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Purple loosestrife (Lythrum salicaria L.) in a southeastern sedge meadow

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PURPLE LOOSESTRIFE *(Lythrum salicaria L.)* IN A SOUTHEASTERN WISCONSIN SEDGE MEDOW

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ABSTRACT

Floristic and seed bank composition of a sedge meadow containing purple loosestrife was examined in 1987 and 1988. Eleocharis spp., Spiraea tomentosa, Triadenum virginicum, and Lycopus spp. were widespread while infrequent or absent in nearby sedge meadows without purple loosestrife, suggesting that these species have similar microsite requirements. Changes noted in some species over time probably resulted from changes in climatic and soil moisture conditions. The seed bank reflected the dominant herbaceous vegetation but lacked a few species having moderate frequencies in the established vegetation. Limited samples, unsuitable germination conditions in the greenhouse, autumn seed germination by some species and inability to survive prolonged inundation may explain the paucity of seed of some species that were frequent in the vegetation. Herbicide treatment of above ground purple loosestrife tissue was effective but did not result in a decline in frequency, probably because of resprouting. Areas with few individuals of purple loosestrife can be effectively managed by hand spraying individual plants and by removing flowering stalks at the time of herbicide treatment.

INTRODUCTION

Purple loosestrife (Lythrum salicaria) is a tall, perennial member of the Lythraceae occurring in wetland habitats throughout the northeastern and midwestern United States and Canada (Stuckey 1980). It was introduced into the United States from Europe in the early 1800's and reached the glaciated wetlands of the Great Lake States by 1990. Thompson and Stuckey (1980) estimated the potential range of purple loosestrife in the seven states of Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota and Iowa at three million acres. In 1984, a survey of approximately 10% of Wisconsin roads found 486 populations in the southeastern counties of Waukesha, Jefferson and Waupaca (Reinartz et al. 1987). In 1987, an estimated 25,000 colonies, of nearly five million purple loosestrife plants, covering 30,000 acres were present in Wisconsin (Henderson 1987). The plant can now be found as far north as Lake Superior.

Wetlands dominated by purple loosestrife have lost many native, and some rare, endemic wetland species with a concomitant loss of productivity (Evans 1982). Purple loosestrife infestations usually result in the loss of waterfowl

food species and important cover plants (McKeon 1959; Smith 1959; Friesen 1966). The loss of plant diversity can only be followed by a loss in the number and variety of wildlife inhabiting purple loosestrife dominated areas (Malecki and Rawinski 1979). The only wildlife value of purple loosestrife lies in the limited cover it forms, cover that can be better provided by several other emergent aquatics (Smith 1959).

Purple loosestrife tolerates a wide variety of environmental conditions. Seeds remain viable for several years (92% viable after 20 months submergence), remain dormant over the winter months, require little light for germination, and have an optimal germination temperature of 20°C (Clapham 1956; Shamsi and Whitehead 1974; Rawinski 1981). After germination, seedlings grow rapidly, develop a strong root system and are capable of flowering in as little as 8-10 weeks (Shamsi and Whitehead 1974). Seedlings can survive brief periods of submergence of 30 to 40 cm, and once established, mature plants can survive 50% shading, low nutrient conditions, and acid or alkaline soils, as well as short term immersion (Smith 1959; Shamsi and Whitehead 1977; Thompson and Stuckey 1980).

Seed output can reach 100,000 seeds per plant with dispersal mainly by wind and water (Shamsi and Whitehead 1974). Once a seed source is established, 50 years may pass before the plant becomes a problem (Thompson and Stuckey 1980). This situation can change rapidly when a wetland plant community is stressed by artificial draining, natural drawdown, land clearance, road building or other disturbance (Evans 1982). Usually local eradication of purple loosestrife has been successful only when immediate action was taken. Hand pulling, controlled burning, cutting, mowing, water level manipulation and herbicide treatment are some management practices that have been employed (Louis-Marie 1944; McKeon 1959; Malecki and Rawinski 1979; Thompson and Stuckey 1980; Evans 1982; Rawinski 1985; Reinartz et al. 1987). None of these methods have been entirely successful in controlling purple loosestrife on a large scale. This study was undertaken to 1) determine the floristic composition of an established sedge meadow containing purple loosestrife (approximately 200-300 plants in a 0.25 hectare area); 2) determine the number of viable seeds in the seed bank; 3) determine the effectiveness of hand spraying individual purple loosestrife plants with Glyphosate (Roundup). Herbicide treatment was the control method of choice because easy access to a relatively small number of purple loosestrife plants made hand spraying feasible and Evans (1982), Rawinski (1985), and Reinartz et al. (1987) noted that some success had been achieved using Glyphosate.

Site Description

The study site is located in the Kettle Moraine region in Delafield Township, Waukesha County in southeastern Wisconsin and is part of an area that has been artificially drained for several decades and was strip mined for peat

approximately 8-10 years ago. After mining, approximately 15 cm of peat remained, on which the present vegetation became established. The peat has a pH of 6.45 with 20 ppm phosphorus, 100 ppm potassium, 4.15 ppm water soluble nitrate, 695 ppm magnesium, and 1866 ppm calcium.

The average yearly precipitation for Waukesha County is 76.4 cm (Steingraeber and Reynolds 1971). Rainfall in 1985 was 17.5 cm below the yearly normal and 7.6 and 11.2 cm above normal in 1986 and 1987 respectively (Zolidis 1988). From May to September 1988, rainfall was 20 cm less than normal (Carroll College Weather Station 1988).

METHODS

The floristic composition of the area was determined based on frequency of occurrence of species in 1.0 by 0.5 meter quadrats placed side by side along 4 transects. One hundred ninety quadrats were sampled in June 1987 and 200 quadrats/date were sampled in August 1987 and June and August 1988. Nomenclature follows Gleason and Cronquist (1963).

Eleven seed bank samples 20 cm by 20 cm by 4 cm deep (total surface area 0.44 m^2) were collected in early April 1987 and 40 samples, 10 by 10 by 4 cm deep (total surface area 0.40 m^2), were collected in May 1988. Spring collection assured that seedlings emerging from the samples came from seed that had been cold stratified for at least one winter. Samples were returned to the laboratory and placed in a cold room ($4^{o}C$) until transferred to plastic trays in the greenhouse. Several additional trays were filled with potting soil and placed among the seed bank trays to detect the presence of greenhouse contaminants. Seedlings emerging from the seed bank samples were identified and removed approximately weekly and less frequently as fewer seedlings emerged.

G-tests were used to test for differences in species frequency in the vegetation (Sokal and Rohlf 1981). Only species with a frequency of at least 15% on one sampling date were tested. The statistical significance of changes in seed density ($\#/m^2$) were tested with one-way analysis of variance (Minitab, Ryan et al. 1985). Because of heterogenous variances, data were log transformed to meet the assumptions of parametric tests. Only species with at least 100 seeds/m^2 were tested individually.

Herbicide (2-3% solution) was applied in each of three years; 1985, 1986 and 1987. Individual plants were hand sprayed after flowering was initiated. No exact dosage applications were made. Flowering spikes were removed when plants were sprayed and disposed of outside the site in an attempt to reduce seed rain. Because of the small number of plants and the limited area, it was assumed that all individuals had been sprayed at least once each year.

RESULTS

Floristic Composition

Forty-six recognizably different species were found to occur in the vegetation in 1987 and 51 in 1988 (Table 1). The most frequent species in June 1987 were rush (Juncus spp.), St. John's wort (Hypericum canadense), spikerush (Eleocharis spp.), woolgrass (Scirpus cyperinus), reed canary grass (Phalaris arundinacea), grass leaf goldenrod (Solidago graminifolia), panic grass (Panicum spp.), tick seed sunflower (Bidens coronata), steeple bush (Spiraea tomentosa), and fen buckthorn (Rhamnus frangula). Purple loosestrife occurred in 14% of the quadrats. Species whose frequency had increased significantly in August 1987 were spikerush (G = 7.29), boneset (Eupatorium perfoliatum, G = 9.42), and rice cut-grass (Leersia oryzoides, G = 12.94). The frequency of rush (G = 5.91) and fox sedge (Carex vulpinodea, G = 10.03) declined. Purple loosestrife frequency was not significantly different in June and August 1987.

Species abundant in June 1988 were rush, spikerush, grass leaf goldenrod, panic grass, St. John's wort, reed canary grass, woolgrass, beggarticks (Bidens frondosa), willow (Salix spp.), hore-hound (Lycopus spp.), steeple bush, marsh St. John's wort (Triadenum virginicum), fen buckthorn and boneset (Table 1). Purple loosestrife occurred in 8% of the quadrats. In August 1988, the species which had increased significantly since June were spikerush (G = 14.04), tick seed sunflower (G = 7.11) and purple loosestrife (G = 7.11) while rush (G = 26.63), St. John's wort (G = 8.47), woolgrass (G = 8.50), marsh St. John's wort (G = 11.97), beggarticks (G = 72.09) and fox sedge (G = 4.650) declined.

Seed Bank Germinants

Twenty four recognizable taxa emerged from seed bank samples in the greenhouse in 1987 (Table 2). The most abundant seedlings were woolgrass, St. John's wort, rush, panic grass, steeple bush and pointed broom sedge (Carex scoparia). These six accounted for 93% of the seedlings. Four species: woolgrass, St. John's wort, panic grass and rush were present in all seed bank samples. Six species were found in only one sample (Table 2).

Eighteen recognizable taxa emerged from 1988 seed bank samples. The most abundant seedlings were panic grass, St. John's wort, rush, woolgrass, pointed broom sedge and steeple bush. These six accounted for 93% of the seedlings. The most frequently occurring taxa in the seed bank samples were panic grass and St. John's wort. Five of the species were found in only one sample.

In the 1987 samples, 2347 seedlings emerged representing 5336 seedlings/m^2, and in 1988, 862 seedlings emerged representing 2160 seedlings/m^2. Seed density was greater in 1987 samples than in 1988 ($F = 20.88$; df 1,49; $p<0.001$). Individually, the density of woolgrass ($F = 20.88$; df 1,49; $p<0.001$), rush ($F = 7.09$; df 1,49; $p<0.05$), and sedge ($F = 5.38$; df 1,49; $p<0.05$) seedlings were greater in the 1987 samples than in 1988.

Table 1. Floristic composition (%) in a southeastern Wisconsin sedge meadow containing purple loosestrife in 1987 and 1988. Numbers shown are the frequency of occurrence as percent of 0.5 m^2 quadrats in which the species was found. Only species with a frequency of greater than 2% are listed.

Species	1987		1988	
	June	August	June	August
Juncus spp.	83.2	73.0	73.5	48.5
Hypericum canadense	71.6	76.5	54.5	40.0
Eleocharis spp.	56.3	69.5	67.5	83.5
Scirpus cyperinus	49.5	54.0	53.0	38.5
Phalaris arundinacea	43.7	40.5	54.0	59.5
Solidago graminifolia	41.1	49.0	63.5	67.0
Panicum spp.	40.0	46.0	56.0	65.5
Bidens coronata	37.9	47.0	7.5	39.5
Spiraea tomentosa	36.8	46.5	40.0	44.5
Rhamnus frangula	32.1	33.5	35.0	29.0
Salix spp.	27.9	33.0	43.0	38.5
Triadenum virginicum	25.3	32.5	36.0	20.5
Eupatorium perfoliatum	23.7	38.0	32.0	30.0
Rubus hispidus	22.6	30.5	20.5	23.5
Lycopus spp.	21.1	29.5	41.5	43.0
Typha spp.	13.7	21.0	23.5	23.5
Lythrum salicaria	13.7	15.5	7.5	16.0
Agrostis spp.	11.6	15.5	19.5	16.5
Bidens frondosa	11.6	15.0	51.0	12.5
Carex vulpinodea	10.0	2.5	18.0	10.5
Polygonum natans	10.0	13.5	11.0	15.5
Solidago canadensis	10.0	11.5	17.5	18.5
Leersia oryzoides	9.0	16.5	11.0	2.0
Carex scoparia	7.4	3.5	9.5	6.5
Populus deltoides	4.2	10.0	3.5	6.0
Acer spp.	4.2	0.5	5.0	2.0
Viola spp.	3.7	1.5	1.5	0.5
Populus tremuloides	3.7	4.0	3.5	3.0
Alisma plantago-aquatica	3.7	3.5	4.0	0.0
Impatiens spp.	2.6	0.5	0.5	0.0
Sphagnum spp.	2.6	1.0	0.0	1.5
Potentilla norvegica	2.1	1.5	1.5	0.5
Ludwigia polycarpa	2.1	2.5	1.0	0.5
Calamagrostis canadensis	0.5	3.0	7.0	4.0
Asclepias incarnata	0.5	3.0	2.0	1.5
Aster spp.	0.0	0.0	4.0	1.5

Taxa occurring at less than 2% were Aster pilosus, Lactuca spp., Polygonum scandens, Verbena hastata, Taraxacum officinalis, Cornus spp., Ambrosia artemisiifolia, Epilobium spp., Erechtites hieracifolia, Prunus spp., Scirpus atrovirens, Betula spp., Onoclea sensibilis, Oenothera spp., Galium spp., Echinochloa spp., Carex spp.

Table 2. Taxa emerging from soil samples collected in 1987 and 1988 in a southeastern Wisconsin sedge meadow containing purple loosestrife.

Species	1987 Number Seedlings	1987 Density (#/m^2)	1987 Freq. (%)	1988 Number Seedlings	1988 Density (#/m^2)	1988 Freq. (%)
Scirpus cyperinus	1157	2630	100	71	178	55
Hypericum canadense	320	727	100	250	625	93
Juncus spp.	261	593	100	80	200	63
Panicum spp.	255	580	100	313	783	93
Spiraea tomentosa	101	230	82	37	93	50
Carex scoparia	80	182	91	53	133	40
Lycopus spp.	37	84	27	8	20	5
Agrostis spp.	34	77	55	10	25	15
Eupatorium perfoliatum	2	5	18	7	18	13
Eleocharis spp.	30	68	45	15	38	20
Solidago graminifolia	21	48	73	3	10	8
Triadenum virginicum	13	30	36	4	10	8
Solanum nigrum	7	16	27	—	—	—
Rhamnus frangula	7	16	45	—	—	—
Phalaris arundinacea	6	14	18	—	—	—
Ludwigia polycarpa	4	9	18	—	—	—
Salix spp.	3	7	27	—	—	—
Leersia oryzoides	2	5	9	1	3	3
Solidago canadensis	2	5	9	—	—	—
Polygonum spp.	1	2	9	—	—	—
Bidens coronata	1	2	9	1	3	3
Plantago spp.	1	2	9	—	—	—
Carex vulpinodea	1	2	9	—	—	—
Penthorum sedoides	1	2	9	—	—	—
Epilobium spp.	—	—	—	5	13	10
Rubus hispidus	—	—	—	1	3	3
Potentilla norvegica	—	—	—	2	5	3
Unidentified Asteraceae	—	—	—	1	3	3
Totals	2347	5336	—	862	2160	--

DISCUSSION

Species with which purple loosestrife is commonly associated are rarely specified. The United States Fish and Wildlife Service (1979) listed Typha, Phragmites, Spartina, Scirpus and Carex among the genera associated with purple loosestrife. Species such as marsh St. John's wort, steeple bush, hore-hound, fox sedge, water smartweed (Polygonum natans), rice cut-grass, and purple loosestrife that have a higher frequency here than was observed in several nearby sedge meadows (Larson and Stearns 1989) may indicate these species have similar microsite requirements.

Hydrological data collected by Zolidis (1988) indicated that this study site had standing water for much of 1986 and 1987 and a small seasonal water table fluctuation. In addition, pH, potassium and magnesium levels were higher than in nearby sedge meadow areas (Unpublished data). Change in species frequency during

the year is generally a result of climatic and soil moisture conditions. For instance, annuals such as Hypericum canadense and Bidens frondosa increased during a moist year (1987), and declined during a dry year (1988). Similarly, perennials such as woolgrass, Triadenum virginicum, boneset, Agrostis spp., and rice cut-grass increased in 1987 and declined in 1988. Other species that either increased or decreased in both years or remained at a similar frequency may not be as susceptible to environmental fluctuations.

The seedlings emerging from the seed bank in this study differed from the seed bank of a nearby sedge meadow (Larson and Stearns 1987). However, the seed bank reflected most of the dominant species present in the vegetation but lacked some species having moderate frequencies in the established vegetation. Other wetland seed bank studies have found the seed bank to reflect the dominant vegetation with little similarity between different marshes with similar vegetation (van der Valk and Davis 1978; Keddy and Reznicek 1982; Parker and Leck 1985; Larson and Stearns 1987).

The absence or scarcity of seed in the seed bank where the species is frequent in the vegetation may result from several factors. Mature woody plants such as fen buckthorn, willow, and dewberry appear to tolerate different moisture conditions than do their seeds. Several plants, including boneset, smartweed, tick seed sunflower, beggarticks, and reed canary grass that were frequent in the 1987 vegetation, flowered and were expected to be a large component of the 1988 seed bank, but emerged only in low numbers. Boneset has been found to be an abundant component of the seed bank of a nearby sedge meadow (Larson and Stearns 1987). Smartweeds have been found in seed banks studied by van der Valk and Davis (1976; 1978; 1979), Dunn and Best (1983), Parker and Leck (1985) and Leck and Simpson (1987). The smartweed in this area was mostly the terrestrial form of water smartweed which seldom flowered, accounting for the lack of its seed. Specific germination requirements of tick seed sunflower and beggarticks may not have been met in the greenhouse. Comes et al. (1978) found beggarticks to germinate readily if stored submerged and suggested that the seed coat contained a water soluble germination inhibitor. Apfelbaum and Sams (1987) found thousands of reed canary grass seedlings emerging from seed bank samples collected in areas dominated by reed canary grass when placed in a greenhouse in October. They found seed was not innately dormant and could germinate immediately after collection. Comes et al. (1978) found that as little as three months storage in submersed conditions greatly reduced reed canary grass seed germination. Limited sample size, unsuitable germination conditions in the greenhouse, autumn seed germination by some species, and high mortality during periods of standing water may partly explain the paucity of seed of some species in spring samples despite their abundance in the vegetation.

Conversely, St. John's wort, woolgrass, rush and pointed broom sedge produced abundant seed (pers. obs.) that survived saturated soil conditions.

This was reflected in a large 1987 seed bank. The decline of some of these species in the 1988 seed bank may have resulted from two successive moist years which adversely effected seed viability. However, Thompson and Grime (1979) suggested that seasonal variation in seed number for populations of the same species in different habitats was a function of the species rather than the environment.

The absence of purple loosestrife seeds may be partly explained by the removal of the inflorescences at the time of herbicide application; this virtually eliminated the seed rain since 1984. Thus, most purple loosestrife plants occurring after 1985 were thought to be respouts. The herbicide treatments were effective in killing the above ground plant parts, but purple loosestrife is known to resprout after herbicide application (Smith 1959; McKeon 1959; Smith 1964). Only a few seed bank studies have detected the presence of purple loosestrife (Leck and Graveline 1979; Parker and Leck 1985). Reinartz et al. (1987) found purple loosestrife seedling densities ranging from $32/m^2$ in areas surrounding plants receiving a low herbicide dosage to $12{,}000/m^2$ surrounding individual purple loosestrife plants receiving a high herbicide dosage. The increased herbicide dosage killed more of the surrounding vegetation and resulted in a larger gap which apparently was beneficial to purple loosestrife seedlings. Most samples in this study were not collected from areas directly surrounding individual plants, which may in part explain the absence of seed.

A major concern in purple loosestrife management is how it will respond to water level manipulation. Efforts to raise water levels to control purple loosestrife have usually been unsuccessful (McKeon 1959). This may have resulted from the persistence of long-lived seeds in the seed bank. As water levels were raised more seeds germinated. Areas with standing water not deep enough to completely cover the seedlings, a stable water table, and higher pH may be particularly susceptible to infestation by purple loosestrife. In this study, frequency of purple loosestrife did not decline after herbicide treatments, probably because of resprouting. However, this study indicates that purple loosestrife above ground structures are readily killed by herbicide application and loosestrife presence in the seed bank may be reduced by removing flowering stalks.

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