (*Hesperis matronalis* L.) was reported in the survey by many respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive that is spreading. Opinion was divided as to whether it is local or widespread. Contact Us include: Very limited impact. A serious problem in southwestern Ontario. It may dominate small patches in southern Ontario. Not a problem in natural areas in Quebec. Dame's rocket was listed in *The Plant Press* survey as a problem in southwestern and central Ontario (Kaiser, 1986). It is a high priority species for removal from Point Pelee National Park, Ontario

(Dunster, 1990). Dame's rocket is native to Eurasia; in Canada, it is a garden escape that has spread to roadsides, thickets, and open woods in all provinces (Scoggan, 1978-79).

Dog-strangling vine (*Cynanchum nigrum* (L.) Pers. and C. rossicum (Kleopov) *Borhidi* = C. *medium* auct. non R.Br.) was reported in the survey by most respon-dents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a severe invasive of a local nature that is spreading. Contact Us include: Mostly a problem near urban areas. A serious pest in southwestern Ontario. Aggressive in eastern Ontario. Riley (1989) considered it very invasive in ravines in the Toronto area. Dog-strangling vine was listed in *The Plant Press* survey as a problem in central Ontario (Kaiser, 1986). Dog-strangling vine is native to Europe; in Canada, it is a garden escape found in thickets, fields, and roadsides in a few locations in Quebec, Ontario, and British Columbia (Moore, 1959; Scoggan, 1978-79). Kirk (1985) mapped its Ontario distribution.

English ivy (*Hedera helix* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a serious but local problem in southern British Columbia. It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). This Eurasian plant is commonly cultivated in North America and has escaped to open woods in southern British Columbia and southwestern Ontario (Dunster, 1990; Scoggan, 1978-79).

Goutweed (*Aegopodium podagraria* L.) was reported in the survey by many respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature. Opinion was divided as to whether it is stable or spreading. Contact Us include: Very limited in impact. Mainly a problem near habitations. Rarely a problem in eastern Ontario. Goutweed is a Eurasian species that in Canada has escaped primarily to roadsides and waste places of southwest British Columbia, and southern Manitoba to Nova Scotia (Scoggan, 1978-79).

Himalayan blackberry (*Rubus discolor* Weihe and Nees) was not on the list for botanist survey as sent out, however, one respondent reported it as being a serious problem in southwestern British Columbia. Dutson (1973) reports that in California, Himalayan blackberry provides food and cover for the roof rat (*Rattus rattus*), another pest from the Old World that is established in coastal British Columbia (Banfield, 1974). A number of control options are discussed in Dutson (1973). In Canada, this European plant is only known from southern British Columbia (Scoggan, 1978-79; botanist survey).

Hoary-alyssum (*Berteroa incana* (L.) DC.) was reported in the survey by most respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature. Opinion was divided as to whether it is stable or spreading. Contact Us include: Not a problem in natural areas in Quebec. May be a short-lived problem in some Ontario prairies. Hoary-alyssum is native to Eurasia; in Canada, it is established mainly in fields and waste places from southern British Columbia to Nova Scotia (Scoggan, 1978-79).

Kentucky blue grass (*Poa pratensis* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in the Prairie provinces. Contact Us include: It may be partly native and partly introduced in Canada. Kentucky blue grass is native to Eurasia; in Canada, it is found commonly in moist to dry soils from Newfoundland to British Columbia and Yukon (Dore and McNeill, 1980; Scoggan, 1978-79). A number of control options are discussed in Blankespoor (1987); Blankespoor and Bich (1991); and Engle and Bultsma (1984).

Lilac (*Syringa vulgaris* L.) was reported in the survey by many respondents as not being a

problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature that is stable. Contact Us include: Not a problem in natural areas in Quebec. Very limited in impact. Mainly occurring in old fields in Ontario. Rarely spreads far in Ontario. In Nova Scotia it is found mainly near towns. It does not spread in Quebec. It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). Lilac is a widely-planted European shrub that has spread to roadsides and waste places in Saskatchewan, and from Ontario to Newfoundland (Scoggan, 1978-79).

Manitoba maple (*Acer negundo* L.) was reported in the survey by many respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature. Opinion was divided as to whether it is stable or spreading. Contact Us include: Mostly a problem near urban areas. Common in southwestern Ontario. Manitoba maple is native to the Prairies and possibly to parts of Ontario, however, it has been commonly planted in much of the country and it now occurs from Alberta to Nova Scotia (Scoggan, 1978-79).

Mother-of-thyme (*Acinos arvensis* (Lam.) Dandy) was not on the list for botanist survey as sent out, however, two respondents reported it as being a problem in southern Ontario-one considered it to be a serious problem on some alvars. It is a Eurasian species that has become established along roadsides, old fields, and waste places from Prince Edward Island to Ontario as well as British Columbia (Scoggan, 1978-79).

Mullein (*Verbascum thapsus* L.) was reported in the survey by many respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive that is stable. Opinion was divided as to whether it is local or widespread. Contact Us include: Not very aggressive in natural communities in Quebec. Mostly restricted to disturbed communities in Ontario. Not a problem in Ontario natural areas. Mullein is native to Europe; in Canada, it is found commonly in old fields, waste places, and roadsides from Newfoundland to British Columbia (Gross and Werner, 1978; Scoggan, 1978-79). A number of control options are discussed in Gross and Werner (1978).

Multiflora rose (*Rosa multiflora* Thunb.) was reported in the survey by most respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited to moderate invasive of a local nature. Opinion was divided as to whether it is stable or spreading. It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). Multiflora rose is native to Asia but has been widely planted in North America for ornamental and wildlife cover purposes. In Canada, it has become naturalized only in southwestern Ontario where it is found along roadsides and in clearings (Scoggan, 1978-79). A number of control options are discussed in Evans (1983a) and Szafoni (1991).

Nodding thistle (*Carduus nutans* L.) was not on the list for botanist survey as sent out, however, several respondents reported it as being a problem in Ontario and the Prairie provinces. Nodding thistle is native to Eurasia; in Canada, it is found from Newfoundland to British Columbia but it is common only in southern Ontario and the Prairie provinces (Moore and Frankton, 1974). A number of control options are discussed in Feldman et al. (1968).

Norway maple (*Acer platanoides* L.) was reported in the survey by most respon-dents as not being a problem species. Of those who felt it was having an impact, the responses were well distributed between limited, moderate, and severe, however, most rated it as a local problem that is spreading. Contact Us include: A major dominant of some southern Ontario floodplains. Not a problem in natural areas in Quebec. One of the most invasive species in southern Ontario. Mostly a problem near urban areas. Riley (1989) considered it very invasive in ravines in the Toronto area. It is a high priority species for removal from Point Pelee National Park, Ontario

(Dunster, 1990). This tree is native to Europe; in Canada, it has been much planted and has escaped to hedge-rows, thickets, and open woods from southern Ontario to Newfoundland (Scoggan, 1978-79; botanist survey).

Periwinkle (*Vinca minor* L.) was reported in the survey by many respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature that is stable. Contact Us include: Very limited in impact. Mostly a problem in urban areas. Periwinkle was listed in *The Plant Press* survey as a problem in southwestern and central Ontario (Kaiser, 1986). It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). Periwinkle is a Eurasian garden escape that has spread to roadsides, waste places, and open woods in southwest British Columbia, and southern Ontario to Nova Scotia (Scoggan, 1978-79; botanist survey).

Ragweed (*Ambrosia artemisiifolia* L.) was reported in the survey by most respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited or moderate invasive of a widespread nature that is stable. Although ragweed is native in North America, it is primarily a species of disturbed habitats in Canada. Contact Us include: Does not take over habitats where it occurs. Not a problem in natural areas in Quebec. Not a problem in natural communities. Mostly restricted to disturbed communities in Ontario. Due to the weedy nature of ragweed, its native range is uncertain. It is found across Canada, mainly along roadsides, and in cultivated land, waste areas, yards, and beaches (Scoggan, 1978-79).

Scotch broom (*Cytisus scoparius* (L.) Link.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in Nova Scotia. Mosquin and Whiting (1992) regard Scotch broom to be a problem in southwestern British Columbia and one of five invasive alien plants that have had a major impact on natural ecosystems in Canada. Scotch broom is a garden escape from Europe that is established along sandy roadsides, barrens, and open woods in British Columbia, Prince Edward Island, and Nova Scotia (Scoggan, 1978-79).

Siberian peashrub (*Caragana arborescens* Lam.) was not on the list for botanist survey as sent out, however, two respondents reported it as being a problem in the Prairie provinces. This shrub is native to Asia but has been commonly cultivated-especially for hedges and windbreaks in the Prairies-and has spread to open woods and clearings from Alberta to Manitoba, and Quebec (Scoggan, 1978-79).

Spotted knapweed (*Centaurea maculosa* Lam.) was not on the list for botanist survey as sent out, however, several respondents reported it as being a problem in Alberta, British Columbia, and Ontario. It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). It has been the recent target of control efforts in Jasper National Park (E. Abbott, pers. com., 1992). In British Columbia it forms dense stands in mountain meadows (Peschken, 1979). Spotted knapweed is native to Europe where it is not a problem because it is attacked by a complex of specialized organisms (Harris, pers. com., 1992). In Canada, it is found from Nova Scotia to British Columbia (Moore, 1972). A number of control options are discussed in Harris (1984); Harris (1989); Maddox (1982); and Strobel (1991).

Teasel (*Dipsacus laciniatus* L. and *D. fullonum* L. = *D. sylvestris* Hudson) was reported in the survey by most respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive that is stable. Opinion was divided as to whether it is local or widespread. Contact Us include: Not a problem in natural areas in Quebec. Mostly restricted to disturbed communities in Ontario. *D. laciniatus* is potentially a dangerous pest in Ontario. Crowder (1991b) describes the spread of *D. fullonum* in the Kingston area. Teasel is native to Europe; in Canada, *D. laciniatus* is known only from southern Ontario (botanist survey); D. fullonum is found in Quebec, Ontario, and British Columbia (Werner,

1975). A number of control options are discussed in Glass (1991); Packard (1988); and Werner (1975).

White bedstraw (*Galium mollugo* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a potential problem in Ontario and another considered it to be a major problem in some eastern Ontario alvars. Its seeds are very short-lived in the soil seed bank (Roberts, 1986). This Eurasian weed is common in fields and along roadsides in British Columbia, and Ontario to Nova Scotia (Scoggan, 1978-79).

White mulberry (*Morus alba* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being a problem in southern Ontario. It was listed in *The Plant Press* survey as a problem in southwestern Ontario (Kaiser, 1986). It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). Ambrose (1987) considers white mulberry to be a threat to the native and nationally threatened red mulberry (*Morus rubra*) because they hybridize and this 'genetic swamping' of the rare native by the alien could eliminate the native red mulberry. White mulberry is an Asian tree that has spread from cultivation in southern Ontario (Scoggan, 1978-79).

White poplar (*Populus alba* L.) was reported in the survey by most respondents as not being a problem species. Of those who felt it was having an impact, the majority rated it as a limited invasive of a local nature. Opinion was divided as to whether it is spreading or stable. Contact Us include: Not a problem in natural areas in Quebec. Very limited in impact. It is a high priority species for removal from Point Pelee National Park, Ontario (Dunster, 1990). Since most North American white poplars are female, few seeds of the species are produced and this has probably limited its spread and impact (Spies and Barnes, 1982). White poplar, a native of Eurasia, has been widely planted in North America for ornamental purposes; in Canada, it is found commonly from Newfoundland to British Columbia.

Wild marjoram (*Origanum vulgare* L.) was not on the list for botanist survey as sent out, however, one respondent reported it as being aggressive in eastern Ontario. This plant is a Eurasian garden escape that has spread to roadsides, old fields, and open woods in southwest British Columbia, and Ontario to Nova Scotia (Scoggan, 1978-79).

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Canada

Common buckthorn

(Rhamnus cathartica L.)

Alternate Common Name

Buckthorn, European buckthorn

Taxonomic Overview

The genus belongs to the buckthorn family (Rhamnaceae) and consists of about 100 species, primarily of north temperate regions. Many are purgative. The generic name is based on the Greek name *Rhamnos* used for some of the species; *cathartica* means purging, in reference to substances in the bark, leaves, and berries that are strongly purgative when eaten (Soper and Heimburger, 1982). Common buckthorn was described by Linnaeus in 1753.

Distribution

Common buckthorn, a native of Europe, was introduced to northeastern North America (Soper and Heimburger, 1982). In Canada, it is known mainly from southern Ontario but also occurs east to Nova Scotia, and west to Saskatchewan. In Ontario it is found primarily south of the Canadian Shield (Soper and Heimburger, 1982).

Generalized distribution of common buckthorn (*Rhamnus cathartica*) in North America based on herbarium specimens and floras. Solid circles represent individual or local occurrences.

Biology

Common buckthorn is a large shrub or small tree that is generally dioecious (i.e., with male and female flowers on separate plants). The female trees produce small dark fruits called drupes that each contain four seeds. The berrylike drupes occur singly or in small groups in leaf axils (Soper and Heimburger, 1982). The fruit contains a poi-sonous substance (Kingsbury, 1964) that probably deters many potential consumers, however, birds are the chief consumers and responsible for the plant's spread (Heidorn, 1991; Gill and Marks, 1991). Common buckthorn occurs in a range of upland communities including upland and floodplain forests, woodland edges, fencerows, prairies, and old fields. It is able to successfully invade habitats because of its tolerance of a wide range of moisture and light conditions, its prolific seed production, and because of the high viability and rapid germination of the seeds (Gourley and Howell, 1984).

Ecology

When common buckthorn invades a natural area it displaces the native species by the dense shade produced by the stand (Heidorn, 1991; botanist survey comments). Boudreau and Willson (1992) suggest that common buckthorn may be allelopathic, i.e., able to produce substances that inhibit the growth or development of many herbaceous woodland species. Detailed ecological studies need to be conducted to assess the degree of impact in natural areas.

In addition to the plant's negative effect on natural areas, common buckthorn is an alternate host for the fungus that causes oat rust (Soper and Heimburger, 1982).

Present Status and Potential Threat

Common buckthorn presently occurs in a limited portion of Canada and appears to be seriously invasive in only part of this range. Its rapid spread, however, coupled with its ability to invade a range of habitats suggest that it will become a greater problem in the future. In *The Plant Press* survey it was regarded as a problem in southwestern and central Ontario (Kaiser, 1986).

Control Measures

Several methods have been used to control common buckthorn in natural areas including fire, herbicide application, and girdling (Heidorn, 1991). Most methods have produced at least some positive results, however, all methods require follow-up treatment (Heidorn, 1991).

Fire control for common buckthorn requires annual or biennial burns for five or more years (Heidorn, 1991). Fire may be inappropriate for some natural areas due to damage to native species (Heidorn, 1991).

Stem cutting or girdling, in combination with later sprout removal or the application of herbicide to the cut stem can be effective if there is adequate follow-up treatment or monitoring (Hefty, 1984; Heidorn, 1991; Packard, 1987). This method is of course very labour-intensive and probably suitable only for small and highly significant sites. Herbicide application must be done with extreme care to prevent damage to native species (Heidorn, 1991). Common buckthorn grows later in the season than many native plants and this trait can be used to advantage-fall

application of herbicide can effect control of common buckthorn with little negative impact on native species nearby that are entering dormancy (Kline, 1981).

Sometimes it may be necessary or desirable to remove common buckthorn gradually from a natural area that has a large population. If common buckthorn has displaced native shrubs from an area it may be providing the only nest sites in that area for some species of birds (Whelan and Dilger, 1992). Since common buckthorn is dioecious, male plants do not contribute to the seed bank and hence may be safely left to provide nest sites until native shrubs can be reintroduced or naturally regenerate (Whelan and Dilger, 1992).

Survey Summary and Contact Us

The majority of the respondents to the survey rated common buckthorn as a problem that is spreading, however, opinion was divided as to whether it was a severe, moderate, or minor problem and whether it was of a widespread or local nature. Many respondents considered its impact none or unknown. Contact Us included: Common buckthorn is a major problem in southern and eastern Ontario. Common buckthorn is one of the most invasive species in the Ottawa area. In the Ottawa area, it is aggressively spreading and is probably supplanting native species. In Ontario, common buckthorn is one of the most aggressive aliens.

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Canada

Garlic mustard

(*Alliaria petiolata*) (*Bieb.*) Cavara and Grande

Alternate Common Name

Hedge garlic

Taxonomic Overview

The genus consists of two species and belongs to the mustard family (Brassicaceae). Until recently, garlic mustard was known in North America as A. *officinalis* Andrz. The synonym *Sisymbrium alliaria* Scop., has also been used.

Distribution

Garlic mustard is native to Europe. In North America, it occurs primarily in the northeast with isolated populations in British Columbia and Oregon. In Canada, the species is found in Victoria, British Columbia, and in the St. Lawrence Valley from Point Pelee in Ontario to the Quebec City area in Quebec (Cavers *et al*., 1979). The southwestern Ontario counties of Middlesex and Elgin, as well as the larger urban centres, such as Toronto and Ottawa are the main areas of abundance for the species. Cavers *et al*. (1979) state that garlic mustard is restricted to the St. Lawrence Valley and that it does not occur on the Canadian Shield, however, D. White (pers. obs., 1991) recorded it as common in Silver Lake Provincial Park (Lanark County) in an area of deciduous woods well onto the Canadian Shield.

The initial introduction of the plant into Canada was probably for medicinal use and as a green vegetable (Cavers *et al*., 1979; Duke, 1992). The first Canadian record of garlic mustard is from Toronto in 1879. In 1891 it had been collected in Ottawa, Quebec City in 1895, Kingston in 1898, and Victoria, British Columbia in 1948 (Cavers *et al*., 1979).

Generalized distribution of garlic mustard (*Alliaria petiolata*) in North America based on herbarium specimens and floras. Solid circles represent individual or local occurrences. The Colorado site has not been recorded since 1950; the Gaspé station has not been recorded since 1891.

Biology

Garlic mustard is a biennial plant of deciduous woods, floodplain forests, gardens, and roadsides (Cavers *et al*., 1979). During the first year, the plant produces a slender taproot and a basal rosette of leaves that persist over the winter. In the second year, garlic mustard produces a flowering stalk with a terminal cluster of white flowers that produce seeds by early summer (Byers and Quinn, 1988; Cavers *et al*., 1979).

Garlic mustard reproduces by seed production only-there is no evidence of vegetative reproduction or perennation by the formation of adventitious root buds in Ontario, although such root buds have been reported in Europe (Cavers *et al*., 1979). Plant size, and hence seed production, vary widely (Byers and Quinn, 1986)-small plants may produce only 10 seeds while large plants in suitable habitats may produce over 2 700 (Cavers *et al*., 1979). In dense stands in woodland habitats seed production can exceed 100 000 seeds per square metre per year (Cavers *et al*., 1979). Nuzzo (1991) reports a much lower seed production-9 500 seeds per square metre.

There is little information on seed longevity, however, Nuzzo (1991) states that seeds germinate from two to six years after production with most germinating in the second year. Cavers *et al*. (1979) also report that although a few seeds germinate the first spring after their production, the majority germinate the following spring. Seed dispersal is primarily by humans and other animals-wind dispersion is ineffective and the seeds do not float well (Cavers *et al*., 1979). A range of insects, including flies and bees are reported to be possible pollinators of garlic mustard, however, seed production is unaffected when only self-pollination occurs (Cavers *et al*., 1979).

Ecology

It is clear that garlic mustard is displacing native species in some natural areas, however, detailed ecological studies need to be conducted to assess the degree of impact.

In addition to the plant's negative effect on natural areas, it also harbours a strain of turnip mosaic virus (TuMV-Al). Since the centre of abundance of garlic mustard is in an area of Ontario that supports a concentration of rutabaga (*Brassica napus* L. ssp. *napobrassica* (L.) Reichb. and canola (*B. napus* L. ssp. *oleifera* (DC.) Metzger) it was feared that garlic mustard might be an important overwintering reservoir of the strain of the virus that infects rutabaga and canola. Research on Ontario populations of garlic mustard has shown that the strain of turnip mosaic virus infecting garlic mustard is not transmissible to these or other *Brassica* crops (Stobbs and Van Schagen, 1987).

Present Status and Potential Threat

Garlic mustard presently occurs in a limited portion of Canada-primarily southern Ontario. Within that range, however, the species is locally common and often dominates the ground flora

of forests within which it occurs (Cavers *et al*., 1979). Riley (1989) notes many forest areas in southern Ontario that have become invaded by garlic mustard and doubts that the spring flora of these forests will survive the invasion. Cavers *et al*. (1979) report that garlic mustard has replaced native spring ephemerals at many sites in Middlesex County, Ontario and that it has increased in abundance in Elgin County, Ontario in the last 20 years. Garlic mustard was listed in *The Plant Press* survey as a problem in central and southwestern Ontario (Kaiser, 1986). It is a high priority species for removal from Point Pelee National Park, Ontario where it is considered to be a severe threat to upland habitats (Dunster, 1990).

Control Measures

Several methods have been used in the United States to control garlic mustard in natural areas including fire, cutting, and the use of herbicides (Nuzzo, 1991; Nuzzo *et al*., 1991). Most methods have produced positive results, however, all require follow-up treatment (Nuzzo, 1991; Nuzzo *et al*., 1991).

Regular fall or early spring burning has been found effective in oak woods, although repeated burns over several years may be needed to eliminate plants recruited from the seed bank (Nuzzo, 1991; Nuzzo *et al*., 1991). The fire must also be of sufficient intensity to ensure that no unburned areas remain (Nuzzo, 1991; Nuzzo *et al*., 1991).

Physical cutting of plants near the ground prior to or at flowering-time results in high mortality (Nuzzo, 1991; Nuzzo *et al*., 1991). Treatment must be repeated for several years to deplete the seed bank reserves (Nuzzo, 1991). Plants can also be hand-pulled in areas of light infestation, however, enough of the root crown must be removed to prevent resprouting, and soil disturbance can encourage additional germination of garlic mustard (Nuzzo, 1991; Nuzzo *et al*., 1991).

Herbicide application can also be effective in controlling garlic mustard provided certain precautions are observed (Nuzzo, 1991; Nuzzo *et al*., 1991). The best times of application are early spring and late fall. Since garlic mustard sprouts early in the spring and the first-year rosettes remain green through the winter, it can be effectively killed by spot application at a time when most native plants are dormant (Nuzzo, 1991; Nuzzo *et al*., 1991). Roundup (a formulation of glyphosate) and an amine formulation of 2,4-D can be used for hand-spraying and spot application (Nuzzo, 1991; Nuzzo *et al*., 1991).

Annual monitoring for new invasions as well as for recruitment from the original seed bank may be necessary for several years at sites that have been heavily infested (Nuzzo, 1991).

Survey Summary and Contact Us

The majority of the respondents to the survey rated garlic mustard as a severe problem of a widespread nature that is spreading. Many respondents considered its impact to be either none or unknown. Contact Us included: One of the most invasive species of upland habitats in Ontario. Garlic mustard forms dense monodominant stands that seem to smother out all natives.

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Canada

Glossy buckthorn

(*Rhamnus frangula* L.)

Alternate Common Name

Black buckthorn, European alder buckthorn

Taxonomic Overview

The genus belongs to the buckthorn family (Rhamnaceae) and consists of about 100 species, primarily of north temperate regions. Many are purgative. The generic name is based on the Greek name *Rhamnos* used for some of the species. Glossy buckthorn was described by Linnaeus in 1753. It has also been known under the synonym *Frangula alnus* Miller.

Distribution

Glossy buckthorn, a native of Europe, was introduced to northeastern North America (Soper and Heimburger, 1982; Howell and Blackwell, 1977). In Canada, it is known mainly from southern Ontario but also occurs in Nova Scotia, Quebec, and Manitoba. In Ontario it is found primarily in the vicinity of the larger cities (Soper and Heimburger, 1982).

Generalized distribution of glossy buckthorn (*Rhamnus frangula*) in North America based on floras and herbarium specimens. Solid circles represent individual or local occurrences.

Biology

Glossy buckthorn is a shrub or small tree that produces small dark fruits, each containing two to three seeds. The berrylike drupes occur singly or in small groups in leaf axils (Soper and Heimburger, 1982). The fruit contains a poisonous substance (Kingsbury, 1964) that probably deters many potential consumers, however, European Starlings can apparently eat the fruit with impunity and they have been suggested as the primary agent responsible for the spread of glossy buckthorn in Ohio (Howell and Blackwell, 1977). Glossy buckthorn occurs in a range of wetland communities including fens, marshes, and bogs. Although the plant has a preference for wetlands, it also occurs in some upland habitats, such as forests, fencerows, wood edges, prairies, and old fields (Heidorn, 1991; Howell and Blackwell, 1977; botanist survey comments).

Ecology

When glossy buckthorn invades a natural area it displaces the native species by the dense shade produced by the stand (Taft and Solecki, 1990; botanist survey comments).

Present Status and Potential Threat

Glossy buckthorn presently occurs in a limited portion of Canada and appears to be seriously invasive in only part of its limited range. Its rapid spread, however, coupled with its ability to quickly invade natural areas (Howell and Blackwell, 1977; Taft and Solecki, 1990) suggest that it will become a greater problem in the future. In *The Plant Press* survey it was regarded as a problem in southwestern Ontario (Kaiser, 1986).

Control Measures

Several methods have been used to control glossy buckthorn in natural areas including fire, herbicide application, flooding, and girdling (Heidorn, 1991; Taft and Solecki, 1990). Most methods have produced at least some positive results, however, all methods require follow-up treatment (Heidorn, 1991).

Fire has been used to control glossy buckthorn, however, annual or biennial burns may be needed for five or six years or more (Heidorn, 1991). Burning kills most seedlings and older stems of glossy buckthorn but seeds and seedlings growing in saturated soil are unaffected, top-killed plants can resprout, and all can quickly recolonize the area (Heidorn, 1991; Post and Klick, 1988; Post *et al*., 1989; Taft and Solecki, 1990). Fire may be inappropriate for some natural areas due to damage to native species (Heidorn, 1991).

Stem-cutting or girdling, in combination with later sprout removal or the application of herbicide to the cut stem can be effective if there is adequate follow-up treatment or monitoring (Heidorn, 1991). This method is of course very labour-intensive and probably suitable only for small and highly significant sites. Seeds and seedlings are unaffected by this method and can quickly recolonize the site (Taft and Solecki, 1990). Herbicide application must be done with extreme care to prevent damage to native species (Heidorn, 1991).

Survey Summary and Contact Us

The majority of the respondents to the survey rated glossy buckthorn as a severe to moderate problem of a local nature which is spreading. Contact Us included: Glossy buckthorn is a major problem in southern and eastern Ontario. In Quebec it is mostly a problem in floodplain forests where it may hinder the regeneration of trees and affect the diversity of herbs. Glossy buckthorn is one of the most invasive species in the Ottawa area and it is having a severe impact in a provincially significant fen south of Leitrim. In the Ottawa area it is aggressively spreading and is probably supplanting native species. In Ontario glossy buckthorn is one of the most aggressive aliens.

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Leafy spurge

(Euphorbia esula L.)

Alternate Common Name

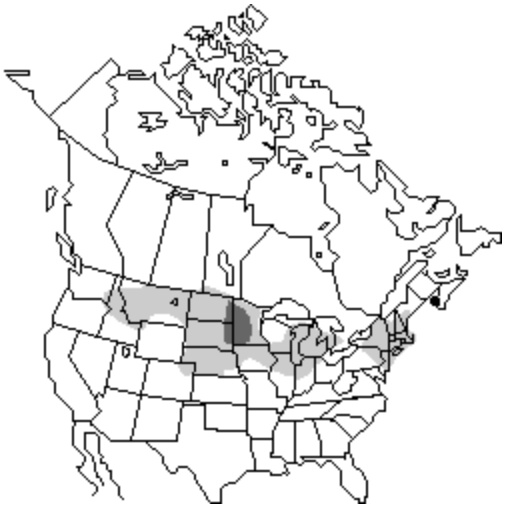
Wolf's-milk

Taxonomic Overview

The genus belongs to the nearly cosmopolitan spurge family (Euphorbiaceae) and consists of about 1 600 species. Leafy spurge belongs to section *Esula* of the genus that also includes the closely related cypress spurge (*E. cyparissias*). There has been considerable disagreement among taxonomists as to whether leafy spurge is a single variable species or an aggregate of several species (Crompton *et al*., 1990). European taxonomists have tended to subdivide leafy spurge into a number of species, subspecies, and hybrids, whereas North American botanists have tended to a more conservative treatment (Crompton *et al*., 1990). In their thorough literature review and statistical study of morphological characters of the *Euphorbia esula* group, Crompton *et al*. (1990) conclude that leafy spurge is a single but variable species that occasionally hybridizes with the closely related *E. cyparissias* to produce E. **x** *pseudoesula*. A gas chromatographic study of a wide range of North American collections of leafy spurge also supported the view that *Euphorbia esula* is best treated as a single variable species (Evans *et al*., 1991). It is probable that part of the variation observed in North American populations of the species is the result of the plant having been introduced many times from different regions of its wide native range (Best *et al*., 1980). Leafy spurge was described by Linnaeus in 1753.

Distribution

Leafy spurge is native to Europe and temperate Asia (Crompton *et al*., 1990). It was introduced to North America probably as a ballast contaminant along coastal New England in the early 1800s and later as a seed contaminant to western North America (Crompton *et al*., 1990). It has a wide distribution in North America, however, it is concentrated in the midwest United States, southern Prairie Provinces, and southwestern Ontario (Best *et al*., 1980; Dunn, 1979). The first North American records are from Massachusetts in 1827, Ontario in 1889, Minnesota in 1890, Manitoba in 1911, Saskatchewan in 1928, Alberta in 1933, and British Columbia in 1939 (Best *et al*., 1980).



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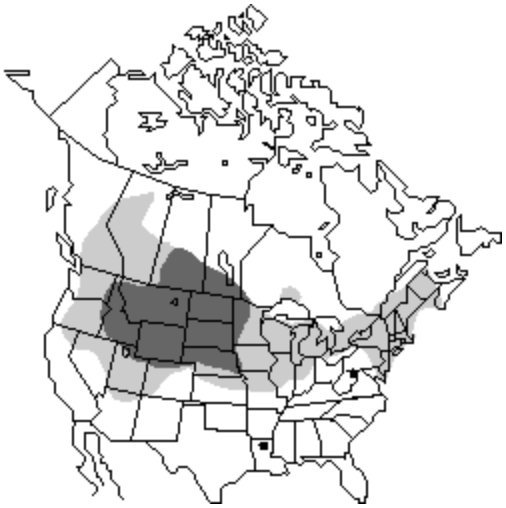

1980

Range expansion of leafy spurge (*Euphorbia esula*) in North America (after Best *et al*., (1980); Dunn (1979); and floras). Darker fill represents region with populations of dense stands, solid circles represent individual or local occurrences.

Biology

Leafy spurge occurs in a range of open upland habitats including native ungrazed prairies, natural savannas, open woods, rangelands, agricultural lands, and roadsides (Best *et al*., 1980; Cole, 1991; Selleck *et al*., 1962).

Leafy spurge is an herbaceous perennial that reproduces by seed and by persistent underground roots that are capable of producing new above-ground shoots (Best *et al*., 1980). The extensive roots are frequently found at 2.4 m and may occur as deep as 9 m (Best *et al*., 1980). The stems are erect (to 1 m high), tough, and woody; the inflorescence is terminal and comprised of many inconspicuous unisexual flowers (Best *et al*., 1980). The flowers are almost entirely insect pollinated-primarily by Diptera and Hymenoptera (Best *et al*., 1980). Cross-pollination, however, may not be necessary for seed production (Best *et al*., 1980; Selleck et al., 1962). Individual flowering shoots produce up to 250 seeds, and in dense patches, this can result in an annual production of over 8 000 seeds per square metre (Best *et al*., 1980). The plant overwinters as dormant roots and seeds (Best *et al*., 1980). Initial seed dispersal is by the 'explosive' rupturing of the mature capsule that can propel the seeds five metres (Best *et al*., 1980). Further seed dispersal is by insects, animals, and birds, as well as by agricultural machinery and seed contamination in grass seed, grain, and hay (Best *et al*., 1980). There is also evidence that the seeds are myrmecochorous, i.e., they are involved in an ant-plant mutualism in which the ants collect the seeds in order to harvest an attached fleshy protuberance called a caruncle. The seeds benefit from this relationship by being protected for a time by the ants but

the former are ultimately dispersed, often to superior substrates for germination and establishment (Pemberton, 1988). Seeds of leafy spurge are relatively long-lived with an estimated 13% annual loss of viability-most are non-viable after eight years in the soil (Bowes and Thomas, 1978; Evans *et al*., 1991). Selleck et al. (1962) reported seeds to remain viable no longer than five years.

Vegetative reproduction is the principal means of patch expansion once a plant is established at a site. Even though seedlings are found near the outer edges of a patch, they are not a significant method of reproduction in the patch (Best *et al*., 1980).

All parts of the plant contain a poisonous latex capable of killing cattle that eat quantities of the plant and causing dermatitis in humans and livestock (Best *et al*., 1980).

Ecology

Leafy spurge is an aggressive plant that can spread rapidly by seed production and vegetative reproduction. In mixed-grass prairie leafy spurge is capable of dominating the habitat and significantly decreasing the diversity and abundance of the existing native species (Belcher and Wilson, 1989). Leafy spurge may be allelopathic, i.e., produces substances that inhibit the growth or development of other nearby species (Steenhagen and Zimdahl, 1979).

Present Status and Potential Threat

From an initial start in Canada in the late 1800s and early 1900s, leafy spurge now occurs extensively in the southern Prairie provinces and southern Ontario. All indications are that it will continue to expand its range in Canada. The principal native habitats affected by this alien plant are prairies, savannas, and open woods. In the United States, leafy spurge is regarded as a serious national pest of rangelands, croplands, and pastures (Dunn, 1979). In North Dakota alone, annual losses from leafy spurge-both direct and indirect-are estimated at $92 million (Thompson *et al*., 1990). It may also present a serious threat to endangered species because of its aggressive competition with most types of herbaceous vegetation (Evans *et al*., 1991). Leafy spurge may be having a negative impact on Manitoba populations and may represent a potential threat to newly discovered Saskatchewan stands of the nationally threatened species western spiderwort (*Tradescantia occidentalis*) according to Smith and Bradley (1990) and Godwin and Thorpe (1991).

Control Measures

There is a long history of attempting to control leafy spurge in North America, primarily on agricultural land. Initial methods involved the use of various chemical herbicides-more recently, the focus has been on biological control.

Although direct control measures will be necessary in established patches of leafy spurge in natural areas, a more long-term goal should be to decrease soil disturbances for it is these disturbances that promote the establishment of the species (Pemberton, 1988). Consideration must also be given to the particular habitat involved-various habitats may respond differently to similar control methods (Heidel, 1982).

Chemical herbicides have been generally effective in controlling leafy spurge on agricultural land, however, they only control the plant for a limited time, they are expen-sive, and they contaminate groundwater (Best *et al*., 1980; Lym and Messersmith, 1985; Lym and Messersmith, 1990; Yang *et al*., 1991). The effectiveness of 2,4-D was first tested in the 1940s, however, several applications were needed along with a good stand of competing grass (Best *et al*., 1980). Later, picloram was found to kill nearly the entire root system in a patch and achieve control of the plant for three to five years (Best *et al*., 1980). Regrowth of the patch appeared to originate from existing seeds and if the site was retreated before the regrowth produced seeds, normally in the second year after germination (Selleck *et al*., 1962), effective control could be extended for six to ten years (Best *et al*., 1980). The use of picloram, however, has not been recommended for use in high-quality natural areas in Illinois (Cole, 1991). Picloram is very slow to break down in soil and its movement in ground water can be considerable (Harris, pers. com., 1992). In the western portion of the range, dicamba has provided good results (Messersmith and Lym, 1990). Glyphosate can be used where infestations occur near water or under trees (Messersmith and Lym, 1990).

Refinements in the timing and rate of application of herbicides in recent years has led to more effective control with reduced costs, both financially and environmentally (Messersmith and Lym, 1990). For maximum effect, herbicides should be applied either just prior to true flowering or during the fall regrowth period (Messersmith and Lym, 1990). Growth regulators, such as cytokinin or gibberellic acid, have been tested in combination with certain herbicides to determine if they enhanced the effect of the herbicide, however, such enhancement was not observed (Ferrell *et al*., 1989).

The above herbicides are non-selective for leafy spurge and hence they would have to be used with extreme care in natural areas to ensure that native species and natural values were not harmed.

Leafy spurge is considered to be a good candidate for biological control because of its wide distribution, dispersed population, and lack of domestic natural enemies (Dunn, 1979). Although leafy spurge is an aggressive weed in North America, it is not a problem in Britain or Europe (Selleck *et al*., 1962; Harris, pers. com., 1992). Whether this difference in impact is due primarily to the lack of insect or other predators of the plant in North America, or whether the difference is due to a combination of factors, such as different agricultural practices, weather conditions, or competing species, is unclear (Selleck *et al*., 1962). One potential problem in the development of a biological control program, however, will be the diversity of the species. This species diversity translates into a diversity of chemical compounds present in different populations. The chemical diversity of the plant may elicit a range of responses of biological control agents as they interact with different plant populations (Evans *et al*., 1991).

Leafy spurge is well protected against insect attack-sticky latex flows from any wound and this latex tends to trap insects or clog mouthparts (Best *et al*., 1980). There are some 96 insect pests of the plant in its European range (Heidel, 1982); many are being tested as potential biological control agents (Batra, 1983; Best et al., 1980; Harris, 1989; Messersmith and Lym, 1990; Ziegler, 1990).

Hyles euphorbiae (leafy spurge hawkmoth) is a leaf feeder that is established near Ottawa, Ontario. It has generally failed to become established in the west because ants destroy the young larvae and the overwintering pupae suffer excessive mortality due to low winter temperatures (Best *et al*., 1980; Forwood and McCarty, 1980). When introductions of this species do survive, they offer too little control too late in the growing season (Messersmith and Lym, 1990).

Chamaesphecia empiformis is a root borer that has been released but has so far failed to become established in Saskatchewan (Best *et al*., 1980). Harris (pers. com., 1992) considers this root borer to be specific to cypress spurge and not likely to survive on leafy spurge. *Oberea erythrocephala* is a stem and root borer that was first introduced in Canada in 1979 and in the United States in 1980 (Rees *et al*., 1986). It has either not survived or had minimal impact on leafy spurge (Messersmith and Lym, 1990). Harris (pers. com., 1992) reports that it is now doing well in North Dakota. A gall-forming midge, *Bayeria capitigena* (syn. *Spurgia esulae*), was introduced in the northern United States in 1985 (Messersmith and Lym, 1990; Pecora *et al*., 1991), however, it has had minimal effect on leafy spurge density where released even though it has reproduced readily (Messersmith and Lym, 1990).

Four flea beetles have been introduced to date-*Aphthonia flava* and *A. cyparissiae* were introduced in Saskatchewan in 1982 and in Montana in 1985; *A. czwalinai* and *A. nigriscutis* were introduced in 1988 and 1989 respectively (Messersmith and Lym, 1990; Pemberton and Rees, 1990). The flea beatles have shown promise in greenhouse and field trials and *A. nigriscutis* has reduced leafy spurge stems at an experimental site in Manitoba by 90% (Messersmith and Lym, 1990). Harris (pers. com., 1992) reports that *A. nigriscutis* is now well established at hundreds of prairie sites as well as sites in British Columbia, Ontario, and Nova Scotia. *A. cyparissiae* is well established on the prairies and in British Columbia, as well as having strong colonies in Ontario, and Nova Scotia (Harris, pers. com., 1992).

Research is currently underway to identify and test fungi that might be pathenogenic to leafy spurge, however, such work is in an early stage (Yang *et al*., 1990; Yang *et al*., 1991). Some promise has also been shown by a native blight *Alternaria tenuissima* f. sp. *euphorbiae*, however, it requires favourable conditions for infection and such conditions are not widespread (Messersmith and Lym, 1990).

Physical control methods, such as mowing and burning, have little effect (Messersmith and Lym, 1990) because the extensive and deep root system simply resprouts. It has been found that burning can have some benefit when used in conjunction with herbicides. When leafy spurge is burned, vegetative growth is stimulated and the plant becomes more vulnerable to herbicides (Cole, 1991). Hand-pulling, digging, or tilling is generally ineffective because even small portions of the root system can resprout (Cole, 1991) and such an operation can result in considerable soil disturbance. Even if all shoots of a patch are regularly removed by hoeing before they are five centimetres high, leafy spurge will continue to send up new shoots for three years (Selleck *et al*., 1962).

Although leafy spurge is poisonous to cattle, sheep can eat young plants (Dunn, 1979) and continuous grazing by sheep can control the plant (Bowes and Thomas, 1978; Best *et al*., 1980), however, this would not likely be a suitable control method for natural areas.

Survey Summary and Contact Us

The majority of the respondents rated the impact of leafy spurge to be none or unknown. Those who thought it was a problem were equally divided as to the degree or extent of impact or whether the plant was spreading or stable. Contact Us included: it has the potential in Quebec to interfere with native vegetation. It is presently having no impact on natural areas in Quebec. It is not a serious problem in southwestern Ontario. In Manitoba, it is a very bad problem.

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Conclusions

The problem of invasive species in natural areas is a complex one that is not amenable to simple solutions.

Natural areas can be invaded by native species and these invaders can displace members of the original flora, however, most botanists consider this to be a natural process even if such invasions may be at least partly the result of human activity (Apfelbaum, 1985).

Although the Canadian flora contains a large number of alien species, the majority are restricted to highly disturbed urban and agricultural areas. A small number of aliens, however, are having a range of negative effects on natural areas in Canada. These effects include a reduction of biodiversity and the impairment of recreational use of wetlands. There is a broad consensus that purple loosestrife is having the greatest impact of any alien in wetland natural areas. The situation in upland natural areas is less clear due to regional differences in the impact of particular species.

The worst problems with invasive aliens are occurring in the areas of the country that have seen the greatest human disturbance. As long as such disturbances continue to impact natural areas, alien plants will continue to invade these areas.

There has been much debate as to the best approach to deal with the problem of invasive aliens in natural areas. Some argue that nothing should be done either because it is futile to attempt to control the widespread species that are having the most effect, such as purple loosestrife or because natural checks and balances in the system may ultimately respond to the invader and effect control without human intervention. Others argue that the most invasive species are having profound effects on the ecological integrity of many natural areas and action must be taken immediately to avert widespread reduction in biodiversity.

A broad range of methods have been tried in an attempt to control or eliminate invasive aliens in natural areas. Physical or chemical methods can be effective for local infestations, however, they are too labour-intensive, costly, and often environmentally damaging for widespread control. Ecological or integrated pest management can provide long-term control of exotics in small or highly significant sites, however, it may be too labour-intensive for large areas. For widespread invasive species, the only possibility for achieving both long-lasting control and minimal environmental damage is to develop biological controls.

Some have proposed that invasive aliens of natural areas be declared 'noxious weeds' in order that governments be compelled to take action. Such an approach, however, may be premature if safe and effective controls have not yet been developed for a particular species. Control attempts might be taken that would have little long-term success and result in additional environmental damage.

If control program priorities are to be established, consideration must be given to the effect of the invasive species on natural areas, the vulnerability of the species to current control methods, the environmental impact of such control methods, and the costs of the control program.

Introduction

Areas that are largely undisturbed by human activity and support primarily species that are native are becoming increasingly rare, particularly in the southern portion of the country. In addition to direct human pressure as a result of environmental manipulation, the invasion of alien plant species is a significant threat to the existence of these natural areas. The establishment and aggressive spread of these plant species, not originally occurring in an area, as a direct or indirect result of human activity, can result in the displacement of some of the original component species in the vegetation. The mere establishment of nature reserves or parks does not ensure that valuable, representative examples of native vegetation are protected. Management must address the effects of invasive aliens if such areas are to retain the values for which they were set aside. For example, a prime wetland.

Sixteen wetland and 44 upland plants, mostly aliens, are identified in Part I as invasive (of varying degree) of natural habitats in Canada and options for their control are discussed. The control of undesirable weed species has long been recognized as a critical issue in agricultural land use that has resulted in the enactment of legislation requiring their control under specified circumstances. The application of federal and provincial Weed/Seed Acts for the management of non-native plants and the maintenance of ecological integrity was recently investigated for national parks in western Canada (Achuff *et al*., 1990). This section discusses the utility of these Weed Acts for the control of invasive aliens of natural habitats in general and is a first step to addressing the issue.

The status of Weed Acts in Canada is first described. Then, a collective summary of the general substance of these Acts is provided, followed by details specific to particular Acts that may be relevant to their use in limiting the spread of invasive species. The applicability of the current Acts and regulations to the invasive species identified is discussed. This is followed by a general discussion of the approaches that could be taken to increase the effectiveness of Acts for the purposes of dealing with invasive species. Where to obtain Weed / Seed Acts provides addresses from which copies of Weed Acts may be obtained as well as information on the department that administers these Acts and all the species included under the Act.

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Weed Acts in Canada

Federal Seeds Act

The federal *Seeds Act* (Canada, 1985a and Table 1) is concerned with the establishment of standards for the sale, importation, and exportation of commercial seed and the registration of plant varieties to be sold or imported as seed. Seed grade is determined in part by weed seed content.

Provincial Weed Acts

At the provincial level, Weed Acts address both weeds and weed seeds. All provinces except Newfoundland have Weed Control Acts (Table 1). In New Brunswick, however, the Act (published in 1969) has not been proclaimed and is unenforceable. Neither the Northwest Territories nor Yukon Territory has a Weed Act. The provincial control of weeds is laid out typically in two parts. The Act defines the terms used, describes the circumstances under which the Act is used, lays out the framework for Act implementation, outlines the obligations of the parties mentioned in the Act and penalties for not complying, describes exceptions to the Act, and provides procedures for altering the Act or regulations. Under the Act, regulations are described that provide additional details related to the basic Act that are necessary to apply it. For example, regulations typically contain the list of species to which the Act applies (e.g., Quebec, 1977), and may outline general methods for destroying species (Ontario, 1988b), provide specific recommendations for controlling particular species (Prince Edward Island, 1991), or provide other details not covered in the Act.

Table 1: Summary of provincial Weed Acts and the federal Seeds Act

			NUMBER OF SPECIES LISTED				
JURISDICTION	**WEED ACT** (Proclaimed/Updated)	**REGULATIONS** (Proclaimed/Updated)	NATIONALLY	PROVINCIALLY	REGIONALLY	TOTAL	**CURRENT ACT STATUS**
NF	-	-	-	-	-	-	no Act exists
PE	1987/none	1991/none	-	1	0	1	newly established
NS	1967/none	1968/1977	-	27	7	34	under major review
NB	-	-	-	-	-	-	Act written 1969 never proclaimed

Provisions of Weed Acts

Federal Seeds Act

In the Seed Regulations (Part 1) under the *Act* (Canada, 1985b), seed grades are defined for each crop based on seed germinability or percent living seed and limitations for the occurrence of weed seeds. For some species, grade standards also include restrictions on smut, ergot bodies and sclerotia bodies present. Seeds approved by the Canadian Seed Growers' Association as being breeder or select seed is exempt from packaging and prescribed standards regulations under the *Act*.

Registration of a plant variety (Seeds Regulations, Part III) (Canada, 1985b), permitting its sale as seed in Canada, requires that information be provided on the name, origin, history, methods of development, morphology, physiology, agronomic characteristics, results of experimental trials comparing the new variety to reference varieties, and seed supply and distribution. Information on the relationship between the variety and native species or habitats is required. The seeds of roots, vegetables, herbs, flowers, and trees are exempt from the requirement of variety registration in Canada.

The *Seeds Act* is administered by Agriculture Canada and it applies to every person or their employees or agents. The Minister of Agriculture may determine the species of plants whose seeds are considered to be weed seeds. The *Act* is enforced by inspectors. Upon conviction of an offence under the *Act*, fines and imprisonment terms vary depending upon the type of conviction.

The Weed Seeds Order (Canada, 1986) under the *Act* classifies 72 plant species as noxious weeds. Twenty-nine species are classified as prohibited noxious weeds in all crop seed. Fourteen are primary noxious weeds and 17 are secondary noxious weeds in most crop seed. An additional six secondary noxious weeds are listed for certain crops. Nine species (three of which are classified as primary or secondary noxious weeds for other crops) are classed as noxious weeds in particular crops. Finally, all seeds in a mixture that are not considered noxious and are not crop seeds are termed 'other weed seeds'. Seed grades reflect limitations on the abundance of each class of weed seed.

Provincial Weed Acts

Provincial Weed Acts were established primarily as a tool for enhancing agricultural land use and thus they have been applied, on a provincial scale generally, to a fairly narrow range of plant species. Although most Acts leave the definition of noxious weed vague, permitting their application to any species or habitat, their non-traditional use for the control of species invasive in natural habitats may require re-examination by those currently administering the Acts.

The eight provincial Weed Acts reviewed have many clauses in common. For the purposes of

this review, repetitive summaries of each Act were not considered useful. The contents of the Acts are discussed generally and collectively, and provincial differences are noted.

Purpose

Provincial Weed Acts were established as agricultural aids for the control of plant species that may detrimentally affect the agricultural use of land or reduce crop values. Typically they address controlling the spread of these weeds from other land to agricultural land and their control on agricultural land. In Nova Scotia, the Act also addresses species that are capable of inflicting economic loss or ill health on people. The *Weed Control Act* of Prince Edward Island (1987) has the broadest purpose-to prevent adverse effects of noxious weeds on any person, crop or other desirable plant, animal, or property.

Whereas the control of noxious weeds at subprovincial jurisdictional levels often emphasizes the control of agricultural weeds, these jurisdictions also use Weed Acts to support the control of plant species affecting horticultural (lawn maintenance, horticultural businesses/research) and recreational land uses, as well as those affecting environmental integrity, e.g., purple loosestrife (*Lythrum salicaria*) is not listed provincially in Ontario, but is listed by many subjurisdictions (Anonymous, 1992).

Act Administration

All the provincial Acts are under the administration of the provincial departments responsible for agriculture.

Plants to which acts apply

Plants to which the Acts apply are typically designated as noxious weeds. In some provinces additional classifications or subdivision of this classification are based on the effects of noxious weeds (Nova Scotia, 1968), habitat and location (Quebec, 1977) and the severity of the problem a species poses (Alberta, 1980b). The list of weeds to which an Act applies is provided as a regulation under the Weed Act.

In most Acts (e.g., Alberta, 1980a; British Columbia, 1973; Manitoba, 1968; Ontario, 1988; Quebec, 1979), 'noxious weed' is not defined in relation to effects caused. Plants or seeds are defined as noxious weeds by virtue of being listed in the regulations. Given the details provided in these Acts concerning prevention of weed dispersal through movement of agricultural machinery and the disposal of refuse containing weed seeds from grain elevators, crop storage facilities, seed cleaning plants, etc., and their administration by departments of agriculture, it is clear that 'noxious weed' primarily or traditionally refers to (but need not be) a species that may cause problems for farmers although they are not explicitly defined and no species is explicitly excluded.

The Nova Scotia Regulations (1968) clearly define noxious weeds as being capable of spreading from the source to cultivated or pasture land or capable of inflicting economic loss or ill health on people in the province. The *Weed Control Act* (Prince Edward Island, 1987) has the broadest definition of noxious weed and includes a plant, its seeds or spores, or plant disease affecting or is likely to adversely affect any person, crop or other desirable plant, animal, or property. The listing of European watermilfoil (*Myriophyllum spicatum*), an aquatic weed, in the Alberta Act is an exception to the agricultural rule.

The number of plants considered noxious in a province varies from 227 (Manitoba) to one (Prince Edward Island) (see Table 1). In addition, three to 21 other species have been

designated noxious weeds within regional jurisdictions in Nova Scotia, Ontario, Quebec and British Columbia. In Alberta, 23 species are identified as noxious, but an additional 36 nuisance weeds and seven restricted weeds are also identified in the province. In the Acts, no distinction is made between native and alien weed species. Over the next couple of years, both the Nova Scotia and Manitoba lists will undergo major review. The latter will be substantially shortened.

Species designation

In most provinces, municipal governments are given the power to list species as noxious weeds within their jurisdiction through by-laws. These by-laws must be approved by the Minister of the department responsible for administering the Act. As well, the Minister may, typically with assistance from a provincial advisory council, make recommendations for species listing covering the province as a whole or with respect to particular portions of it. Typically these recommendations concerning species listing are then passed on to the Lieutenant-Governor in Council or the government (Quebec) for final approval. In Alberta, however, it is the Minister who finally approves the regulations.

Habitats to which acts apply

On a provincial scale, the Acts all clearly apply to any habitat that harbours weeds with the potential to spread to farmland (or land used for horticultural purposes, Ontario). In Quebec, some species are considered noxious weeds only when found on cultivated or pasture land. Disturbed upland habitats in the vicinity of farmland are therefore the main focus of Act application. Generally, undisturbed upland and wetland habitats would receive minimal attention since the spread of important agricultural weeds from them is less important than from agricultural habitats.

In Nova Scotia, habitats of species likely to cause economic problems or ill health are also focal points for Act application. In Prince Edward Island, the definition of noxious weed is quite broad (see section-Plants to which Acts apply); hence, habitats to which the Act applies are essentially unrestricted.

Although the provincial focus is on agricultural weeds, generally in subjurisdictions, the habitat focus is broader since the purposes of designation are broader (e.g., to protect land quality for agricultural, horticultural, recreational, park land use; see section-Purpose).

Action required under the ActsPurpose

Most Acts require the 'destruction' of noxious weeds (Manitoba, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan), others specify their 'control' (British Columbia). The Alberta Act requires the control of noxious weeds and the destruction of restricted weeds. Action requirements under the Acts of each province are outlined below.

Alberta

~ control term descriptionof noxious weeds means to inhibit propagation, destroy the weed and carry out measures prescribed by an inspector for control

~ destruction of restricted weeds requires that all growing parts must be killed and that the reproductive mechanisms of the weed be rendered non-viable

~ the spread or scattering of nuisance weeds must be prevented

British Columbia

~ noxious weeds must be controlled

Manitoba

~ noxious weeds are to be destroyed to prevent growth, ripening and scattering of weeds/seeds

Nova Scotia

~ destruction means preventing the ripening of seed for species likely to spread to cultivated land and it includes the elimination of species likely to cause economic or health loss

Ontario

~ noxious weeds must be destroyed; methods for the destruction of plants and seeds are suggested in the regulations

Prince Edward

~ destroy means to take whatever action is necessary to prevent Island reproduction and spread of noxious weeds

Quebec

~ noxious weeds are to be destroyed before the seed ripens

Saskatchewan

~ noxious weeds are to be destroyed

Three Acts provide guidance concerning methods for weed control or destruction (Alberta, Ontario, Nova Scotia). The British Columbia Act specifies that regulation for control under the *Noxious Weed Act* cannot be made until they are approved by the Environment and Land Use Committee established under the *Environment and Land Use Act*. Control practices for the single species to which the Act applies are outlined in the regulations. It is the Minister of the Environment who has the power to implement a control program. The remaining provinces (Manitoba, Quebec, Saskatchewan) provide no guidance for weed handling.

Responsibility for weed control on lands

Most Acts require all occupiers of land to control or destroy noxious weeds thereon. Where there is no occupant or where the occupant resides outside the jurisdiction of the by-law, the landowner is responsible. In Ontario and Prince Edward Island, it is the landowner who is required to control weeds. In Quebec, the responsibility for control resides with landowners, land occupiers and persons operating land. Under the Manitoba Act, responsibilities for weed control are also laid out for earthwork and land between the low water mark and the limit of owned property.

Only three Acts outline wide-ranging responsibilities for weed control on Crown land. Under the British Columbia Act, the occupier of Crown land, and therefore the person having the responsibility for weed control on it, is the member of the Executive Council designated to be

occupier by the Minister of Agriculture and Food (or his appointee). The Acts for Alberta and Manitoba explicitly state that the Crown is generally bound by the Act.

Acts in Ontario and Nova Scotia limit their discussion of responsibilities for control on Crown land to land associated with public highways in the possession of the province (for lands associated with provincially owned highways that are in the possession of a municipality, it is the municipality that is responsible for weed control). In three Acts (Prince Edward Island, Quebec, Saskatchewan), there is no mention of specific responsibilities of the Crown. The Saskatchewan Act addresses only land and roads within municipalities.

Other situations to which the acts apply

In addition to the control of weeds growing on or found on land, most Acts prohibit specifically the transport of produce and the movement of machines contaminated with weeds or weed seeds. Some address the responsibilities of operators of grain elevators, seed cleaning plants, and grain-grinding operations to dispose of all refuse containing weed seeds in a manner that will prevent them from spreading. The deposition of weeds or seed in any place where they might grow is prohibited in Ontario and Manitoba. The Ontario regulations also address the necessity of transporting and depositing soil, gravel or other substances to prevent scattering and establishment of weeds.

Act jurisdiction

Weeds may be designated noxious throughout the provincial jurisdiction or by smaller jurisdictions (e.g., county, municipality). Local municipalities may pass by-laws designating species as noxious weeds within their jurisdiction that are not included in the list of provincial weeds (e.g., Ontario) but they must be approved by the Minister responsible for the Act or the Lieutenant-Governor in Council (depending on the province). Weed inspectors at various jurisdictional levels who enforce the Act are required by law in Manitoba and Ontario and are optional under other Acts.

Exemptions

Two Acts specifically describe areas that are exempt (British Columbia, Ontario). In British Columbia, the Act does not apply to land outside the boundaries of a municipality, other than a regional district, when the Lieutenant-Governor in Council considers it to be waste or sparsely populated land. Municipal land considered by the council of a municipality as waste or sparsely populated may also be exempt upon consent of the minister. Under the Act of Prince Edward Island, the Lieutenant-Governor may exempt any property or person from the Act. In Alberta, the Minister responsible for the Act may exempt a tract of land he considers to be waste land. In Ontario, noxious weeds that are far enough away from any land used for agricultural or horticultural purposes and do not interfere with these land uses are exempt from the Act. The Acts of Manitoba, Quebec, and Saskatchewan do not discuss exemptions. Ultimately, since the Minister responsible for the Act, Lieutenant-Governor in Council, or the government (depending upon the province in question) has the power to effect changes in the regulations, they also could use this power to exempt persons and land from the Act.

Enforcement mechanism

Weed inspectors may be appointed to represent various levels of government (municipal, county, province). It is the duty of these officers to respond to complaints concerning noxious weeds and to see that property occupiers and equipment operators follow the requirements laid out under the Act and regulations. They concentrate on situations where agricultural or

horticultural interests are seriously threatened by the proliferation of weeds. They have the right to inspect land and property for noxious weeds, issue a directive requiring occupiers to carry out weed control within specified time limits, and to apply the recommended control measures (at the cost of the occupier) should the occupant fail to do so.

In Ontario, conditions under which inspectors may order weeds to be destroyed are spelled out in the regulations. Weed destruction is required where the inspector is of the opinion that propagation of the noxious weeds would be prevented or substantially reduced if they were destroyed, and except in the case of poison ivy (*Rhus radicans*) and ragweed (*Ambrosia artemisiifolia*), that lands other than the lands on which the noxious weeds are growing are likely to be damaged by propagation of the noxious weeds.

In Manitoba, municipalities may designate areas as 'weed infested' by by-law and have the weeds eradicated by agreement with the owner, or by by-law authorize the land to be worked as required to destroy the weeds, prohibit sowing of crops or require the land to be used only for pasture. A municipality, through a resolution, may authorize an inspector to destroy weeds he considers to be in danger of ripening seeds without notifying anyone when seed ripening is a threat. In Nova Scotia, as well, inspectors may prohibit the sowing of crops.

In Manitoba, Nova Scotia and Saskatchewan, specific guidelines are provided for inspectors concerning the extent and conditions under which crop damage is permitted when weeds are controlled.

Costs and payment for weed control

It is the responsibility of the property occupant or owner (including municipalities and the provincial government) to carry out weed control at their own expense. In cases where weed inspectors initiate weed control directly, typically the costs are added to the occupant's tax bill. Under the Saskatchewan Act, yearly limits have been placed on the amount of money that weed inspectors can spend on weed control on unoccupied urban land ($80/lot or $200/acre on unsubdivided land) and land in rural municipalities ($100/acre to a maximum of $4 000 for any quarter section).

In Nova Scotia, municipalities may be reimbursed for 75% of the cost of the original cleanup and maintenance of control for three weeds-hoary-alyssum (*Berteroa incana*), Jimsonweed (Datura stramonium), and nutgrass (*Cyperus rotundus*)-and 50% for seven additional weeds (depending upon county within which the municipality lies). No other Act discusses reimbursement for control, although many raise the possibility for cooperative management among municipalities and between municipalities and the province.

Fines for noncompliance

Failure to comply with orders for weed destruction given by inspectors can result in fines ranging from $5 to $5 000.

Act modification

The provincial Minister of the department with responsibility for administering the Act may make changes in the regulations or may recommend changes to the regulations to the Lieutenant-Governor of the province who can approve, modify, or reject these changes. Changes to the Acts require approval by the provincial legislatures.

Use of Current Weed Acts
Opportunities and problems

Because the Weed Acts discussed in Section "Provisions of Weed Acts" are not written for the purpose of protecting natural habitats their use may be limited. It is important, however, to determine the extent to which these Acts, already well-established administratively, could be used be used for this purpose and how they might be updated to be more useful.

Federal Seeds Act

Of the 44 species listed in Part 1 as invasive, to varying extents, in native upland habitats, five are considered noxious weeds under the federal *Seeds Act* (Table 2). Three are classed as prohibited noxious weeds-leafy spurge (*Euphorbia esula*), nodding thistle (*Carduus nutans*), and spotted knapweed (*Centaurea maculosa*); one is a primary noxious weed-Canada thistle (*Cirsium arvense*); and one is a secondary noxious weed-ragweed(*Ambrosia artemisiifolia*). These are the invasive species most frequently listed in provincial Weed Acts. None of the species invasive in wetland habitats (Part 1) are listed as a noxious weed under the federal Act. All invasive species, however, would be considered 'other weeds' in crop seed.

Currently, the focus of the *Seeds Act* is on the maintenance of crop seed integrity. Its application for control of invasive alien species would be as a preventative measure-prevention of spread and establishment of new populations by seed from existing ones and limiting the opportunities for introduction of new invasive aliens as seed. Listing alien species as prohibited noxious weeds would have the greatest impact on their control, but this addresses only one mechanism for alien species proliferation (in crop seed). Extension of the *Act* to cover wildflower seed mixes might also assist in preventing the spread and establishment of alien species. The use of the current registration requirements for varieties, however, would be ineffective because so many types of plants are exempt and no consideration appears to be given for impacts on native vegetation and potential for escape. The federal *Seeds Act* could be thought of as a weak preventative strategy for invasive species control-it does not address concerns related to established populations.

Provincial Weed Acts

Provincial Weed Acts address the control of both weed seeds and weeds already established. For this reason, they offer greater scope for use in controlling alien species in natural habitats.

Species listed in regulations

Of the 16 species invasive in natural wetland habitats, only two major species are listed: Eurasian watermilfoil (*Myriophyllum spicatum*) for Alberta and purple loosestrife (*Lythrum salicaria*) for Manitoba, Prince Edward Island, and five counties/district municipalities and 43

municipalities/townships in Ontario (Anonymous, 1992).

Table 2 shows that of the 44 invasive species of natural upland habitats discussed in Part 1, two major species-leafy spurge and common buckthorn; three moderate species-Canada thistle, yellow sweet-clover, and white sweet-clover; and seven minor species-ragweed, absinth, hoary-alyssum, nodding thistle, spotted knapweed, teasel, and mullein are covered by one or more of the provincial Weed Acts. Thus, there remain 14 wetland and 32 upland species whose control cannot currently be addressed under these Acts because they are not listed as noxious weeds.

Table 2: Invasive species of natural upland habitats in Canada and their coverage (*) by provincial Weed Acts and the federal Seeds Act

SPECIES	PE	NS	PQ	ON	MB	SK	AB	BC	CAN
Major Invasive Aliens									
Common buckthorn (*Rhamnus cathartica*)	-	*	-	*	*	-	-	-	-
Leafy spurge (*Euphorbia esula*)	-	*	-	*	*	*	*	*	PRO
Moderate Invasive Aliens									
Canada thistle (*Cirsium arvense*)	-	*	*	*	*	*	*	*	PN
Yellow sweet-clover (*Melilotus officinalis*)	-	-	*	-	-	-	-	-	-
White sweet-clover (*Melilotus alba*)	-	-	*	-	-	-	-	-	-
Minor Invasive Aliens									
Absinth (*Artemisia absinthium*)	-	-	-	-	*	-	-	-	-
Hoary-alyssum (*Berteroa incana*)	-	*	-	-	*	-	-	-	-
Mullein (*Verbascum thapsus*)	-	-	-	-	*	-	-	-	-
Nodding thistle (*Carduus nutans*)	-	-	*	*	*	-	R	Cariboo District	PRO
Ragweed (*Ambrosia artemisiifolia*)	-	*	8 counties	*	*	*	-	-	SN
Spotted knapweed (*Centaurea maculosa*)	-	-	-	*	*	*	R	*	PRO
Teasel (*Dipsacus spp.*)	-	-	-	-	*	-	-	-	-

** AB=Alberta, BC=British Columbia, CAN=Canada, MB=Manitoba, NB=New Brunswick, NF=Newfoundland, NS=Nova Scotia, NT=Northwest Territories, ON=Ontario, PE= Prince Edward Island, PQ=Quebec, SK=Saskatchewan, YT=Yukon Territory. Unless indicated, all numbers refer to species of noxious weeds (N=nuisance weed, PN=primary noxious weed, PRO=prohibited noxious weed, R=restricted weed, SN=secondary noxious weed). Where appropriate, the subjurisdiction in which a species is considered a weed, is noted. (Weed Acts do not exist for Newfoundland, Yukon Territories and Northwest Territories. The Act for New Brunswick has never been proclaimed*

For the alien species already listed in the Acts or regulations, additional attention must be given to their control in habitats other than those in agricultural areas (provided compatible control measures exist). This additional workload could be shouldered jointly by provincial ministries of the environment or natural resources having expertise with respect to natural habitats and the ministries of agriculture with weed control expertise. In any event, the addition of new areas for which weed control is required will necessitate a greater allocation of human resources to implement the Act effectively.

Habitats covered by acts/regulations

Although there are no restrictions within provincial Acts on habitats to which they apply, emphasis is traditionally placed on the habitats of species that are problematic to agricultural use of land. Several Acts have been used to list wetland species as provincial noxious weeds-

Alberta (Eurasian watermilfoil), Manitoba (purple loosestrife), and Prince Edward Island (purple loosestrife). The Ontario Act has been used by numerous subjurisdictions to list a wetland species (purple loosestrife) as a noxious weed.

Control measures

In natural habitats, control options may be more restricted than in farmland since the maintenance of co-occurring, desirable species and community integrity would be one of the primary goals of alien species control. There may be no satisfactory control measures for some of these invasive species as the weed control industry has focused on species that pose problems in agricultural areas. Listing an invasive alien species as a noxious weed will do little to assist with its suppression unless effective control measures applicable in natural habitats are available.

Import, sale, and transport

Listing a species as a provincial (or subjurisdictional) noxious weed effectively prohibits its sale and transportation, reducing its rate of spread. This would assist in preventing the spread of species that are spread because of their horticultural interest (e.g., purple loosestrife), but would do little to deal with plants already established for which control measures are unknown.

Responsibility for weed control

One of the concerns often brought up concerning control of species in natural habitats under a Weed Act is the extent of the obligation of the Crown. Under most Acts, the Crown is specifically committed to land associated with highways. The Alberta Act indicates simply that the Crown is bound by the Act and does not describe specific circumstances under which it applies to Crown land.

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Canada

Options for Modification of Weed Acts for their use in controlling Invasive Species

The utility of the federal *Seeds Act* for controlling invasive species in natural habitats is considered minimal (see Section "federal *Seeds Act*"). Options for Act modification in this section will therefore concentrate on provincial Acts where there is considerably more potential for their use.

Below, several options are described for modifying the current provincial Weed Acts to make them suitable for use in controlling invasive species. Some stand independently while others must be applied concurrently for each to be effective. For example, the effectiveness of expanding the number of species on the list will not be significant without increasing human resources to effectively implement the Acts.

Expand species list to include invasive species

In Manitoba and Nova Scotia, Weed Acts are currently under review. Input at this time concerning the inclusion of invasive species could be appropriate. In the other provinces where reviews are not currently in progress, a review could be suggested. The addition of invasive species to the Weed Acts will be effective as a control measure only if control options appropriate to natural habitats are available.

Attention should first focus on wetland and upland species that are classified as principal or major invasive species.

Formally expand description of circumstances where act applies

The Acts are primarily written to control the spread of weeds to agricultural land, not native habitats. In theory, no habitat is exempt from an Act. Before the Acts are applied to natural areas they should be modified to include a definition of natural habitat, acknowledge the value of native habitat, and require the control of invasive species therein. This would take place in conjunction with the expansion of Act administration.

Prepare supporting documentation for species listing in act

The documentation provided in Part 1 of this publication is the first step in identifying potential candidates for listing as invasive noxious weeds and provides some information on control

measures. Additional concrete details on the status of invasion and impact for all these species and research on effective control measures would enhance the possibility of inclusion in a Weed Act.

Exceptions

A problem often raised concerning expanding Weed Acts to cover native habitat is that the Crown would be legally responsible for weed control over a vast area that would be impractical to achieve. Within the current Weed Acts, provision is made for exemptions to the Act based on land size and remoteness. Exemptions could be made for the Crown under appropriate circumstances such that the Crown need not spend its entire budget on control. For example, control obligations could be limited to wetland areas of particular classes (in Ontario) and areas from which invasive species could disperse to high quality wetland habitats. For uplands, control might be required in areas identified as sensitive in regional/natural resources department plans and areas from which invasive species could spread to these valuable upland habitats.

A quick review of the list of invasive species of concern indicates that many are of horticultural interest and the potential for a conflict of interest exists. This conflict could be resolved if the habitats in which these species are considered weeds, are spelled out explicitly in the Weed Act.

Financial incentives for landowners

Currently, all landowners or occupiers (including municipalities) are responsible for all or a substantial portion of the costs of weed control. The use of various subsidies for activities associated with farming has already been established as a precedent. Tax rebates or partial payment of expenses for controlling invasive species could be used to encourage landowners to carry out the intentions of the Act. Accompanying this would be a need for careful direction of management activities through landowner education.

Currently, the Nova Scotia government (Nova Scotia, 1968) reimburses municipalities 75% of the original cleanup and maintenance of control for three noxious weeds and 50% for seven more (throughout the province or in designated counties).

Expansion of act administrative responsibilities

If more species are to be added to the current lists of noxious weeds, more human resources will be required to effectively enforce the Act. As well, the habitats and appropriate control approaches may differ from those in an agricultural setting. For both these reasons, the involvement of a new department(s) such as the one(s) responsible for natural areas management should be given the responsibility for administering the Act in natural habitats.

Implementation of Act Changes

Implementation of the suggestions for Weed Act modification in order to encompass invasive species, will have to be approached on a provincial basis. A federal department could provide guidance, on a province-by-province basis, concerning species to add to Weed Acts, control information, other act changes, etc. The first step would involve educating the appropriate people (in ministries of agriculture and natural resources) in each province about the general problem of invasive species in natural habitats, the magnitude of the problem and species involved in their province, and the objectives of invasive species management. Then, options must be explored for achieving the objectives through existing Weed Acts or new invasive species acts (or by other means). The province most open to this approach should be consulted first. The *Weed Control Act* of Prince Edward Island is broad enough in scope to include invasive species of natural habitats, and purple loosestrife (major wetland invader) has already been listed. The Manitoba *Noxious Weed Act*, as well, already lists this one wetland species. Thus there is a precedent for listing species not strongly connected with agricultural impact. Experience gained through the evolution of these acts can be used to establish an appropriate approach for handling the remaining provinces, beginning with one where the problem of invasive species is greatest.

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Complementary Approaches to Invasive Species management Beyond Weed Acts

Other acts

In Section "Options for Modification of Weed Acts for their use in controllong Invasive Species", suggestions were made for modifying the current Weed Acts to make them more useful for the control of invasive species of natural habitats. In the interim while these changes are considered, and in the absence of critical information on control methods for some species, there are other actions that could be taken to reduce the impact of invasive species. Legislation could be drawn up to prevent only the sale and transport of invasive species for which control measures are not available. Regulations pertaining to ballast water dumping and the movement of other commodities should be tightened or altered to prevent the introduction of invasive species and the subsequent need to control their spread. To further reduce the opportunities for invasive alien introduction into Canada, a new federal weed control Act that addresses the importation of any plant parts (not just seeds, as in the current federal *Seeds Act*) and requires the provision of information on the potential of the new species to invade natural habitats could be enacted.

Public education and involvement

Public education concerning alien species that are already acknowledged to be invasive and potential invaders would help reduce their impact on native habitats. Guidance could be provided to the general public and land managers concerning the purchase of garden plants (those to buy or not to buy, questions to be asked at nurseries) and land management practices to reduce the impact of invasive species.

Effective administration of Acts with species lists expanded to include more invasive species will require an increase in human resources. Besides new municipal/provincial employees there is a less costly source of human resources that could be tapped. The education and subsequent assistance by the public at large and public organizations in the control of invasive species has already been demonstrated through the purple loosestrife management initiatives. It is easy for the public to identify with this species and it should be encouraged to be a focus for all invasive species. The effectiveness of public involvement will be correlated with the effort expended for public education. One of the keys to dealing with invasive species is preventing their arrival and establishment in natural habitats. The public could be involved in a monitoring and reporting procedure.

Further investigations

During preparation of the lists of species that are invasive in natural habitats in Part 1, the authors conducted a preliminary review of control practices for each species identified. For many

species, information was found to be lacking or, at most, very sparse. A more detailed, critical evaluation of potential control methods is required. The need for research to develop innovative control approaches suitable for application in natural habitats, while maintaining associated native species is indicated.

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Canada

Where to obtain Weed / Seed Acts

Jurisdiction	Organization
Canada	Seed Section Plant Products Branch, Agriculture Canada K. W. Neatby Bldg., Rm. 1117 960 Carling Ave. Ottawa, Ontario K1A 0C6
Prince Edward Island	Dept. of Agriculture P.O. Box 1600 Charlottetown, P.E.I. C1A 7N3
Nova Scotia	Plant Industry Branch N.S. Dept. of Agriculture and Marketing Box 500 Truro, N.S. B2N 5E3
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec Complex scientifique 2700, rue Einstein Sainte-Foy, Québec G1P 3W8
Ontario	Ontario Plant Industry Branch Ministry of Agriculture and Food Guelph Agriculture Centre P.O Box 1030 Guelph, Ontario N1H 6N1
Manitoba	Manitoba Agriculture P.O. Box 2000 Carman, Manitoba R0G 0J0
Saskatchewan	Soils and Crops Branch Agriculture Saskatchewan 3085 Albert St. Regina, Saskatchewan S4S 0B1
Alberta	Plant Industry Division Alberta Agriculture 7000 - 113 Street Edmonton, Alberta T6H 5T6
British Columbia	Crop Protection Branch

B.C. Ministry of Agriculture, Fisheries and Food
17720 - 57th Ave.
Surrey, B.C. V3S 4P9

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