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Special Publication
No.145
January 1994

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Minnesota Department of Natural Resources
Division of Fish and Wildlife
Ecological Services Section

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(Funding for document digitization was provided, in part, by a grant from the Minnesota Historical & Cultural Heritage Program.)

Minnesota Department of Natural Resources
Special Publication 145, 1994

MINNESOTA'S PURPLE LOOSESTRIFE PROGRAM: HISTORY, FINDINGS, AND MANAGEMENT RECOMMENDATIONS[1]

Luke C. Skinner, William J. Rendall, and Ellen L. Fuge

Minnesota Department of Natural Resources
Ecological Services Section
500 Lafayette Road
St. Paul, MN 55155-4025

Abstract.--Minnesota's Purple Loosestrife Program, the first of its kind in the United States, was established in 1987 by the Minnesota legislature to protect the state's vast acres of wetlands, lakeshores, and streams from the negative impacts of purple loosestrife. The program has four main functions: broadening public awareness, conducting inventories of infestations, researching control methods, and carrying out control work.

The program's research showed that treatments with herbicides are the most effective method of controlling purple loosestrife at the present time and that the herbicide Rodeo (glyphosate) when selectively applied is the most effective herbicide. Application techniques are limited when using Rodeo because it is a broad spectrum herbicide that kills all emergent vegetation. The herbicide Garlon 3A (triclopyr), not yet labeled for aquatic use and tested under an experimental use permit, will be the herbicide of choice when labeled for aquatic use. The advantages of Garlon 3A are because it is selective for broadleaf plants, can be applied with more techniques, and is lower in cost than Rodeo.

Research on biological control methods for loosestrife is underway and shows promise. Several insects from Europe, two leaf-eating beetles and one root-boring weevil, have shown a high selectivity for loosestrife and the ability to significantly feed on and cause damage to loosestrife plants. If successful, biological control methods could provide long-term control in large, well-established infestations of loosestrife where herbicides have been ineffective.

State rules and regulations have direct impact on management of purple loosestrife in Minnesota. When purple loosestrife was declared a noxious weed by the Minnesota Department of Agriculture, all sales in Minnesota were banned, and public awareness and control efforts by public, local, and state agencies increased. Nevertheless, it is difficult, if not impossible, to enforce control on private and public lands because of the vast amounts of loosestrife statewide. Thus, development of a statewide priority list for controlling loosestrife infestations has become a key part of the program.

Minnesota's program recommends that management strategies for statewide control use a watershed approach. Efforts should be made to keep uninfested and lightly infested watersheds free of purple loosestrife. Control work should start at the top of the watershed to stop the downstream flow of seed. Since large, well-established loosestrife infestations are nearly impossible to control with herbicides, efforts should be targeted at satellite populations away from large infested areas. An integrated pest management (IPM) approach should be developed to take advantage of all available control methods.

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[1]Funding for this program was approved by the Minnesota Legislature as recommended by the legislative Commission on Minnesota Resources and then provided to the Minnesota Department of Natural Resources for the years 1988 and 1989.

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Introduction

Minnesota's Purple Loosestrife Program, the first of its kind in the United States, was established in 1987 by the Minnesota state legislature to protect the state's vast acres of wetlands, lakeshores, and streams from the negative impacts of purple loosestrife. Between 1924 and 1989, purple loosestrife steadily spread to thousands of acres of wetlands in Minnesota. Seventy years after the recorded establishment of loosestrife in Minnesota, concerned citizens sought state legislation to limit intentional introduction and spread of the plant and to establish a control program.

No other state had established a statewide control program, and questions about purple loosestrife were many: What was the distribution of loosestrife in Minnesota? What problems did purple loosestrife cause in wetland habitats and with wetland management techniques? What losses were being incurred because of loosestrife infestations? Could loosestrife be adequately controlled, and what were the best control methods? What were the potential negative impacts of control measures on wildlife, habitat, water quality, and people? What would the costs of control efforts be? What agencies or authorities would be responsible for implementing and regulating control efforts? How could the public and affected agencies be educated about the problem?

The establishment of the Minnesota Purple Loosestrife Program provided the opportunity to pursue answers to these many questions and put Minnesota in the lead nationwide in the battle against the spread of purple loosestrife. This special publication was prepared to allow others to benefit from the experience of Minnesota's control program.

Occurrence and Taxonomy

The Loosestrife Family

The plant family that includes the loosestrifes, Lythraceae, is composed of approximately 22 genera encompassing 500 species. Members of this family are most abundant in the American tropics. Five of these genera occur in Minnesota: *Decadon, Ammannia, Didiplis, Rotala,* and *Lythrum* (Ownbey and Morley 1991). The three species of *Lythrum* occurring in Minnesota are purple loosestrife, *L. salicaria* L., wand loosestrife, *L. virgatum*, and winged loosestrife, *L. alatum.*

The only native species, winged loosestrife, is unfamiliar to most people because of its infrequent occurrence and its inconspicuous flowers. It grows in wet prairies as a natural component of the native vegetation. Purple loosestrife and wand loosestrife are native to Europe and are sold in this country as a number of different cultivars. Purple loosestrife is the species that has become naturalized in wetlands throughout the state. No collections of wand loosestrife are found in the University of Minnesota Herbarium, which suggests that this species has not been found in the wild or that specimens have been misidentified (Harper 1986).

Origin of Purple Loosestrife

Purple loosestrife, a showy perennial (Figure 1), grows as a native wetland plant throughout the temperate regions of Europe and Asia (Thompson et al. 1987). In its native habitat, it is usually a minor component of the wetland vegetation. After disturbance to a plant community, however, it functions as a pioneer plant; that is, the species flourishes at first but declines in abundance after two or three years (Shamsi 1976).

Generally a combination of factors controls the growth of a small population of a plant species within a plant community. These factors may include disease, predatory insects, intermittent changes in moisture regime, and competition from other plants for the same niche. A single factor may cause minor setbacks but not control or suppress population growth. In purple loosestrife's native habitat, several factors work together and establish a balance between reproduction and death, causing the plant's population size in a particular area to remain at levels that do not exclude other common members of the plant community.

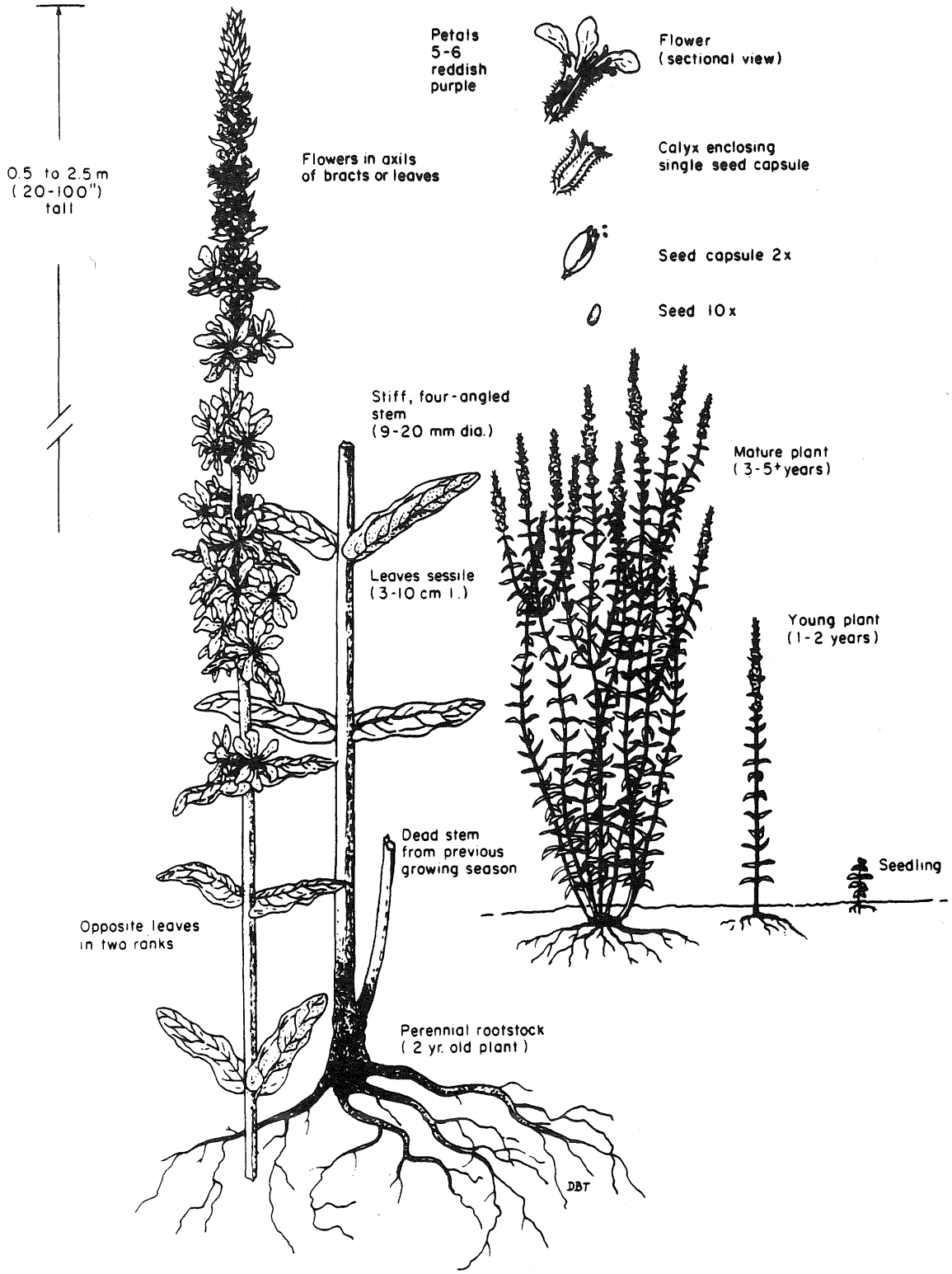

Figure 1.--Structure, growth forms, and field identification characters of purple loosestrife, *Lythrum salicaria* (Thompson et al. 1987).

Introduction of Purple Loosestrife to North America

The introduction and spread of purple loosestrife in North America follows the same pattern as that of many other exotic plants and animals (Laycock 1966). They are closely associated with the migration of people across the ocean and their subsequent settlement of the continent. Seed and rootstock are thought to have arrived by several means. A major source may have been seed transported in the ballast of ships carrying goods and people between the Old and New Worlds (Thompson et al. 1987). Animal fur is also a well-recognized vector of seed for unintentional introduction of plants to new areas (Stuckey 1980 as cited in Thompson et al. 1987). Purple loosestrife was valued as an herb and may well have been intentionally brought as seed or rootstock from its native habitat (Thompson et al. 1987).

Thompson et al. (1987) documented the spread of purple loosestrife from the eastern seaboard in 1900, westward into the Midwest by 1940, to its establishment in the northern half of the United States by 1985 (Figure 2). Collections of *L. salicaria* in the University of Minnesota Herbarium document the early existence of purple loosestrife in Minnesota. The first collection of naturalized purple loosestrife was made in 1924 from Ramsey County. The first 12 specimens were collected between 1924 and 1967.

Because of purple loosestrife's appeal as a perennial garden plant, intentional introduction of the plant has continued. The following quote from the gardening magazine *Southern Living* illustrates how this plant has been promoted: "Loosestrife is a perennial every garden needs. It's stunning in leaf and flower, and grows just about everywhere" (Bender 1985). The *Minnesota Horticulturist* magazine published an article in which purple loosestrife was described as "a graceful perennial commonly found in Minnesota flower gardens and adding a beautiful lavender cast to many Minnesota wetlands" (Ray 1984).

Beekeepers value purple loosestrife for its long blooming season and numerous flowers. In the *American Bee Journal*, Bunch (1977) promoted purple loosestrife as a honey plant: "It may produce nectar for four or five weeks as the plants are covered with florets from near the ground all the way up to the tips of plants which grow to five, six or more feet high."

Cultivars

The popularity of purple loosestrife as a perennial garden plant in North America stems from its beautiful, persistent purple blooms, its full shape, and its tall stature. It is undeniably a striking backdrop for a garden or landscape. It is also hardy, tolerant of a wide variety of moisture and nutrient regimes, and virtually free of insect pests and disease. These attributes are, of course, the very ones that make this plant such a formidable invader. Plant breeders in the United States have developed at least 15 cultivars of *L. salicaria*, *L. parentage* and 10 of *L. virgatum* parentage (Table 1).

The professed sterility of horticultural varieties has been disproved by seed germination studies (Anderson and Ascher 1991; Ottenbreit 1991). Although most cultivars have high germination rates, some may not be prolific seed producers (Table 2). After several generations of offspring, however, reversion to the fertile state of the parent commonly results. These progeny, therefore, could be capable of aggressively invading wetland habitat (Harper 1986). Which cultivars may be invasive, however, is not known (Cutright 1986).

Identification of the different species and cultivars of purple loosestrife continues to be a problem. Plants that are actually *L. salicaria* are often sold as cultivars of *L. virgatum*, probably because of erroneous identification (Harper 1986). David Bates, botany professor at Cornell University and Lythrum expert, has stated: "Unfortunately, *Lythrum salicaria* and *L. virgatum* tend to integrate with each other morphologically. The only way one can actually verify the application of names is to make good herbarium specimens of each cultivar and send them to the herbarium for identification. Without that level of involvement, it will be difficult to control the sale of *L. salicaria* because most nurserymen and field inspectors simply will not be able to identify what is being

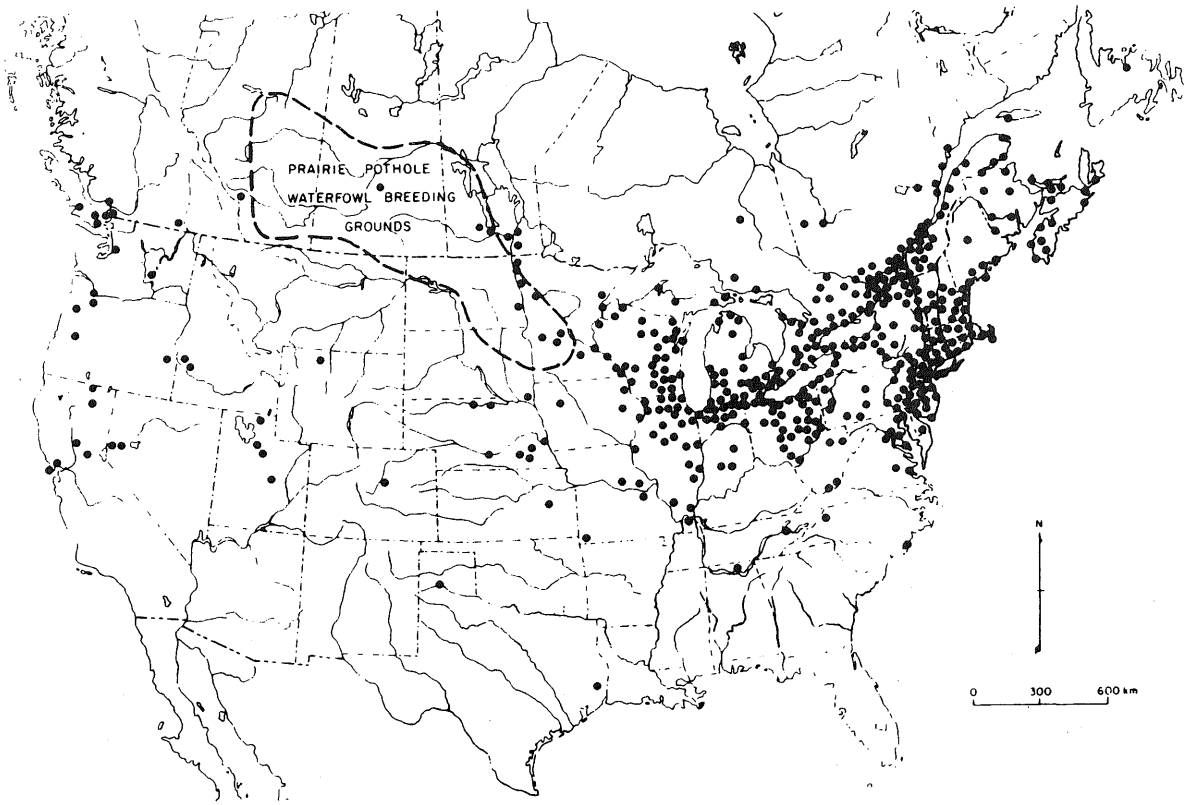

Figure 2.--Distribution of purple loosestrife, *Lythrum salicaria*, in North America as of 1985 (Thompson et al. 1987).

Table 1.--Horticultural cultivars of *Lythrum* currently under cultivation in the United States. (N.O. Anderson, University of Minnesota, personal communication).

Lythrum salicaria L.
var. *tomentosum*
var. *Roseum Superbum*
Atropurpureum
Brightness
Firecandle, Fire Candle, or Feuerkerze[1]
Flashfire, Flash Fire, or Stichflamme[1]
Gypsy Blood or Zigeunerblut
Happy[2]
Lady Sackville
Mr. Roberts
Robert[2]
Rose Gleam
Rosy Gem[2]
The Beacon
Lythrum virgatum
Dropmore Purple[3]
Morden Gleam (Morden Pink x *L. alatum*)
Morden Pink (male sterile mutant of *L. virgatum*)
Morden Rose (Morden Pink x *L. alatum*)
Pink Spires
Purple Dwarf
Purple Spires
Rose Queen
Rosyglow or Rosy Glow
The Rocket

[1] Despite the discrepancy between the English and German names for these varieties (Feuerkerze = "quick fire", Stichflamme = "flame stick" or "candle stick"), this is the way they are listed in the catalogues in which they are sold.

[2] Disputed parentage; also classified as *L. virgatum*.

[3] Disputed parentage; also classified as *L. salicaria*.

Table 2.--Germination in seeds of *Lythrum* taxa from wild and cultivated populations (Ottenbreit 1991).

Populations	Germination (%)
A.) Cultivated Populations	
Lythrum virgatum x *L. salicaria* cv. Dropmore Purple	80.0
L. virgatum cv. Morden Pink	--.-
L. alatum x Morden Pink cv. Morden Gleam	86.5
L. alatum x Morden Pink cv. Morden Rose	89.5
L. virgatum cv. Rose Queen	74.4 *
Lythrum cv. Mr. Robert	97.0
Lythrum cv. Lady Sackville	86.0
Lythrum cv. Rosy Glow	90.0 *
L. salicaria (TOR 79-019)	94.5
L. salicaria (OSL 83-029)	88.5
L. salicaria (LEI 83-130)	92.0
L. virgatum cv. Pink Spires (DBG 84-161)	91.0
L. virgatum (DBG 84-165)	91.0
L. virgatum (GEN 83-122)	93.0
L. virgatum (SHR 80-322)	87.0
L. virgatum (LEI 83-131 L.v)	75.0
L. virgatum (Lei 83-131 L.s)	87.0
Lythrum sp.	88.5
B.) Naturalized Population	
Lythrum sp.	100.0
Lythrum sp.	93.0
Lythrum sp.	99.5
Lythrum sp.	96.0
Lythrum sp.	99.0
Lythrum sp.	100.0
Lythrum sp.	97.0
Lythrum sp.	100.0
Lythrum sp.	99.5
Lythrum sp.	99.5

Note: Values are means of 4 samples of 50 seeds each; 40 seeds each for the populations indicated by the asterisk.

sold. I'm not sure professional botanists will be able to either" (as cited in Rendall 1989). In most cases, herbarium records may not be of much use. Genetic markers would most likely be the best way to tell cultivars apart (Welling and Becker 1992).

Biology and Ecology

Description

Purple loosestrife is an erect, broad-leafed perennial (Figure 1). Mature plants can range in height from 1.5 to 8 feet. The angular stems, which may be four- to six-sided, become woody with age and persist through the winter. The

stems are usually pubescent but are sometimes smooth. The broad, shrublike crowns of mature plants consist of from 30 to 50 stems arising from a single rootstock. The stems die back each year but are persistent and stay standing for up to two years.

Leaves of the genus *Lythrum* are long and narrow and are closely attached to the stem. Although opposite leaf arrangement is typical, leaves may also be in whorls of three or four, and sometimes alternate.

The purple flowers are generally six-petaled, although, as in the other taxonomic characteristics of this plant, there is much variation. The spike-like inflorescence is composed of numerous flowers closely arranged in the leaf axils of ascending flower-bearing branches (Gleason 1952; Rawinski 1982; Heineke 1977). Purple loosestrife is a tristylic species, the flowers of individual plants having one of three different pistil lengths (Darwin 1865). In addition to the three common style morphs, a fourth flower type, described by Stout (1925), is frequent enough to warrant recognition.

Reproduction and Spread

Purple loosestrife can reproduce by sexual or vegetative means. Flowering occurs from July through September. The seeds produced through sexual reproduction are about 400 x 200 microns (Thompson et al. 1987), approximately the size of ground pepper. Seed set begins in mid-July in early flowers and continues as flower development progresses into late summer (Thompson and Stuckey 1980). The percentage of viable seeds has been documented from 88% in Minnesota plants (Welling and Becker 1990) to 100% in seed collected in Manitoba (Ottenbreit 1991). Thompson et al. (1987) found the mean number of seeds per capsule to be 90, with 1,000 capsules per stem, and 30 stems per plant, resulting in a mean of 2,700,000 seeds per plant. Seeds are gradually shed from the capsules throughout the winter months (Ottenbreit 1991).

The seed bank beneath a well-established stand of purple loosestrife can be immense. A square meter of soil 5 centimeters deep has been found to contain as many as 410,000 seeds (Welling and Becker 1990). The seeds are most concentrated directly below the plant that produced them, and their numbers decrease as the distance from the mother plant increases (R. Henderson, Wisconsin Department of Natural Resources, personal communication). The small, lightweight seeds can be transported by wind but are more commonly dispersed by flowing water. Animals can transport seed in their fur, feathers, or in mud adhering to their feet, and people can transport seed on their clothing, muddy boots, or vehicles.

The spread of purple loosestrife is primarily a function of seed dispersal. In disturbed areas, however, vegetative or asexual reproduction can be important. Although the root crown expands and produces more shoots each year, the maximum growth of the root crown is limited to about 20 inches (Thompson et al. 1987). Stem and root pieces can produce adventitious roots leading to the establishment of new plants (Thompson et al. 1987; Rawinski 1982). Disturbances or control efforts that cut up the plant are therefore conducive to the spread rather than the destruction of the plant. When seedlings are covered by at least 10 inches of water, they become dormant, and the developed leaves fall off. The tips of these defoliated stems are capable of forming a rosette of new leaves and adventitious roots. Many of these "plantlets" break off and float away. When these propagules lodge on a suitable substrate, they can take root and grow (Darryl Kroeker, Ducks Unlimited Canada, personal communication).

Habitat

Purple loosestrife tolerates a broad range of variation in climate, soil type, and nutrient levels. The parameter most critical to the spread of loosestrife is the amount of water available (Thompson et al. 1987). Moist soils exposed to sunlight are necessary for loosestrife seeds to germinate. Once established, the mature plants can tolerate various water regimes. Habitat types in which loosestrife grows in Minnesota range from rivers and lakes to roadsides and gardens (Table 3). Loosestrife has become

established in many of Minnesota's natural communities, threatening native vegetation throughout the state (Table 4).

Establishment and Competition

Any moist soil exposed to sunlight, often through some type of disturbance, can offer purple loosestrife seed a substrate on which to germinate. In areas of dense vegetative cover, which can inhibit the establishment of loosestrife, the action of flowing water past stream banks and around sedge hummocks maintains bare soil that provides sites for seed germination. Drawdowns caused intentionally or by drought can expose mudflats in lakes and streams. If loosestrife seed is present, carpets of seedlings often result under these conditions. Drought conditions existed in the Midwest in the mid-1970s and again in the mid-1980s, and the establishment of purple loosestrife exploded during those years (Henderson 1987; Minnesota Department of Natural Resources et al. 1986).

Although purple loosestrife can survive in 50% of full sunlight, growth and reproduction are inhibited in reduced light levels (Thompson et al. 1987). Terry Schreiner of the Minnesota River National Wildlife Refuge (personal communication) has noted that dense stands of reed canary grass, *Phalaris arundinaceae*, offer effective competition to purple loosestrife, inhibiting its establishment.

The effect of reduced light levels on growth and reproduction is evident at a site in St. Louis County, Minnesota. The introduction of purple loosestrife in this area can be traced to an ornamental planting of purple loosestrife 10 years ago. The area around the garden site is open, sunny, and heavily populated by loosestrife. Flowing water has carried the seed downstream from the nearby garden into a cedar swamp. The loosestrife that managed to become established beneath the canopy is elongated and produces few flowers. But where there are openings in the canopy that provide sun, the loosestrife is dense and flowers profusely.

Where aquatic plant species grow in local habitats can be a function of water depth or soil moisture levels. At several sites in Minnesota, cattails, *Typha* spp., growing in standing water

Table 3.--Percentage of purple loosestrife infestations in various site type categories of the Minnesota Purple Loosestrife Program.

Site Type[a]	Percent (%)
Ditch (drainage)	5
Garden (landscaping)	5
Lake (pond)	32
Meadow (pasture, upland site, prairie)	2
River (stream)	9
Roadside (ditch)	15
Wetland (marsh, swamp, etc.)	29
Other (parking lots, etc.)	1
Undefined	2

[a] As defined by the Minnesota Purple Loosestrife Program.

Table 4.--Purple loosestrife habitat in Minnesota as recorded on University of Minnesota Herbarium labels.

Herbarium Label Description
Lake shore
Edge of lake
Grassy shoreline
Sandy filled in shore of lake
Shallow water bayside sandbar
Creek bed
Sand bar
River bank
Wet gravel at edge of (river)
Small marsh
Long grassy meadow
Wet meadow
Roadside meadow
Sedge meadow by fen
Low grassy thicket
Drying portion of fen
Saline flat
Prairie
Roadside ditch

remained uninfested by loosestrife, which was well established on adjacent drier ground. This observation suggests that loosestrife will not invade the deeper water. If water levels drop, however, loosestrife can become established on the exposed soils. When water levels again rise, the established loosestrife is virtually unaffected by the deeper water. If deep water conditions persist around mature plants, they are capable of forming aerenchyma, tissue that allows oxygen to reach the roots, which protects the plant from drowning.

In purple loosestrife's native habitat, 120 insects are associated with the plant and help to control its growth (Batra et al. 1986; Blossey and Schroeder 1986; Schroeder and Mendl 1984). In contrast, the insects that feed on loosestrife in North America do not damage the plant enough to reduce its size or vigor (Hight 1990). Consequently, some monospecific stands of loosestrife in the northeastern states have shown no reduction of size or vigor in the last 20 years, whereas in the British Isles, prolific stands of loosestrife established after disturbance became interspersed with other species and lost dominance after a few years (Thompson et al. 1987).

Ecological Impacts

The negative impacts on aquatic ecosystems resulting from invasions of purple loosestrife far outweigh its attributes as an attractive ornamental and a productive honey plant. Thompson et. al. (1987) have thoroughly documented the ecological impacts of loosestrife in North America. The initial effect this plant has on native wetland vegetation is to displace it. Purple loosestrife can form dense monotypic stands eliminating virtually all other wetland plants. Common plants such as cattails, sedges (*Carex* spp.), and smartweed (*Polygonum* spp.) as well as most wetland plant species cannot compete with loosestrife. Loosestrife can also displace vulnerable rare plant species dependent on natural wetland habitats.

Consequently, the animals that rely on the native vegetation for food, shelter, and breeding areas cannot use these heavily infested areas. Waterfowl do not feed on loosestrife (McKeon 1959; Friesen 1966; Malecki and Rawinski 1979). As loosestrife thrives, the area becomes less suitable for waterfowl because of the elimination of valuable food plants and nesting sites.

Purple loosestrife replaces cattail, a plant critical to muskrats and other wildlife species. Muskrats sometimes help loosestrife dominate a wetland by selectively feeding on loosestrife's principal competitors, like cattails.

Loosestrife may interfere with wetland productivity by replacing mosaics of submergent and emergent vegetation. Normally, the interface between vegetation zones is the most productive part of the marsh. Invertebrates, a crucial food source for breeding waterfowl hens and their broods, concentrate at the edge of these zones. A monotypic stand of loosestrife can replace native zones and eliminate the valuable edge effect.

Fish species may also be affected by the introduction of purple loosestrife. Northern pike, *Esox lucius*, spawn in flooded meadows, where submersed terrestrial vegetation, especially grasses and sedges, provide habitat for spawning pike and zooplankton that are eaten by the newly hatched northern pike fry. Loosestrife can push out native plants and close up these shallow areas. Purple loosestrife stems are woody, and developing plants become increasingly rank and impenetrable after two or three years. It is speculated that dead loosestrife may not be as usable for food by zooplankton and other detritivores as are grasses, sedges, and other native wetland vegetation.

Minnesota has an enormous amount of habitat that could be invaded by purple loosestrife. There are approximately 12,000 lakes encompassing more than 100,000 miles of shoreline; 10,000 marshes larger than 10 acres; several million acres of wet meadows, peatlands, and wooded swamps; 100,000 miles of streams and rivers; 25,000 miles of highway drainage ways; and thousands of miles of other public and private drainage ditches. Many of Minnesota's natural communities that are protected to provide waterfowl breeding areas and wildlife habitat, and to preserve native plant communities are at risk from the impacts of loosestrife (Table 5).

Table 5.--Examples of protected natural communities infested by purple loosestrife in Minnesota.

Natural Community[a]	Management Unit
River beach	Mississippi R. Is. SNA Ft. Snelling St. Pk.
Wet meadow	Minn. R. Valley NWR Frontenac St. Pk.
Floodplain forest	Upper Miss. R. NWR
Emergent marsh	Bayport WMA
Sedge meadow	Ordway Prairie TNC Milest WMA McCarthy WMA
Shrub swamp	Perched Bog WMA
Calcarious seepage fen	Black Dog SNA Perched Bog WMA
Conifer swamp	Site 808 near Voyageurs Nat. Pk.
Hardwood swamp	Hastings SNA

[a] As defined by the MN-DNR Natural Heritage Program, 1993.

Actions Leading to Establishment of Minnesota's Program

At the national level, concern about the expansion and impact of purple loosestrife in moist habitat began in the 1960s and slowly increased as the plant expanded its range into the Midwest. In 1980, the U.S. Fish and Wildlife Service (USFWS) issued a purple loosestrife alert to their refuge managers asking them to watch for loosestrife infestations. In the Midwest, where the invader was evident but had not yet displaced large amounts of native flora, the USFWS alert and other publicity raised awareness of the growing problem (Thompson 1989).

In Minnesota, efforts to restrict the sale of purple loosestrife and to promote statewide control of infestations began in 1982. At that time, concerned citizens began educating the Minnesota Nurseryman's Association about purple loosestrife's threat to wetlands. In 1983, the Minnesota Department of Natural Resources (DNR) warned the public of the plant's aggressive nature in the DNR's magazine, the *Minnesota Volunteer* (Pfannmuller and Djupstrom 1983).

Growing concern about purple loosestrife among environmental and conservation organizations lead to the formation of the Purple Loosestrife Coalition on November 12, 1984. Its members included the Minnesota Waterfowl Association, The Wildlife Society, the Sierra Club, Minneapolis Audubon, the Izaak Walton League, Friends of the Minnesota Valley, Chanhassen Environmentalists, and the MN Conservation Federation. The coalition sought to pass a bill that would ban the sale of purple loosestrife in 1985. However, the bill was tabled by the Minnesota House of Representatives because of concern about the horticultural value of purple loosestrife (Harper 1988).

In November 1985, an interagency Purple Loosestrife Work Group was established. The work group included four agencies: DNR, Minnesota Department of Transportation (DOT), Minnesota Department of Agriculture (MDA), and the USFWS. In June 1986, the work group produced an Interagency Action Plan (Minnesota Department of Natural Resources et al. 1986). A section in the action plan identified the resources at risk if purple loosestrife continued to spread in Minnesota:

- An investment in wetlands of $25 million by the state and of millions of dollars more by the USFWS.
- Opportunities for 140,000 waterfowl hunters, 24,000 licensed trappers, and innumerable numbers of wildlife observers.
- Approximately $1 million spent annually by the DOT to preserve wetlands, streams, and rivers adjacent to highway construction projects.
- Fishing quality and opportunities for 2.5 million licensed anglers, especially for certain fish species such as northern pike.

- Increased cost of drainage ditch maintenance and rehabilitation. Because of its invasive nature and woody growth, purple loosestrife could affect roadside and agricultural ditch cleaning. Given that purple loosestrife quickly reestablishes, ditches infested with the plant may need more frequent cleaning depending on the rate of siltation it causes. On state highways, for example, ditches in cattail habitat are cleaned approximately every five years. Approximately one-half million dollars is spent annually to clean ditches; this amount could increase once purple loosestrife becomes established.

- Natural and domestic wild rice, a $14 million crop and an important food source for wildlife. Purple loosestrife may affect both natural and commercial wild rice production in various ways. Commercial wild rice paddy operations create ideal germination conditions for purple loosestrife through water level manipulation. Loosestrife could interfere with harvesting because of its woody stems. Natural rice stands may be displaced by purple loosestrife.

- Forage value of lowland pastures and hayfields. Pastures and hayfields are threatened as loosestrife invades, matures, and becomes too woody for forage.

Although the Work Group's report recommended numerous necessary actions for the four agencies to take, neither staff nor funding was available to accomplish the activities. Therefore, the Purple Loosestrife Coalition submitted a funding proposal to the Legislative Commission of Minnesota Resources (LCMR) to establish a two-year pilot control program at a cost of $225,000. The LCMR did not approve the program in their normal proceedings, but recommended seeking a larger appropriation. With that in mind, the coalition approached the 1987 legislative session seeking legislation banning the sale and propagation of purple loosestrife and a $825,000 biennial appropriation. A compromise was reached that made it illegal to sell purple loosestrife and also established the LCMR-funded pilot program with a $196,000 biennial budget.

Legislation and Regulation History

With its establishment by legislation (see appendix) in 1987, the Purple Loosestrife Program became the nation's first state program to curb the plant's spread. Concurrently, it became a misdemeanor to sell purple loosestrife, *Lythrum salicaria*, in Minnesota (see appendix), and the Minnesota Commissioner of Agriculture designated purple loosestrife, a noxious weed (see appendix). This status prohibits the sale and transportation of the plant into, out of, or within the state. The noxious weed law also requires landowners to remove or control the plants growing on their land.

The MDA did not designate wand loosestrife, *L. virgatum*, a noxious weed at the same time because horticulturists thought its cultivars and varieties did not readily spread and that some cultivars were sterile. It was also thought that hybrids, varieties, and cultivars of wand loosestrife could be identified and distinguished from those of purple loosestrife.

Between July 1987 and August 1988, the MDA inspected *Lythrum* species at nurseries and greenhouses to stop the illegal sale of purple loosestrife. By 1989, it was increasingly evident that many problems were associated with controlling sales of purple loosestrife and its cultivars. Improper labeling and the inability to identify the different species of *Lythrum*, particularly specimens without flowers, made enforcement of the law nearly impossible. The supervisor of Regulatory Services for MDA called the situation "a regulatory nightmare."

How could the law be enforced without a way to accurately identify the pest? According to the MDA, three options existed: (1) repeal the law (2) designate all *Lythrum* species as noxious weeds, or (3) maintain the current law but require that all growers provide specimens to a recognized authority for identification and approval for sale within Minnesota.

Strong support by the public for control of loosestrife and clear evidence of an environmental problem argued against repealing the law. The third option of verifying existing stock was not possible until the completion of

further research and documentation. Therefore, in the opinion of the regulatory agencies involved, inclusion of all non-native *Lythrums* in the noxious weed law was the best alternative. On November 30, 1988, the Minnesota Commissioner of Agriculture issued a new order (Order #3) making *L. salicaria* and *L. virgatum* and all their cultivars noxious weeds (see appendix).

During the 1988 Minnesota legislative session, two additional legislative actions occurred to clarify landowners' responsibilities for control of purple loosestrife in public waters and to assist landowners with the costs of control on farmland. The first action amended the noxious weed law to make the Commissioner of Natural Resources responsible for the control of purple loosestrife in public waters and designated wetlands (see appendix). This action took the burden off the landowner for controlling loosestrife on lakeshores, wetlands, and streams. The second action by the legislature appropriated $50,000 for the eradication of purple loosestrife on farmland where the farmer is required to eradicate loosestrife because of the noxious weed law (see appendix).

Two long-standing DNR Commissioner's orders, converted to rules in 1993, affect the control of loosestrife in Minnesota. Commissioner's Orders 2210 and 2244 (Minnesota Rule, Chapter 6280) regulate the issuance of permits for control of aquatic plants, including loosestrife, in designated public waters (see appendix). Two items of importance in these orders are that there is no charge for permits to control loosestrife, and that no permit is required when removing loosestrife by hand.

Minnesota's Purple Loosestrife Program: Responsibilities and Accomplishments

The four main responsibilities of the Purple Loosestrife Program are broadening public awareness, conducting inventories of infestations, researching control methods, and carrying out control work. All four components are critical to the success of controlling loosestrife on a statewide basis.

Public Awareness

Public awareness is the foundation of a sound program to control purple loosestrife. A public aware of the problems associated with the plant helps by reporting infestations, discontinuing plantings, removing or controlling plants, and promoting legislation and agency actions that support control. This public assistance is essential for an effective statewide control program.

The Purple Loosestrife Program is broadening public awareness in several ways. Since 1987, over 125,000 brochures and 5,000 posters have been distributed throughout Minnesota to schools, conservation organizations, state, county and city agencies, and the general public. "On the Loose," a newsletter published annually since 1987, keeps agency staff, nature centers, weed inspectors, extension agents, and citizens current on topics such as laws, funding, research, and recommended control techniques.

The program uses other media such as slide shows, public speaking, state fair displays, and traveling displays to educate the public. A slide show titled "Purple Loosestrife: A New Threat to Our Wetlands and Wildlife" is available at the DNR library. Many visitors to the Minnesota State Fair have viewed the display about purple loosestrife in the Minnesota DNR building. The program also uses newspaper, magazine, television, and radio coverage when opportunities arise.

Inventory

State inventories of purple loosestrife infestations provide information about the number, size, and type of sites, which is necessary for designing a control strategy. Inventories in Minnesota are conducted by area wildlife managers, county agriculture inspectors, local weed inspectors, DOT staff, and the general public. Report cards are used to document incidental sightings by the public and state agencies' staff (Figure 3). Items recorded on the loosestrife report form are the observer's name, locality of the site, county and township of the site, nearest road intersection, type of site (lake, wetland, etc.), plant quantity, and a map

of the vicinity.

Most inventories are carried out and most sightings are made during loosestrife's blooming period, when the plant is most visible. Inventories can also be conducted during the winter and spring, when the tall, rigid loosestrife stems are very visible once snow and wind break down the surrounding vegetation. Winter surveys may even be superior to summer surveys in some instances because access is easier on frozen wetlands.

Once a loosestrife infestation has been recorded on a report form, the information is transcribed, mapped, and entered into a computer file. This information is the basis for prioritizing statewide control work on state, federal, and private land. Reports with complete lists of loosestrife infestations in each county are distributed to DNR and MN-DOT staff, county agricultural inspectors, and the U.S. Fish and Wildlife Service for appropriate actions.

The inventories have documented that Minnesota presently has 38,000 acres infested by purple loosestrife. The infestations range from a few plants per acre to thousand of plants on the infested acre. Sixty-eight of Minnesota's 87 counties have loosestrife infestations. Figure 4 shows the distribution of purple loosestrife in the state. Over half of the sites are located on lakeshores or in wetlands (Table 3). One

NA-01314-01

PURPLE LOOSESTRIFE REPORT

(Please fill out one form for each area with loosestrife plants)

NAME: _____ ☐ Send me more report forms.

ADDRESS: _____ HOW MANY? _____

_____ ZIP _____

PHONE: ( ) _____

ASSOCIATION: _____

LOCATION OF PURPLE LOOSESTRIFE

Name of Lake or City: _____

County: _____

Township: _____

Nearest Road Intersection: _____

_____

Diagram (show roads, distances, and outline of the loosestrife patch).

TYPE OF AREA (Check One)

☐ Marsh or Wetland ☐ Meadow or Pasture

☐ Pond or Lake ☐ Roadside

☐ Stream or River ☐ Garden

☐ Ditch ☐ Other (specify)

_____

NUMBER OF PLANTS (Check One)

☐ Less than 20 ☐ 20 - 99 ☐ 100 - 999 ☐ More than 1,000

Figure 3.--Standard purple loosestrife, *Lythrum salicaria*, report form for reporting incidental sightings made by general public, conservation groups, state and local governments, etc.

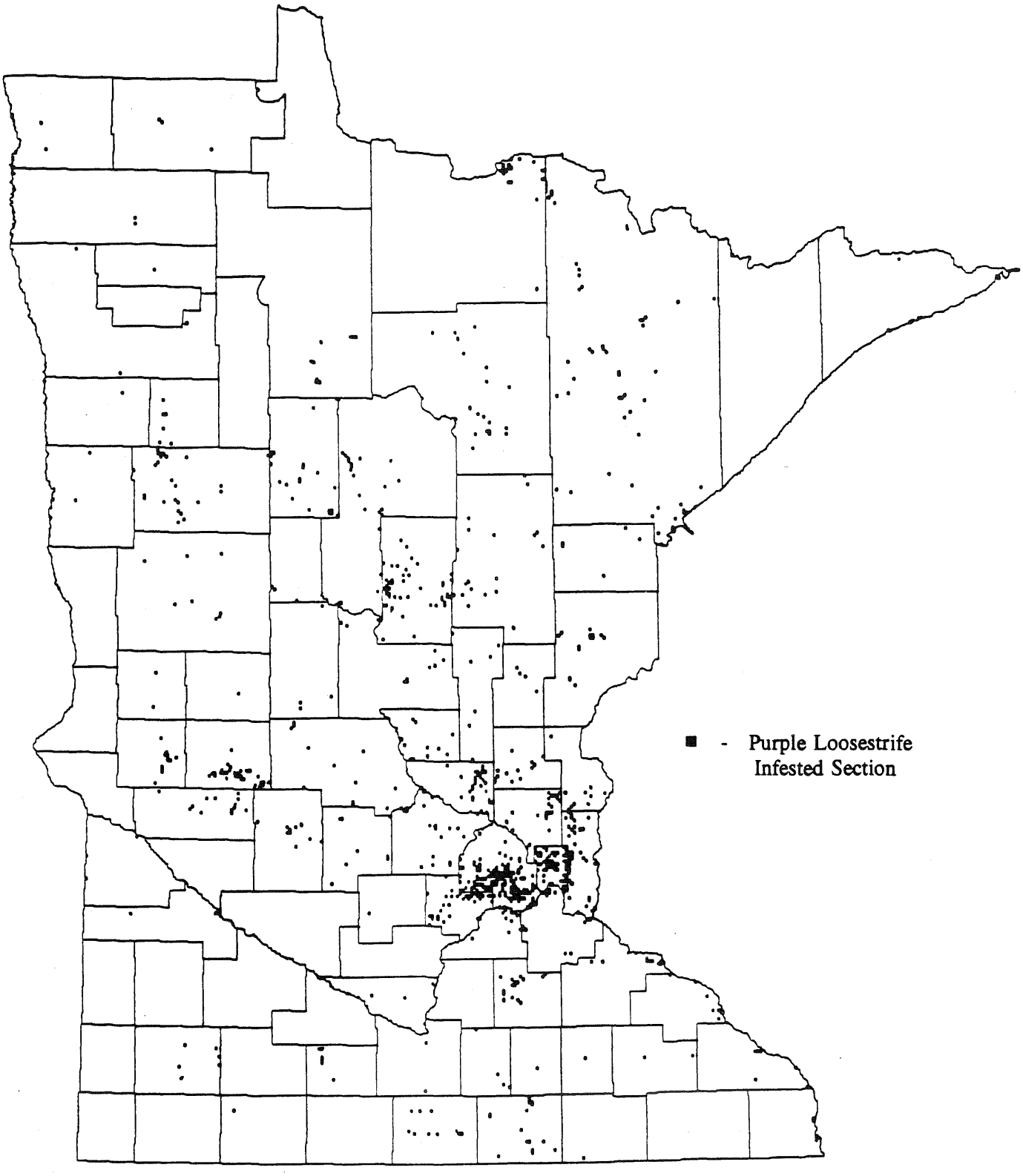

Figure 4.--Distribution of purple loosestrife, *Lythrum salicaria*, in Minnesota by township section, 1989.

significant statistic is that one-fourth of the sites have over 1,000 plants per site (Table 6). These large infestations are nearly impossible to control. Several areas in Minnesota that have heavy infestations of purple loosestrife are sites that collections of *L. salicaria* in the University of Minnesota Herbarium document as having an early occurrence of the plant (Table 7).

Research

Review of Control Methods. The Purple Loosestrife Program began its research of control methods with a review of past research. Purple loosestrife control was first initiated in the 1950s by wildlife managers and researchers. Early control efforts, both mechanical and chemical, were largely unsuccessful (Gagnon 1953; McKeon 1959; Smith 1959; Smith 1964; Friesen 1966). The advent of new herbicides and a better understanding of purple loosestrife biology and ecology has led to better control methods in recent years.

Table 6.--Percentage of purple loosestrife infestations in Minnesota classified by number of plants in infestation.

Number of Plants	Infestations (%)
1-20	29
21-99	22
100-999	23
>1000	27

Table 7.--Sites with heavy purple loosestrife populations in 1987 and their herbarium records from 1967 or earlier.

Site	County	Year
Lake Minnetonka	Hennepin	1947
Morris	Stevens	1952
Duluth	St. Louis	1952
Lake Minnewashta	Carver	1967
Lake Winona	Winona	

Four methods of mechanical control have been tried since 1959: flooding, cutting, burning, and hand pulling. Flooding of established loosestrife stands was unsuccessful (McKeon 1959; Rawinski 1982). The flooding stressed the loosestrife, causing a few mortalities, but the majority of the plants survived with no reduction in cover. Purple loosestrife seedlings were also tested for their susceptibility to flooding. Balogh (1986) flooded loosestrife seedlings under greenhouse conditions for periods of three and eight weeks. After three weeks of flooding, many live seedlings remained. Eight weeks of flooding, however, was very successful: no plants survived after the seventh week. Balogh concluded that the duration of flooding was more important than the depth of flooding in causing seedling mortality.

Cutting of loosestrife at the water level and below the water level was attempted by McKeon (1959) with little success. The loosestrife resprouted, reinhabiting the area from which loosestrife was removed. Malecki and Rawinski (1979) found that the loosestrife resprouted quickly after cutting and that if cut early enough in the year, the loosestrife would resprout, flower, and set seed that same season.

Burning was also unsuccessful at controlling loosestrife. Burns conducted by McKeon (1959) and Rawinski (1982) failed to kill the rootstock, and the loosestrife resprouted following the burns.

The most successful mechanical control method for purple loosestrife is removal by hand. Rawinski (1982) notes that for this method to be successful, the whole plant should be removed, including the entire root system. When roots pieces are left behind, they resprout. This method of control is labor intensive and time consuming. Soil disturbance from pulling or other mechanical means also creates conditions that promote seedling establishment from the seed bank.

Control of purple loosestrife with herbicides was largely unsuccessful until the introduction of glyphosate. Glyphosate killed adult loosestrife plants (up to 95%) with great consistency (Maleki and Rawinski 1980; Balogh 1986; Notestein 1986; Reinartz et al. 1986).

Glyphosate is, however, a broad spectrum herbicide and effectively killed all other wetland plant species. When sprayed in a broadcast fashion, all vegetation was eliminated, opening up the canopy, and providing ideal conditions for loosestrife germination from the seed bank (Rawinski 1982; Balogh 1986; Notestein 1986).

2,4-D has been the second most commonly used herbicide for purple loosestrife control. Although its ability to control loosestrife is inconsistent, it is used because of its selectivity for broadleaf plants and its low cost (Gagnon 1953; McKeon 1959; Smith 1959; Smith 1964; Notestein 1986). Most wetlands are dominated by monocots such as cattails, sedges, grasses, and rushes, *Scirpus* spp., which are not affected by a treatment of 2,4-D. Aquatically labeled 2,4-D products are most effective on first-year seedlings of loosestrife.

The use of replacement species or competitive species in the suppression of purple loosestrife is still in the early stages of research. A species that competes successfully with purple loosestrife in a wide variety of conditions and is itself not a problem has not yet been found. Furthermore, discing and seeding areas invaded by loosestrife can produce conditions that promote the growth and spread of loosestrife.

Japanese millet, *Echinochloa frumentacea*, shows some potential as a replacement species, but it is not a native species, and it does not appear to be invasive (Thompson et al. 1987). Rawinski (1982) tested seven plant species for control of purple loosestrife seedlings. Soon after a drawdown on a small loosestrife infested pond, Rawinski placed Japanese millet seed on the newly exposed mudflat. The millet suppressed the growth of loosestrife seedlings well, at least in the short term. Rawinski also tested reed canary grass, *Phalaris arundinaceae*; nodding smartweed, *Polygonum lapathifolium*; water-plantain, *Alisma subcordatum*; switch grass, *Panicum virgatum*; yellow nutsedge, *Cyperus esculentus*; and alkali bulrush, *Scirpus paludosus*. Each species was planted by itself and in a mixture with loosestrife seed. Only the millet showed promise in suppressing loosestrife growth. Its success could be due to its ability to withstand periodic flooding during the growing season.

Balogh tested nodding smartweed; saltmarsh cockspur grass, *Echinochloa walteri*; and *Cyperus ferruginescens* in competition with purple loosestrife. Field studies showed that nodding smartweed dominated purple loosestrife during the first year of growth when seed was planted at natural seed production rates. Saltmarsh cockspur grass and *Cyperus ferruginescens* were not successful in competing with loosestrife seedlings in the first year of growth. In laboratory studies loosestrife dominated the nodding smartweed under artificially maintained low light levels and saturated soil conditions.

Cooperative Research. From the literature review and extensive discussions, the Purple Loosestrife Program staff concluded that there was insufficient understanding of purple loosestrife biology and management to initiate a broad-scale control effort and that basic research was needed to determine appropriate control methods. In 1988, a cooperative group began to study new chemicals and rates and methods of application for effective purple loosestrife control. The agencies involved were the Minnesota DNR and DOT, the Wisconsin DNR, Hennepin Parks, DOW Chemical Company, the University of Minnesota, local herbicide dealers, and Ducks Unlimited of Canada.

The group's goal was to decide what research was needed and to insure that all necessary research was accomplished without excessive duplication. The group tested three herbicides: Rodeo (glyphosate), Garlon 3A (triclopyr), and 2,4-D products labeled for aquatic use. The herbicides were applied with high-volume handguns, backpack sprayers, and low-volume broadcast techniques at various application rates and at selected times during the 1988 and 1989 growing seasons.

The group's field trials found that glyphosate, labeled for aquatic use as Rodeo, was the most effective herbicide available for control of loosestrife. Because it is a broad spectrum herbicide, however, Rodeo will harm or destroy any vegetation to which it is applied (Table 8) and is thus recommended *only* for spot spraying. Broadcasting Rodeo can eliminate the entire vegetative cover of an area. The retention of a

Table 8.--Mean percent change in cover of purple loosestrife *Lythrum salicaria L.*, and specific non-target species one year after treatment with glyphosate and a surfactant (Skinner and Hollenhorst 1989).

Treatment	Rate*	Mean change in cover (%)				
		L. salicaria	Sagittaria	Impatiens	Gramineae	Thelypteris
Glyphosate + X-77	1.0 + 0.1	-41	-100	+ 400	-91	-86
Glyphosate + X-77	1.0 + 0.25	-49	+ 25	+ 900	-87	0
Glyphosate + X-77	0.5 + 0.1	-64	-100	+ 813	-89	-33
Glyphosate + X-77	0.5 + 0.25	-47	-100	+2100	-91	-45
Glyphosate + Cidekick II	1.0 + 0.1	-90	-100	+967	-97	- 9
Glyphosate + Cidekick II	1.0 + 0.25	-46	-100	-85	-85	-48
Glyphosate + Cidekick II	0.5 + 0.1	-70	-100	-77	-77	-21
Glyphosate + Cidekick II	0.5 + 0.25	-44	-100	-97	-97	-44
Control	---	+ 6	-100	0	0	-35

Note: The genera and one family listed above denote more than one species (spp.)
* Percent by volume of herbicide and surfactant in solution with water.

dense vegetative canopy is extremely important for the suppression of seed germination and seedling growth of purple loosestrife. If the vegetative canopy is removed, the soil surface is exposed to sunlight, and seed germination is promoted. In most cases, purple loosestrife seedlings are so numerous and aggressive that they outcompete other moist-soil plant seedlings. The resulting dense, monotypic stand of loosestrife can be worse than the colony initially present (Table 9).

The results of trials using See 2,4-D and Weedestroy AM 40 (both 2,4-D products) showed the effectiveness of these herbicides to be variable and unpredictable (Table 10). These herbicides are selective herbicides that can be used for broadcast or high-volume aquatic applications on dense or extensive stands of loosestrife. Selective herbicides affect the dicots, or broadleaf plants, while having little impact on the monocots such as grasses, sedges, and cattails. These 2,4-D herbicides can eliminate a year's production of seed, but they do not kill the plants, which will resprout the following year.

The program also evaluated another selective herbicide. Garlon 3A, a triclopyr that is not labeled for aquatic use, was tested in 1988 and 1989 under an experimental use permit from the U.S. Environmental Protection Agency. The cooperating agencies conducted field and test plot trials with generally positive results (Tables 11 and 12). Garlon 3A was more effective than the 2,4-D products in killing the entire plant rather than just the above-ground portion (Table 13). Garlon 3A did not kill the nontarget monocots such as grasses, sedges, and cattails (Table 14). The best results were obtained when Garlon 3A (called Renovate when labeled for aquatic sites) was applied with large amounts of water (1% Garlon 3A) and when the loosestrife plants were sprayed until they were wet.

Low-volume aerial applications of Garlon 3A were also tested by the MN-DNR and proved ineffective at the rates (1.5 and 3.0 lb/A) applied. Six test plots were randomly established to test aerial treatments at Big Marine Lake, Minnesota. One month after treatment, the loosestrife looked in general very healthy. More research is needed on aerial treatments to test different rates, timing of applications, and volume of water in applications.

Hennepin Parks of Minnesota, in addition to cooperating in the herbicide research, documented the distribution and spread of purple

Table 9.--Mean-percent change in cover of purple loosestrife, *Lythrum salicaria*, and non-target plant species one year after second glyphosate (Rodeo) application[a] (Skinner and Hollenhorst 1989).

Species	Mean change in cover (%)
L. Salicaria	+ 175
Typha	- 57
Sagittaria	+ 267
Gramineae spp.	- 80
Carex	- 96
Impatiens	+ 525

[a]Glyphosate was applied at 1% solution with water.

Table 10.--Mean-percent change in cover of purple loosestrife, *Lythrum salicaria*, and non-target plant species one year after 2,4-D treatment[a] (Skinner and Hollenhorst 1989).

Species	Mean change in cover (%)
L. Salicaria	- 24
Typha	+ 113
Sagittaria	0
Gramineae spp.	+ 334
Carex	- 24
Impatiens	+ 281

[a]2,4-D was applied at .5% solution with water.

Table 11.--Mean-percent reduction of purple loosestrife, *Lythrum salicaria*, and cattail with triclopyr (Garlon 3A) one year after treatment, Morris and White Bear Lake, Minnesota (Becker et al. 1989).

		MORRIS		WHITE BEAR LAKE	
Growth Stage	Triclopyr Rate lb/A	Purple Loose-strife	Cattail	Purple Loose-strife	Cattail
Early Flower	3.0	33	10	77	13
Early Flower	6.0	45	15	98	60
Late Flower	3.0	32	30	68	3
Late Flower	6.0	38	48	93	3

Table 12.--Mean-percent change in cover of purple loosestrife, *Lythrum salicaria L.*, by growth stage one year after treatment with triclopyr[a]. Carver Park Reserve, Minnesota (Skinner and Hollenhorst 1989).

Growth Stage	Mean change in cover (%)
Pre-flower	- 95
Early-flower	- 92
Late-flower	- 81
Post-flower	- 73
Early/later-flower	- 80
Control	+ 10

[a] Triclopyr was applied at 1% solution with water, and all treatments contained 0.25% X-77 surfactant.

Table 13.--Purple loosestrife, *Lythrum salicaria*, control at White Bear Lake, Minnesota (Becker et al. 1989).

		Percent Control			
		Spring Applied		Fall Applied	
Herbicide	Rate (lb/Acre)	P. Loosestrife 9/15/89	Cattail 9/15/89	P. Loosestrife 9/15/89	Cattail 9/15/89
Triclopyr	3.0	77	0	68	3
Triclopyr	6.0	92	8	93	3
2,4-D	3.0	28	0	37	0

Table 14.--Mean percent change in cover of specific non-target plant species by growth stage one year after treatment triclopyr[a] (Garlon 3A); Carver Park Reserve, Minnesota (Skinner and Hollenhorst 1989).

	Mean change in cover (%)			
Growth stage	Typha	Sagittaria	Gramineae	Carex
Pre-flower	- 50	- 38	- 1362	- 40
Early-flower	- 27	- 65	+ 639	- 36
Late-flower	- 3	+ 292	+ 375	+ 106
Post-flower	- 50	+ 128	- 8	0
Early/late-flower	- 40	+ 117	+ 664	+ 75
Control	- 13	- 39	+ 104	+ 25

[a]Triclopyr was applied at 1% solution, and all treatments contained 0.25% X-77 surfactant.

loosestrife in Hennepin Parks and studied the use of plant competitors to suppress loosestrife growth at the seedling stage (Skinner and Hollenhorst 1989). The plant competition studies showed that none of the species tested could suppress loosestrife seedling growth under natural conditions. Only cattails, under specific conditions (artificially manipulated) suppressed loosestrife seedling germination and growth.

Test burns of purple loosestrife were carried out by both DNR and Hennepin Parks with poor results. Both loosestrife test areas were treated with an herbicide, then burned after the loosestrife had died. In both cases, the burn provided ideal conditions for loosestrife to germinate from the seed bank, resulting in carpets of purple loosestrife seedlings.

Nonchemical Control Methods. The results of the work with herbicides reinforced the view that removal of the mature plants was only part of the answer to purple loosestrife control. Program staff concluded that a more comprehensive long-term management strategy had to be developed to deal with the massive seed bank accumulated beneath established loosestrife stands. Consequently, a two-year $200,000 research project, funded by the state legislature as recommended by the LCMR was established.

In July 1989, the DNR contracted with four researchers at the University of Minnesota and one at the University of Winnipeg in Manitoba, Canada to begin research that would lead to long-term management strategies for purple loosestrife including nonchemical methods. This research included studies of the reproductive genetics and taxonomy of purple loosestrife, of how large and how long-lived the loosestrife seed bank is, and of how it can be eliminated or suppressed. What kind of plants might be used as replacement species in wetland management to discourage the growth of loosestrife was also researched (Welling and Becker 1992). These investigations are providing background data for biological control experiments and for the development of a management plan using an integrated pest management (IPM) strategy on purple loosestrife.

The Purple Loosestrife Program is cooperating with the United States Department of Agriculture-Beneficial Insect Lab (USDA-BIL) and Cornell University on research conducted for the development of a biological control for loosestrife. This involves a lengthy screening process to select suitable insects that will feed on purple loosestrife without harming desirable plants in areas where they are released. To help aid this research, the DNR's Purple Loosestrife Program collected and shipped over 500 loosestrife root crowns and ample amounts of seed to Europe to be used in the biological control research.

In 1992, three insects were approved for release in the United States by the U.S. Department of Agriculture. A root-boring weevil, *Hylobius transversovittatus*, and two leaf-eating beetles, *Galerucella calmariensis* and

G. pusilla, have shown the most promise for controlling loosestrife. Minnesota, along with six other states, received these three insect species for release and evaluation. To date, MN-DNR and MDA have seven release sites to research these insects on the field. All three insect species have shown that they can survive Minnesota winters and become established, but it is too early to know how effective these insects will be as biological control agents in Minnesota. Research at Cornell University is also being funded by the MN-DNR to facilitate the establishment of the European insects currently in Minnesota and bring into the United States two additional European flower-feeding beetles for the control of loosestrife.

Control Work

The Purple Loosestrife Program began control work in 1988 with several methods, primarily chemical treatments. Because the staff lacked experience in managing loosestrife, chemical treatments made during 1988 were considered experimental. Selective spot spraying, in most cases with the herbicide Rodeo (glyphosate), was used on small infestations of less than 100 plants. A solution of 1% Rodeo and .25% Ortho X-77 surfactant was used in all treatments. DNR crews treated roughly 300 acres, taking 342 worker hours to complete the work. Commercial applicators hired by the DNR treated 700 acres, taking 1,311 work hours to complete the task. The total cost for these treatments was $55,000. All treatments completed by the DNR were applied from the ground using either backpack equipment or truck-mounted high-pressure sprayers. More control work was completed by private citizens, but the total amount is unknown.

In 1989, the program expanded control work to include more loosestrife infestations. For the first time, large infestations were treated from the air. Four hundred eighty seven acres mostly located in the western counties of Minnesota were treated with Rodeo or 2,4-D. Two experimental sites in Washington County were treated from the air to test the effectiveness of Garlon 3A herbicide. Aerial applications were the least expensive way of applying herbicide to loosestrife infestations, averaging $47 an acre. Three hundred ten acres were treated for loosestrife on the ground with backpack sprayers and high-pressure sprayers. Ground applications were more costly, averaging $157 an acre for DNR crews and $310 an acre for commercial applicators. A total of $104,000 was spent on loosestrife control work in 1989.

Although ground applications were more expensive, they were also more effective than aerial applications. A much higher percentage of control was accomplished by spot treating the new small infestations before a large seed bank could develop. Aerial applications made to large stands of loosestrife with Rodeo killed all emergent vegetation in the treated areas. The following season, the treated areas were dominated by carpets of loosestrife seedlings and adult loosestrife plants that survived the treatment. Subsequent treatments had similar results.

The Purple Loosestrife Program continues to treat 600 to 700 acres a year at a cost of $70,000. These efforts are concentrated on small, new infestations in watersheds with small populations of purple loosestrife.

Conclusions and Management Recommendations

Purple loosestrife is here to stay in Minnesota as well as in North America. Like most exotic species, loosestrife is impossible to eliminate once it becomes established. Because of its hardy and aggressive nature and its prolific seed production, purple loosestrife will continue to flourish and expand in the state and nationwide. Today's control options are very limited and provide only short-term control. Control techniques are labor intensive and costly and must be applied annually for an undetermined number of years.

Thus, managing purple loosestrife on a statewide basis is a difficult task that needs realistic management objectives, such as keeping loosestrife out of uninfested watersheds and slowing its spread. To accomplish these objectives requires close coordination of the program's four main responsibilities: broadening public awareness, conducting

inventories of infestations, researching control methods, and carrying out control work.

Public Awareness and Inventories

The program will continue its efforts to increase public awareness about purple loosestrife. A statewide control plan will not succeed without the support and help of the citizens of Minnesota. Citizens can help in inventories, control work, fundraising, and garnering legislative support for the loosestrife program.

Statewide inventories are key to establishing priorities for control work when funding and control techniques are limited. Enlisting the public in reporting incidental sightings helps to establish a solid database of loosestrife infestations. When possible, incidental sightings should be checked for accuracy, especially if they are new, small infestations, which will have highest priority for control.

The cooperation of state agencies such as the DOT and the MDA and of local government representatives such as county agricultural inspectors are also key to developing a solid database. These agencies have field staff statewide who can be trained to identify and report infestations in their area. This database can help facilitate work for all agencies controlling purple loosestrife, and an ongoing inventory can track the rate and degree of spread.

Research

Development of effective long-term control methods is an important goal of the program's research. Research on biological controls, the use of competitive species, seed bank dynamics, and the use of more selective herbicides is essential to achieve long-term control of purple loosestrife. Removal of existing loosestrife plants is not the final solution. Seed banks in established loosestrife infestations are very large and have seeds that are viable for many years. Methods are needed to deplete the seed bank or to provide continual long-term control of the adult plants.

Ultimately, the use of herbicides should be reduced: they provide only short-term control and have potential negative impacts on aquatic sites with repeated use. An integrated pest management strategy should be developed that uses several control techniques.

The best hope for long-term control is biological control, which has the potential to reduce large loosestrife infestations allowing native vegetation to reestablish itself. Biological control will never eliminate loosestrife, but would reduce it to one of many plant species present. If biological controls prove effective, labor costs and herbicide use will be reduced and continual control can be achieved. Most research needs, however, are not state specific and cooperative efforts between state and federal agencies are essential to speed the development of more effective control methods.

Control Strategies

Laws and regulations have increased public awareness and the amount of control work performed by state agencies, local units of government, and private landowners. The DNR, however, does not have the resources to control all the loosestrife infestations for which it is responsible. This situation makes it difficult for county agricultural inspectors and local weed inspectors to enforce control on private lands. For example, enforcing control of a few plants on private land is unrealistic when the state manages a wetland across the street that is full of loosestrife that is not being controlled. In 1991, the noxious weed law was revised to include language that directs the DNR to create a statewide priority list for controlling loosestrife (see appendix). Loosestrife sites on the list are treated in order until control funds are depleted. Thus, development of a statewide priority list for controlling loosestrife infestations has become a key part of the program.

Because water is the main avenue of spread for loosestrife seed, the program recommends that current management strategies for controlling purple loosestrife use a watershed approach. Preventing loosestrife from becoming established in uninfested watersheds and preventing the spread within watersheds should be the highest priority. Control work should start at the top of

watersheds to prevent seed flow downstream. If control work is started lower in the watershed, the sites can become reinfested from infestations upstream. Spread can be prevented by controlling the new, small infestations as they appear in uninfested watersheds.

The program does not recommend control attempts on large infestations because mechanical methods and herbicide treatments available are ineffective. Furthermore, attempts to control large infestations can divert limited funds from many small infestations where the potential for control is higher. Infestations will then increase exponentially and the end result will be many more large infestations (Moody and Mack 1988).

The most effective control for purple loosestrife is to spot-treat each loosestrife plant with the herbicide Rodeo (glyphosate). This method can be used for a variety of site types and infestation sizes. The herbicide rates preferred for controlling loosestrife are 1% herbicide solution in water. A surfactant such as Valent X-77 or Cidekick II should be added to the herbicide mix at a rate of 0.25%. These rates are for backpack or high-pressure handguns.

Once Garlon 3A becomes labeled for aquatic use, it will be the herbicide of choice because of its selectivity for broadleaf plants and its lower cost. Garlon 3A should be applied at the same rate as Rodeo. There are occasions when loosestrife can be treated with a boom applicator. In this situation, only broadleaf selective herbicides such as Garlon 3A should be used. For boom application, Garlon 3A should be applied at a rate of 3 to 5 lb/A. A surfactant should be used at 0.25% in solution.

Systematic treatment of loosestrife stands is essential to ensure that each plant gets treated. If desirable, a dye can be added to the herbicide mix to mark plants that have been treated. Marking is especially useful when infestations are large or spread out. Systematic treatment can be also achieved by other means, including marking treated areas with ribbon or having the applicators walk side by side through the area.

Other control methods, such as hand removal of plants, can be effective in certain situations. Table 15 provides a guide for choosing a method for controlling loosestrife, depending on site characteristics and infestation size.

In conclusion, herbicides can be used to control and sometimes eradicate small infestations of purple loosestrife. However, when purple loosestrife cannot be eradicated, control from the use of herbicides is usually short-term. Therefore, large, well established infestations of purple loosestrife generally should not be treated with herbicides. On a state level, herbicides can be used most effectively by targeting control efforts at small, isolated infestations to minimize expansion into these newly infested areas. The ability for long-term control of purple loosestrife is dependent upon finding successful biological control agents. Efforts should be made to accelerate the biological control efforts by coordinating at the state, region and national levels. Without these efforts, purple loosestrife will continue to invade and degrade wetland resources.

Table 15.--Recommended control methods for purple loosestrife, *Lythrum salicaria*, by site characteristics and size of infestation.

Site Characteristics	1-20 plants scattered	20-100 plants scattered/ small clumps	100-1,000 plants small clumps/ dense stands	>1,000 plants Large stands >75% coverage
Walkable or drivable	Hand remove plants and destroy all parts.	Same as left or selectively spray with Rodeo.	Spot-spray Rodeo or broadcast-spray selective herbicide.	Broadcast-spray selective herb./ Biological control when available.
Accessible by boat	Same as above or selectively spot-spray w/herbicide.	"Selectively" spotspray with Rodeo.	Spot-spray Rodeo or broadcast-spray selective herbicide.	Broadcast-spray selective herb./ Biological control when available.
Inaccessible by ground or water	"Selectively" broadcast spray w/herbicide.	"Selectively" broad-cast spray with herbicide.	Biological control when available.	Biological control when available.
Sensitive site (e.g., rare plants)	Hand Remove/ Wick application of Rodeo.	Hand Remove/Wick application of Rodeo.	Biological control when available.	Biological control when available.
Chemical use prohibited	Hand remove plants and destroy all plant parts.	Hand remove plants and destroy all plant parts.	Biological control when available.	Biological control when available.

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Appendix

Legislation and Regulations Pertaining to Purple Loosestrife in Minnesota

1987 legislation establishing a statewide control program for purple loosestrife.

86.78 Control of Purple Loosestrife
Subdivision 1. **Definition.** For the purpose of this section, "purple loosestrife" means *Lythrum salicaria*.

Subdivision 2. **Establishment of a control program.** The commissioner of natural resources shall establish a control program to curb the growth of purple loosestrife. The commissioners of agriculture and transportation must aid and cooperate with the commissioner of natural resources to establish, implement, and enforce the control program.

1987 legislation banning the sale of purple loosestrife.

18.182 Penalty for the sale of purple loosestrife
A person who sells purple loosestrife, *Lythrum salicaria*, is guilty of a misdemeanor.

1987 Department of Agriculture Commissioner's Order declaring purple loosestrife, *Lythrum salicaria*, a noxious weed.

Department of Agriculture Commissioner's Order No. 1: Addition of Plant Species to the List of Noxious Weeds Established in Agricultural Rule 1505.0730.

Pursuant to authority vested in me by session laws, 1987, section 83, I, Jim Nichols, Commissioner of Agriculture, hereby deem Purple loosestrife, Latin name *Lythrum salicaria*, to be a noxious weed as defined in Minnesota Statutes 1987, section 18.171, subdivision 5.

Dated at Saint Paul, Minnesota, this 29 day of May, 1987.

1988 Department of Agriculture Commissioner's Order revising 1987 Order No. 1.

Department of Agriculture Commissioner's Order No. 3: Addition of plant species to the list of noxious weeds established in agricultural rule 1505.0730

Pursuant to the authority vested in me by Minnesota Statues, section 18.171, subdivision 5, as amended by Minnesota laws 1987, chapter 404, section 83, I, Jim Nichols, Commissioner of Agriculture, hereby deem purple loosestrife Latin name, *Lythrum salicaria* and *Lythrum virgatum* and any combinations thereof, to be a noxious weed as defined in Minnesota statues 1987, section 18.171, subdivision 5. This order supersedes commissioner's order No. 1 issued May 29, 1987, deeming purple loosestrife Latin name *Lythrum salicaria* as a noxious weed.

1987 Noxious weed law as it pertains to purple loosestrife.

18.191 Destruction of noxious weeds.

Except as otherwise specifically provided in sections 18.181 to 18.271, 18.281 to 18.311, and 18.321 to 18.322, it shall be the duty of every occupant of land or, if the land is unoccupied, the owner

thereof, or an agent, or the public official in charge thereof, to cut down, otherwise destroy, or eradicate all noxious weeds as defined in section 18.171, subdivision 5, standing, being, or growing upon such land, in such manner and at such times as may be directed or ordered by the commissioner, the commissioner's authorized agents, the county agricultural inspector, or by a local weed inspector having jurisdiction.

Except as provided below, an owner of nonfederal lands underlying public waters or wetlands designated under section 103G.201 is not required to control or eradicate purple loosestrife (*Lythrum salicaria*) below the ordinary high water level of the public water or wetland. The commissioner of natural resources is responsible for control and eradication of purple loosestrife on public waters and wetlands designated under section 103G.201, except those located upon lands owned in fee title or managed by the United States. The officers, employees, agents, and contractors of the commissioner may enter upon public waters and wetlands designated under section 103G.201 and may cross adjacent lands as necessary for the purpose of investigating purple loosestrife infestations, formulating methods of eradication, and implementing control and eradication of purple loosestrife. The responsibility of the commissioner to control and eradicate purple loosestrife on public waters and wetlands located on private lands and the authority to enter upon private lands ends ten days after receipt by the commissioner of a written statement from the landowner that the landowner assumes all responsibility for control and eradication of purple loosestrife under sections 18.171 to 18.315. State officers, employees, agents, and contractors are not liable in a civil action for trespass committed in the discharge of their duties under this section and are not liable to anyone for damages, except for damages arising from gross negligence.

1988 appropriation language to help fund control of purple loosestrife on farmland.

Purple Loosestrife

$50,000 is appropriated from the general fund to the commissioner of agriculture, to be available until June 30, 1989, for the eradication of purple loosestrife, *Lythrum salicaria* on farmland where the farmer is required to eradicate the purple loosestrife because of the noxious weed law.

Department of Natural Resources Commissioner's Order that regulates aquatic plant control in protected waters.

Commissioner's Order 2210 - Regulations for the issuance of permits for the destruction and control of aquatic plants, algae, snails, leeches and other invertebrate aquatic life in protected waters - section 2(b) states *"An aquatic nuisance control permit is required to: (1) apply herbicides or other chemicals to any protected waters and (3) destroy emergent aquatic vegetation in any protected waters, except allowed by section 2(c) (1) and (2)."*

Department of Natural Resources Commissioner's Order that allows purple loosestrife to be cut or pulled without a permit in protected waters.

Commissioner's Order No. 2244 - Amending Commissioner's Order 2210, regulating the issuance of permits for the control of aquatic nuisances.

Pursuant to authority vested in me by law, I, Joseph N. Alexander, Commissioner of Natural Resources, hereby prescribe the following amendments to Commissioner's Order No. 2210, regulating the issuance of permits for the control of aquatic nuisances.

Section 1. Section 2 (b) (3) of Commissioner's Order No. 2210 is amended to read as follows;
(3) Destroy emergent aquatic vegetation in any protected waters, except as allowed by Sec. 2 (c).

Sec. 2. Section 2 (c) of Commissioner's Order No. 2210 is amended by adding paragraph (5) as follows:
(5) Cut or pull purple loosestrife (*Lythrum salicaria*). Any person who cuts or pulls purple loosestrife under the authority of this section shall immediately and permanently remove the same from the water.
Sec. 3. Section 4 (a) of Commissioner' Order No. 2210 is amended by adding paragraph (7) as follows:
(7) Purple loosestrife (*Lythrum salicaria*).
Sec. 4. Section 5 (a) (1) of Commissioner's Order No. 2210 is amended by adding paragraph (G) as follows:
(G) To control purple loosestrife (*Lythrum salicaria*) by chemical means: no charge.
Sec. 5. Except as provided by this order, all provisions of Commissioner's Order No. 2210 shall remain in full force and effect.

Date at Saint Paul, Minnesota this 3 day of September, 1986.

1990 amendment to noxious weed law requiring the Commissioner of Natural Resources to create an annual priority list for controlling purple loosestrife.

M.S.18.191 DESTRUCTION OF NOXIOUS WEEDS.
Except as otherwise specifically provided in sections 18.181 to 18.271, 18281 to 18.311, and 18.321 to 18,322, it shall be the duty of every occupant of land or, if the land is unoccupied the owner thereof, or an agent, or the public official in charge thereof, to cut down, otherwise destroy or eradicate all noxious weeds as defined in section 18.171, subdivision 5, standing, being, or growing upon such land, in such manner and at such times as may be directed or ordered by the commissioner, the commissioner's authorized agents, the county agricultural inspector, or by a local weed inspector having jurisdiction.

Except as provided below, an owner of nonfederal lands underlying public waters or wetlands designated under section 103G.201 is not required to control or eradicate purple loosestrife (*Lythrum salicaria*) below the ordinary high water level of the public water or wetland. To the extent provided in this section, the commissioner of natural resources is responsible for control and eradication of purple loosestrife on public waters and wetlands designated under section 103G.201, except those located upon lands owned in fee title or managed by the United States. The officers, employees, agents and contractors of the commissioner may enter upon public waters and wetlands designated under section 103G.201 and may cross adjacent lands as necessary for the purpose of investigating purple loosestrife infestations, formulating methods of eradication, and implementing control and eradication of purple loosestrife. The commissioner, after consultation with the commissioner of agriculture, shall by June 1 of each year, compile a priority list of purple loosestrife infestations to be controlled in designated public waters. The commissioner of agriculture must distribute the list to county agriculture inspectors, local weed inspectors, and their appointed agents. The commissioner of natural resources shall control listed purple loosestrife infestations in priority order within the limits of appropriations provided for that purpose. This procedure shall be the exclusive means for control of purple loosestrife on designated public waters by the commissioner of natural resources and shall supersede the other provisions for control of noxious weeds set forth elsewhere in Minnesota Statutes, chapter 18. The responsibility of the commissioner to control and eradicate purple loosestrife on public waters and wetlands located on private lands and the authority to enter upon private lands ends ten days after receipt by the commissioner of a written statement from the landowner that the landowner assumes all responsibility for control and eradication of purple loosestrife under sections 18.171 to 18.315. State officers, employees, agents, and contractors are not liable in a civil action for trespass committed in the discharge of their duties under this section and are not liable to anyone for damages, except for damages arising from gross negligence.

ACKNOWLEDGMENTS

Funding to establish the Purple loosestrife program was provided by the Minnesota Legislature as recommended by the Legislative Commission on Minnesota Resources during 1988 and 1989. Continued program has been provided through the Water Recreation Account from a surcharge on watercraft licenses. We thank the Minnesota Department of Agriculture, Minnesota Department of Transportation, University of Minnesota, Hennepin Parks, DowElanco Chemical Company and Androc Products Inc. for their assistance with the herbicide research. We also thank Stephen Hight, U.S.D.A.-Beneficial Insect Laboratory, and Rich Malecki and Bernd Blossey, Cornell University, for their assistance with establishing biological control research in Minnesota.

Edited by:
Mary E. Keirstead, Technical Writer and Editor
Paul J. Wingate, Fisheries Research Manager, DNR

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