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Abstract

Purple loosestrife (*Lythrum salicaria*), an exotic wetland plant from Eurasia, has become widespread in the northeast and northcentral regions of the U.S. and Canada. When it becomes established in a wetland, it crowds out most native plant species, and can form dense stands either in standing water or on moist soil. This results in decreased plant diversity and the loss of food and cover species valuable to wildlife. Some attempted control methods, such as controlled burning and water-level manipulation have proven to be unsuccessful. Other control measures, including mechanical cutting, replacement, and cattail competition, have shown encouraging, but inconclusive, results. This study was therefore initiated to further explore the possibility of controlling purple loosestrife through competition with cattails (*Typha angustifolia*) in mixed stands. A competitive edge was given to *Typha* by cutting *Lythrum* and selectively fertilizing *Typha*. First-year results of the study showed a significant decrease in *Lythrum* biomass as a result of cutting treatments. Cutting did not significantly reduce resprouting *Lythrum* stems, as *Lythrum* resprouted in greater numbers than *Typha*, but Typha sprouts grew faster and increased in biomass more quickly than *Lythrum* sprouts. With carbohydrate replenishment to the roots reduced, it is expected that *Lythrum* biomass will be reduced in subsequent years. The stress caused by cutting, and increased shade by the *Typha* canopy, may help to control purple loosestrife spread.

Life History of Purple Loosestrife

Purple loosestrife (*Lythrum salicaria* L.) is a tall, perennial, herbaceous, wetland plant of the family Lythraceae (Heineke, 1977). It is an aggressive, exotic species from Eurasia that has become widespread in the northeast and midwest regions of the U.S. and Canada and is found mainly within the boundaries of the last Wisconsin glaciation (Evans, 1982; Casebere, 1984; Anonymous, 1984). *L. salicaria* was introduced into the U.S. late in the eighteenth century. It first became established in eastern port cities before spreading into the northeast region by the early 1800's (Casebere, 1984). It was probably introduced repeatedly by seeds being carried in ship ballasts (Rawinski, 1982). It was noted as a troublesome species in the 1930's when it aggressively invaded wetlands in the floodplain of the St. Lawrence River in Quebec (U.S. Fish and Wildlife Service, 1979; Stuckey, 1980). It then spread quickly through the U.S. along the Great Lakes, Finger Lakes, and the floodplains of the Hudson, Merrimac, and Delaware rivers (Stuckey, 1980; Evans, 1982).

Infestations occur when wetland communities are disturbed. The disturbance may be in the form of water-level manipulation, natural drawdowns during dry years, land clearance, road building, or waterway development. Such disturbances result in areas of exposed soil where *L. salicaria* can quickly invade (Stuckey, 1980; Evans, 1982).

L. salicaria grows to an average height of 1.5 m with a range of 0.5 to 2.5 m. The stem is four-angled, slightly winged and erect, with simple, opposite or whorled, lanceolate leaves that are sessile and without stipules (Smith, 1962; Heineke, 1977). The plant is most conspicuous during its long flowering season, from early July to mid-September (Evans, 1982; Rawinski, 1982). The upper branches bear long (30 cm) spikes of numerous reddish-purple flowers, which may vary in color from magenta to a deep rose-purple (Smith, 1962). The flowers are pollinated by bees and butterflies (Evans, 1982).

Fertilization produces a tubular capsule which is capable of producing numerous seeds. A normal, healthy plant will produce about 900 capsules, with each capsule having an average yield of 120 seeds, although some plants may produce as many as 300,000 seeds (Shamsi and Whitehead, 1974a; Teale, 1982). Individual seeds are small and light (0.06 mg dry weight).

Purple loosestrife prefers moist, highly organic soils but can tolerate a wide range of environments. It is found growing on both calcareous and acidic soils, can withstand shallow flooding (<0.5 m), and can tolerate up to 50 percent shade (Shamsi and Whitehead, 1974a; Shamsi, 1974; U.S. Fish and Wildlife Service, 1979; Rawinski, 1982). Purple loosestrife can also tolerate poor mineral nutrient conditions, as it has low nutrient requirements and a high nutrient uptake capacity. Under poor nutrient conditions, the root/shoot ratio increases, a phenotypically plastic response characteristic of the species, which provides purple loosestrife with a natural competitive advantage over other wetland species (Shamsi, 1974). However, for germination to occur, purple loosestrife requires warm temperatures (15-20 C) and at least a 13 hour photoperiod. Since the seeds are small and carry little food reserve, germination must occur under conditions in which photosynthesis can quickly occur (Shamsi and Whitehead, 1974b, 1977).

Purple loosestrife seeds are mostly dispersed by water, though aided by wind, adherence to animal fur, feet of waterfowl, and by man's practices of gardening and apiculture (Pellet, 1977; Hayes, 1979; Rawinski, 1982; Casebere, 1984). The seeds float over some distance for several days before sinking. They remain viable for several years of underwater storage, with a drop to 92 percent viability after 20 months (Rawinski, 1982). Germination occurs with the onset of favorable conditions, usually in late spring. The stems emerge from a strongly developed tap root system, which persists through the life of the plant (Shamsi and Whitehead, 1974a). The stems grow rapidly,sometimes exceeding 1.0 cm/day. Flowering occurs 8-10 weeks after germination and starts at the bottom of the inflorescence. The lowest capsules formed will ripen and disperse their seeds while flowering still occurs further up the spike (Rawinski, 1982). With the advent of autumn, the above-ground parts die back. Fresh shoots arise the following spring from buds at the top of the rootstock. With maturity, this upper part of the root system becomes thick and woody (Shamsi and Whitehead, 1974a; Evans, 1982).

Effects on Wetlands

Purple loosestrife usually has a negative impact on the indigenous wetland plant species. When it invades a wetland, purple loosestrife clumps become very dense and choke out the more beneficial, native plant species, such as smartweed (*Polygonum*), jewelweed (*Impatiens*), arrowhead (*Sagittaria*), and other soft-stemmed, herbaceous plants (Novak, 1968; Teale, 1982). The thick root system forms tangles of lodged stems, trapping debris which builds up the ground level to the point of stressing native emergents, such as cattails (*Typha*) (Smith, 1962). The decrease in plant diversity may cause decreased wildlife diversity (Malecki and Rawinski, 1979). Purple loosestrife infestations lead to a loss of wildlife food plants, feeding areas (mud flats) for shore birds, open water areas required by nesting and migratory waterfowl, and access to prey (Rawinski, 1982; Casebere, 1984). Established stands of purple loosestrife do provide nest and brood cover for shore birds, and harbor invertebrates as a food source, but this usefulness is of short duration, as the clumps become impenetrable after 2-3 years (Malecki and Rawinski, 1979).

Purple loosestrife is a problem species in one wetland within Indiana Dunes National Lakeshore and is present in several other wetland areas. It is quite prevalent in Delaware Water Gap National Recreation Area and Cuyahoga Valley National Recreation Area and appears in small numbers at Acadia National Park. Other anecdotal references to its presence in National Park Service areas have not been compiled, but it is likely to be found in many Northeast or Great Lakes parks.

Previous Control Methods

Several methods have previously been tried to control the spread of purple loosestrife, but they have mostly been unsuccessful. Controlled burning has been completely ineffective, as there is no good time during the year for burning. Burning also stresses the native plants, and may thereby enhance purple loosestrife spread (McKeon, 1959; Evans, 1982). Flooding has proven to be ineffective and may also enhance purple loosestrife spread in some cases. The plants respond quickly to shallow flooding, while mature plants can survive short-term immersions (Malecki and Rawinski, 1979; Evans, 1982). Hand-pulling can help control isolated clumps and young plants, but all of the plant parts must be removed or regeneration will occur. Also, the plants must be put in a proper disposal site since uprooted plants can grow adventitious roots (Rawinski, 1982; Evans, 1982; Casebere, 1984). Herbicide spraying has shown some positive results but the plants must be accessible and all must be treated for effective control. Since resprouting occurs, treatment must be repeated every year (McKeon, 1959; Smith, 1959). Smith (1964) showed that better results occurred with heavier applications, but the cost is unreasonable and there is a risk of environmental contamination (Malecki and Rawinski, 1979).

Several newer control techniques have shown some promise in controlling purple loosestrife spread. Late summer cutting can greatly reduce the number of new shoots, as the plants are less able to replenish the carbohydrate reserves needed for growth the following spring, but repeated cuttings would be necessary. The cut portions must be properly disposed since the cut stems can grow adventitious roots if left in the water (Novak, 1968; Rawinski, 1982).

Another method is replacement of purple loosestrife by a more desirable species. Rawinski (1982) planted seeds of Japanese millet (*Echinochloa frumentacea*) by themselves, in a recently drawn down area bordered by purple loosestrife, and in combination with purple loosestrife seeds. Successful control occurred both in the drawdown area and in the combination plots. In some plots, no purple loosestrife shoots were found at the end of the growing season, while in others, shoots that were harvested appeared spindly and lacked vigor. Japanese millet is a successful replacement species because it is a rapid grower and can tolerate periodic flooding. Rawinski expects that this species will be heavily used by wildlife, in comparison with purple loosestrife. Note, however, that Japanese millet is also an exotic species.

Several authors (Smith, 1962; Holweg, 1973) have described competitive interactions between purple loosestrife and cattails (*Typha*), in which the purple loosestrife was able to displace cattails in certain situations. Rawinski (1982) performed the first detailed study of the competitive interaction between these two species by looking at changes in stem density in mixed and adjacent stands of *Lythrum* and *Typha* at varying water depths. The results were inconclusive, as *Lythrum* decreased when there was standing water present but increased in the drawdown plots (Rawinski and Malecki, 1984). Since Rawinski's results were inconclusive and no attempt was made to selectively aid *Typha*'s competitive ability, a study of the potential for inducing cattail displacement of purple loosestrife was initiated at the Indiana Dunes National Lakeshore. This paper describes the study, the first-year results, and what is expected in future years.

Methods

The purple loosestrife-cattail study was conducted in mixed stands of *L. salicaria* and *Typha angustifolia* within the Long Lake wetlands of Lake County, Indiana. The study area is an interdunal wetland located within the boundaries of Indiana Dunes National Lakeshore.

Initially, it was intended that competitive interactions between purple loosestrife and cattails would be assessed under two water level regimes (Rawinski and Malecki, 1984). However, the water levels in the summer of 1985 were lower than normal, thus all study plots had to be located in areas of moist soil without standing water. Forty-two 3x3m plots were randomly established for the various treatments. The perimeter half meter of each plot served as a buffer zone; it received the appropriate treatment but was not sampled. The central 2x2m portion of each plot was halved diagonally to facilitate sampling and to provide a greater number (84) of sampling units. Pre-treatment measurements (July 1985) included water depth and sediment depth determinations, stem counts and plant height measurements of *L. salicaria* and *T. angustifolia*, and stem counts of all other species encountered. Each stem of *L. salicaria* that emerged separately from the soil was counted as a distinct entity, since it was difficult to determine which stems originated from a common rootstock without digging. Plants of both species arose from tufts of soil and roots, common throughout the area. Thus, for consistency, plant heights were measured from the point of soil emergence.

The 84 plots were divided into two groups, based on the stem count ratio of *Lythrum/Typha*, so that responses of populations with differential initial densities could be compared. The 42 low proportion plots had L/T ratios of 0.265 or less, and the 42 high proportion plots had ratios of 0.306 or greater. The plots were numbered for identification and treatments were randomly assigned. The six treatments applied to low proportion plots and also to high proportion plots were:

A) Cutting all *Lythrum* in the plot, leaving *Typha* intact (late July). All of the cuttings were removed and destroyed.
B) Cutting all *Lythrum* in the plot and increasing the competitive ability of *Typha* by selectively fertilizing with fertilizer spikes placed among the cattail rhizomes (late July).
C) Control, no cutting or fertilizing.
D) Cutting all *Lythrum* in the plot, leaving *Typha* intact (late July), followed by a second cutting of resprouting *Lythrum* (early September).
E) Cutting all *Lythrum* and *Typha* (late July).
F) Cutting all *Typha* in the plot, leaving *Lythrum* intact (late July).

Treatments A, B, and C were the primary treatments and were applied to ten sampling plots each for both low proportion and high proportion L/T plots. Treatments D, E, and F were secondary treatments for non- statistical comparisons and were applied to four sampling plots each for both L/T proportions.

The fertilizer used was Ross Gro-Stakes for trees and shrubs (16-10- 9), as suggested by J. Grace (pers. comm.). Each stake was broken into thirds, and two of the pieces were pressed approximately 2 cm into the soil around the rhizomes of each *Typha* plant.

To provide post-treatment data, the sampling procedure for stem counts and plant height measurements used in July 1985 was repeated in September 1985 in all plots except treatment D. The treatments will be repeated in 1986 and resampling will occur in 1986 and 1987.

Regression analysis was used to estimate above-ground biomass by using *Lythrum* and *Typha* plant heights. Forty plants of each species were collected for the analysis, with a range of heights at least as great as observed in the plots. Dry weights were obtained by placing the samples in a drying chamber for a week and then in a drying oven for 24 hours at 105°C (Grace and Wetzel, 1982). An exponential model most closely followed the growth curves. The model for *Lythrum salicaria* was:

$$y = (0.1923)(11.5059)^x \quad r^2=0.943$$

while that for Typha angustifolia was:

$$y = (0.5838)(5.2552)^x \quad r^2=0.888$$

The first-year data for treatments A-C were analyzed by the use of one-way ANOVAs for both high and low proportion plots. The parameters analyzed were mean stem count, mean biomass, mean stem count ratio (L/T), mean biomass ratio (L/T), and the change in each mean from July to September.

Results and Discussion

The results described below are for first year data only. Further control success or change in vegetation might be expected to occur during the second year.

No significant initial differences (P=0.05) in mean stem count and mean biomass ratios were shown between the plots randomly selected for the primary treatments (A, B, and C). It was determined, therefore, that initial differences of stem count and biomass ratios in the plots would not affect the experimental results.

There were no significant differences (P=0.05) in the mean stem count ratios (L/T) between July and September in treatment A and B plots (Figures 1 and 2). Therefore, cutting *Lythrum* did not appear to prevent it from resprouting to its previous numbers. Although not significant, the ratio increased in treatment A plots, and it decreased in treatment B plots. It is uncertain whether or not this decrease resulted from selective fertilization of *Typha*, since the number of *Typha* stems decreased in all plots. If any difference does occur, we hope to observe it in the second year.

The mean biomass ratios were significantly different (P=0.05) (July vs. September) in the primary treatment plots (Figures 3 and 4). Treatment C (control) biomass ratios were significantly greater than for treatments A and B in September, since *Lythrum* biomass increased in treatment C plots while it decreased in A and B plots. This difference would be expected since *Lythrum* biomass in A and B plots

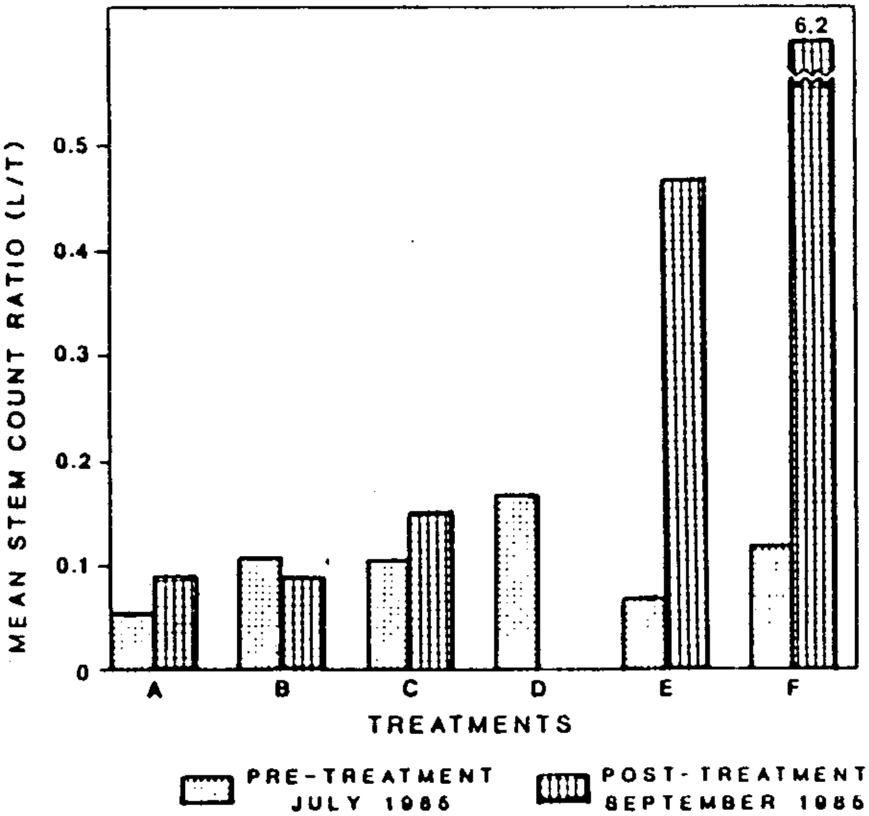

Figure 1. Mean stem count ratios (*Lythrum/Typha*) for low *Lythrum* proportion plots, July and September, 1985.

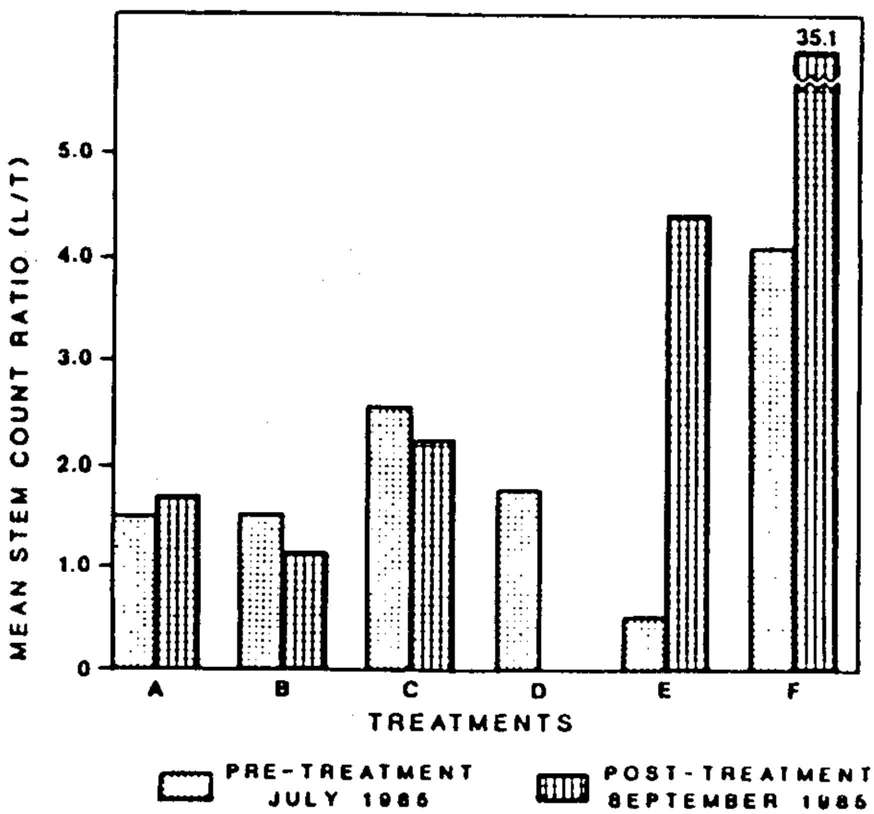

Figure 2. Mean stem count ratios (*Lythrum/Typha*) for high *Lythrum* proportion plots, July and September, 1985.

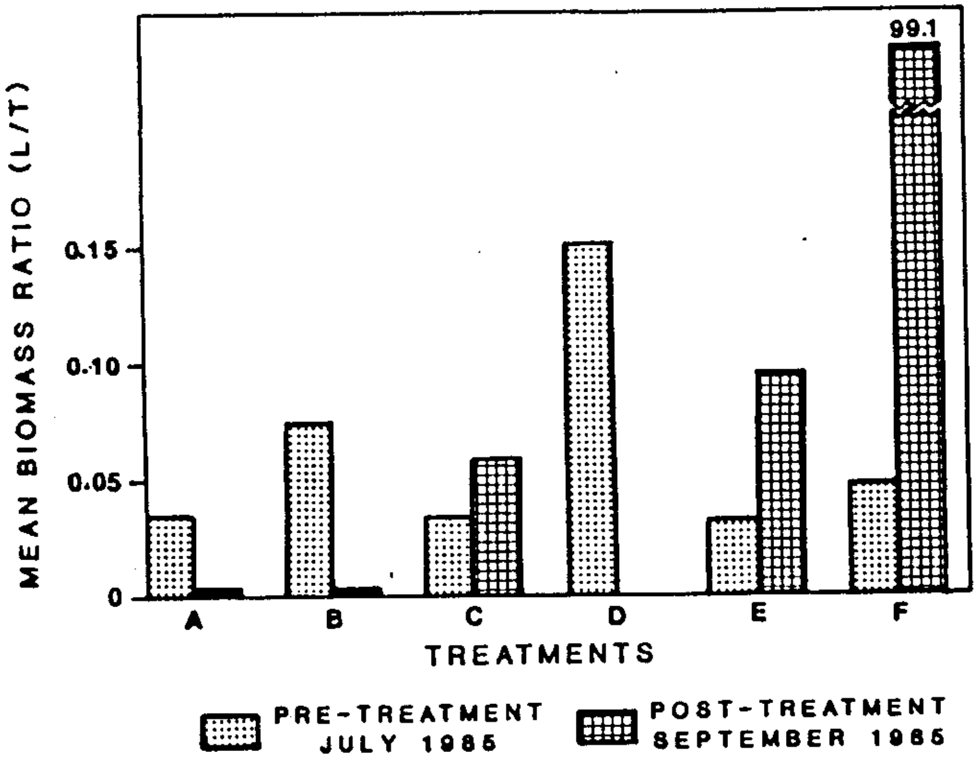

Figure 3. Mean biomass ratios (*Lythrum/Typha*) for low *Lythrum* proportion plots, July and September, 1985.

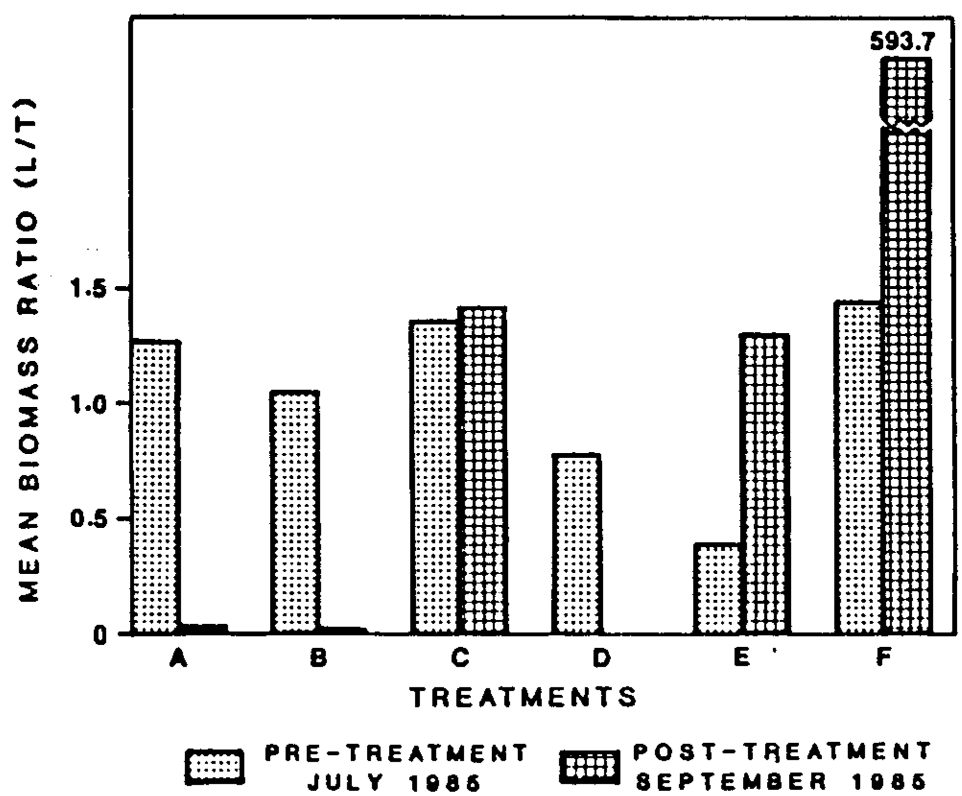

Figure 4. Mean biomass ratios (*Lythrum/Typha*) for high *Lythrum* proportion plots, July and September, 1985.

could not regenerate fully one month after cutting. However, when A and B plots were compared, significant differences were also shown. These differences could not be attributed to selective fertilization of *Typha*, as the *Lythrum* biomass in high proportion plots decreased more in A plots than in B plots, while in low proportion plots the opposite was true. No significant differences were shown for *Typha* biomass between the treatment plots. Therefore, any change in the biomass ratios appeared to be due to the cutting of *Lythrum*.

Cutting *Typha* (treatment F) caused a greater change in the stem count ratio than cutting of *Lythrum* (treatments A and B), since *Lythrum* resprouted in greater numbers than *Typha*. This also occurred in the clear- cut plots (treatment E) (Figures 1 and 2). However, after the initial resprouting, *Typha* stems grew faster and increased in biomass more quickly than *Lythrum* stems. Any effect of treatment D will not be seen until the second year.

An analysis of the high and low *Lythrum* proportion plots, using two-way ANOVA, was performed to determine whether the proportion ranks had any effect on the results obtained. No significant differences (P=0.05) were shown between the two proportion ranks for the *Typha* data (P = 0.066 for stem count; P = 0.055 for biomass). However, *Lythrum* stem count (P = 0.002), total biomass (P = 0.0001) and biomass ratios (P = 0.0001) significantly decreased more in high proportion plots than in low proportion plots. This agrees with other studies (Shamsi, 1976) in that the average plant weight increased with decreasing plant density per unit area. If long-term differences between the high and low proportion plots do occur, the changes should appear in the biomass ratios.

Conclusions

The first-year, short-term results of the purple loosestrife-cattail competition study showed that cutting *Lythrum* did not significantly reduce the numbers of resprouting stems but did significantly reduce total biomass. After cutting, *Lythrum* resprouted in greater numbers than *Typha*, but *Typha* sprouts grew faster and increased in biomass more quickly than *Lythrum* sprouts. *Lythrum* cutting, by reducing the amount of carbohydrates that can be returned to the *Lythrum* roots, is expected to progressively reduce *Lythrum* biomass year by year. The stress caused by cutting, in addition to shading by the *Typha* canopy, may prove to be an effective deterrent to the spread of purple loosestrife. Any effect that selective fertilization of *Typha* may have upon its competitive ability should become apparent in the second and later years.

In the long run, biological control may be a more selective and less labor-intensive method for widespread control of purple loosestrife. However, little work has been completed thus far. In northern and central Europe, purple loosestrife occurs as scattered individuals (Shamsi and Whitehead, 1974a). Research is being initiated by the U.S. Fish and Wildlife Service to identify the biological agents which control the European population of *Lythrum salicaria* and to determine the effects of introducing these agents into North America.

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