

Biological Control of Purple Loosestrife Hog Island and Allouez Bay, Superior, WI

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Abstract

*As human transportation occurs at an ever increasing rate, the possibility of introducing invasive species into an area increases. Hog Island and Allouez Bay are two areas in Superior, WI that are inundated with invasive species brought from many parts of the world. **Lythrum salicaria**, or purple loosestrife, is one of the more aggressive invasive plants. Having no natural predators and the ability to produce millions of seeds per season, purple loosestrife is becoming a dominant species on Hog Island and in Allouez Bay. In an effort to slow the spread and give native species an opportunity to repopulate, two species of beetle of the genus **Galerucella** were introduced into the region where purple loosestrife is spreading. These beetles originate in Europe and naturally prey upon purple loosestrife. High host specificity prevents **Galerucella** from becoming an invasive itself. In the study, successive plant surveys were performed to measure the frequency and ground cover of purple loosestrife. Initial data will provide background for further study but alone only gives an idea of what is happening to the purple loosestrife population. As the new beetle population increase to a density capable of controlling the invasive plant population, more data will be gathered.*

Introduction:

Purple loosestrife (*Lythrum salicaria*) is a non-native, perennial, aquatic/semi-aquatic,



purple loosestrife

purple plant originating in Europe. It was likely introduced to the East coast of the United States during the 1800's in ballast from European ships and has spread west since that time (Carroll, 2000). In the 1800's ballast was often earth, not water ("Purple peril," 2000). Since the most convenient earthen material available to a

ship would be that which is near the water, purple loosestrife could have easily been brought with the ballast material from Europe and deposited. Purple loosestrife can spread by dispersing seeds into the air and water, or by human activity. Improperly cleaned boats or hip waders can spread seeds from one area to the next. Also, companies that sell seeds have sometimes included purple loosestrife seeds. This activity continues to this day but is less common due to education and legislation. Disturbed wetlands are the most common place to find purple loosestrife although it can be found in seasonally flooded and dryer areas (Stamm-Katovich, Ragsdale, Skinner, Becker, 2001). Thus anytime a wetland area is disturbed, by human activity or otherwise, the potential for successful purple loosestrife establishment increases.

The problem with purple loosestrife is its ability to displace native flora and fauna due to its prolific seed producing ability, up to 2.7 million seeds per plant per season (Stamm-Katovich et al, 2001), and absence of natural predators in North America. Purple loosestrife is spreading roughly westward at a rate of 645 km² per year (Schooler, Coombs, McEvoy, 2003). The main impact of purple loosestrife dominance is the eradication of native plant species (Thompson, Stuckey, Thompson, 1987). This causes not only a decrease in plant biodiversity but also diminishes or eliminates water fowl food sources such as sedges and wild rice. Also, nesting sites for Canada geese, great blue herons, wood ducks, canvas backs, black terns and other water fowl are diminished by purple loosestrife. On the other hand, the red winged black bird actually prefers purple loosestrife for nesting (Thompson et al, 1987). Non-bird species are affected by purple loosestrife as well. Mink, muskrat, and turtles are displaced and/or suffer declines as the carrying capacity of wetlands decreases due to purple loosestrife infestation (Thompson et al, 1987).

To prevent the spread and further domination of purple loosestrife there are three general methods one can use. The first is physical removal. Physical removal can be done in two ways. One method involves digging up the purple loosestrife plants in an effort to eradicate them. The problem with this approach is the aggressive manner in which purple loosestrife is able to grow vegetatively from root fragments left in the soil. If digging isn't done very thoroughly, one can cause many purple loosestrife flowers to grow where only one plant used to be. Combined with the ability to produce vast quantities of seeds, purple loosestrife that has been excavated can end up producing many times more seeds in a season and increase the rate of dispersal.

A second method of physical removal is continually cutting the purple loosestrife plants in order to deplete the stores of starch found in the roots. If cutting is done frequently enough the entire purple loosestrife plant dies leaving no roots from which to regrow. While this method avoids the problems of digging, it is the most time consuming and labor intensive making it impractical for large stands of purple loosestrife.

Treatment with an herbicide is another option to control purple loosestrife. The problem with herbicide application is that it introduces poison into the environment. It also has the ability to remove native flora. This is counterproductive because the goal is to allow native species to thrive and because disturbed areas are more susceptible to purple loosestrife invasion. Herbicides can be applied to individual plants/plant stocks by removing the top of stems and dabbing the chemical onto the stock. This method avoids killing native species but still introduces poisons into the soil. As can be imagined, the application of herbicide to individual purple loosestrife plants can be very labor intensive as it involves physically locating all stands of purple loosestrife, removing the tops of every individual stock found, and applying herbicide to the stock. This method is not efficient with large stands or areas that have widely distributed stands.

With chemical treatments inefficient or disallowed by local government agencies and physical removal too labor intensive, biological control is the best remaining option to control large



Galerucella spp.

infestations.

The bio-control agents most commonly used for purple loosestrife are four species of beetle, two in the family Chrysomelidae and two in the family Curculionidae (the weevil family). The

Chrysomelids are *Galerucella pusilla* species look so much alike as adults that

The weevils are *Nanophyes marmoratus* and *Hylobius transversovittatus* (Wilson,

Schwarzlaender, Blossy, Randall, 2004 tissue. The *Hylobius* beetle feeds on root tissues and the *Nanophyes*

beetle feeds on). The *Galerucella* flower tissue (Wilson et al 2004). These Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS), as a bio-control agent for purple

and *G. californiensis*. In general, these two they require a microscope to tell them apart.



Nanophyes marmoratus

beetles feed on leaf

beetles were approved by the U.S.



Hylobius transversovittatus

loosestrife (Blossey, Schroeder, Hight, Malecki, 1994). This agency tests for host specificity and effects on native communities, efficacy as a biological control agent, and danger of a potential bio-control agent becoming invasive (United States Department of Agriculture, 2000). *Galerucella spp.*, approved for release in 1992, were determined to be an appropriate control agent for purple loosestrife due to host specificity, an inability to complete their life cycle in the absence of purple loosestrife, the ability to significantly impact purple loosestrife densities (Blossey, et al , 1994), (Schooler, Coombs, & McEvoy, 2003) , (Wilson et al, 2004) and the compounding damage done when both species are used concurrently(Hamback, 2010). Adult *Galerucella spp.* that overwinter generally emerge in mid to late May. After emerging, adults eat and then mate. Ovaposition in the area takes place in mid-June. Eggs hatch after about a week and larvae take about 5 weeks to fully mature. The rest of the summer is spent accumulating body mass so that overwintering is possible.

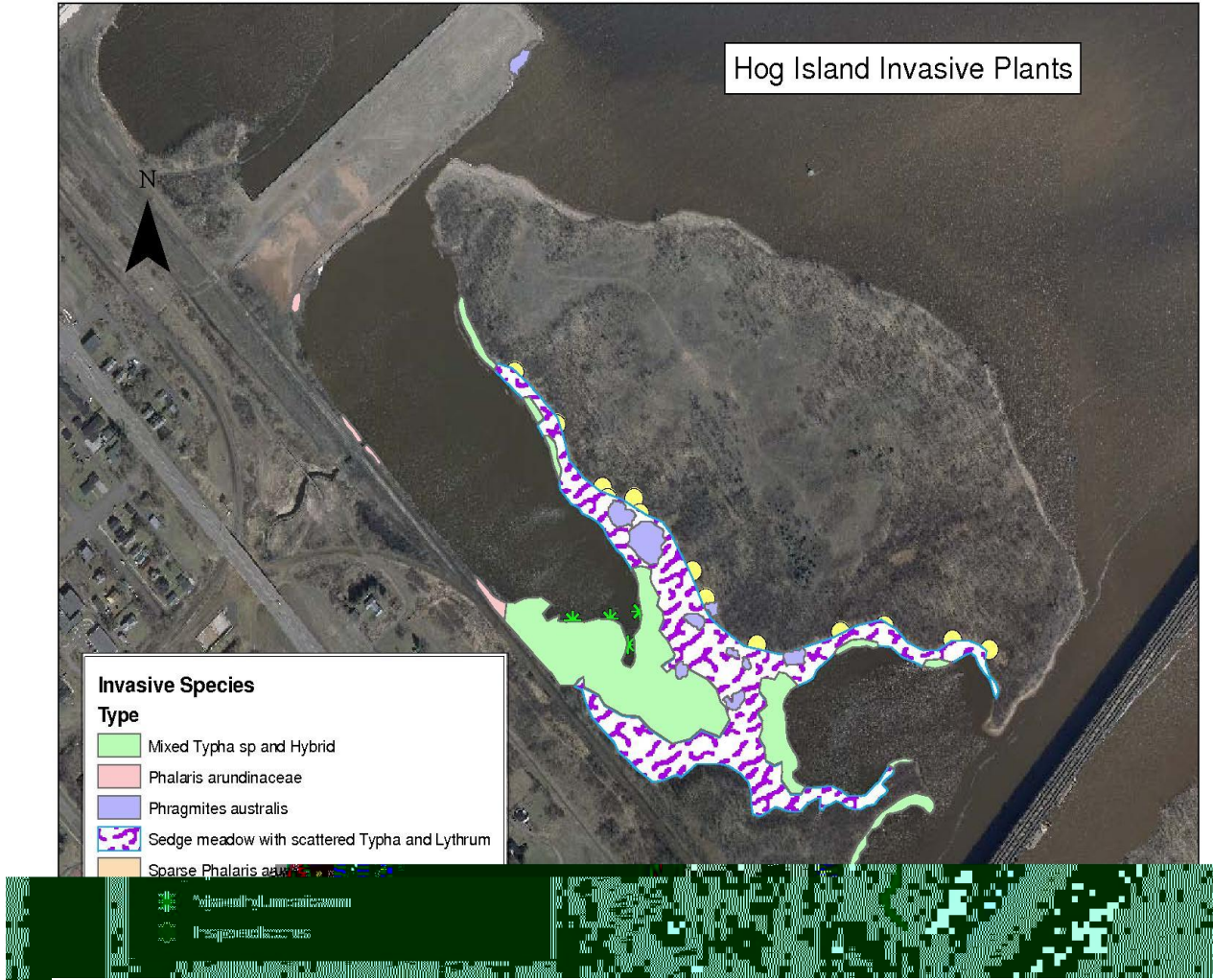




Figure 2

Previous bio-control efforts using *Galerucella spp.* have resulted in purple loosestrife reduction to five percent of uncontrolled densities. That means a purple loosestrife ground cover of just over one percent cover should be possible (Purple loosestrife monitoring, 2008). More important than a specific percent decrease in purple loosestrife density is an increase in biodiversity and native species in the treatment areas Hog Island and Allouez Bay are areas that the WI Department of Natural Resources (WI DNR) and the Lake Superior research Institute at the University of Wisconsin, Superior (UWS) are interested in restoring. Ecological studies of the area have found an increasing abundance of purple loosestrife (Figures 1 and 2 above).

The purpose of this experiment was to reduce the amount of purple loosestrife on/in Hog Island and Allouez Bay to a level that allows native species to thrive and to prevent the further spread of purple loosestrife into neighboring areas. Hog Island is man-made and was created by the deposition of dredge material. It is located just beyond the St. Louis River estuary on the Wisconsin side of Lake Superior. Allouez Bay is immediately adjacent to and surrounding Hog Island. As a man-made area near a population center and international port, Hog Island is a prime site for invasive species to thrive. Prior to treatment Hog Island had approximately 23% ground cover of purple loosestrife with the potential to triple that amount and spread to neighboring areas.

Methods:

Before beetles could be released both release sites and a method of measuring the effect of the beetles needed to be established. A baseline measurement of purple loosestrife density was obtained from a plant species survey conducted during the summer of 2009 by Josh Horkey. The method used involved randomly placing a one meter by one meter grid on a transect line. Ten measurements were taken for each transect with a total of three transects. After the meter squared grid was randomly placed, the number of each species present was recorded. By summing the number of individual plants and dividing by the total area sampled, 10m^2 , a percent coverage was estimated for each transect. Appropriate release sites, those with thick enough stands to support an entire beetle life cycle, were also found during this survey selected for biological treatment (Figures 3 and 4).

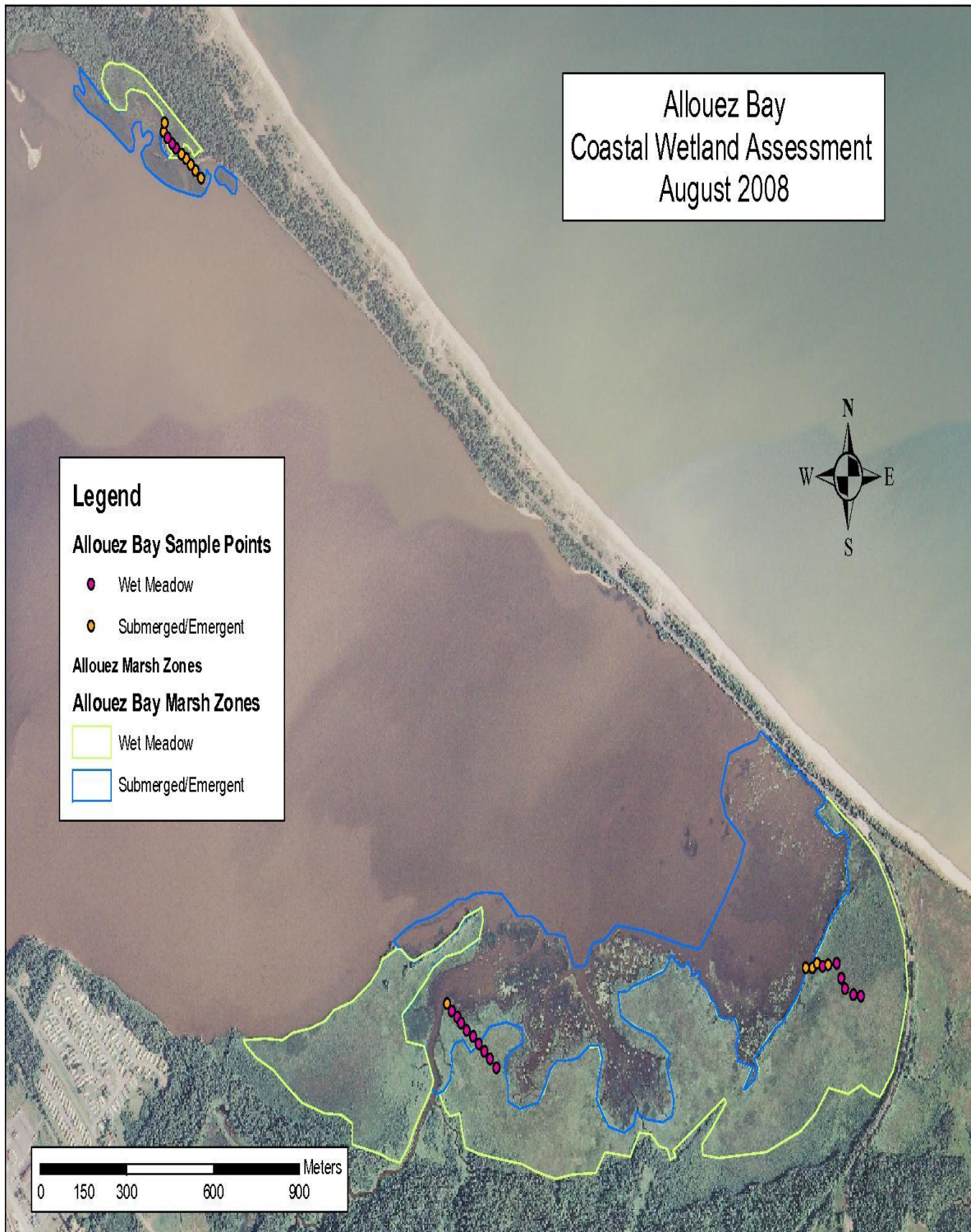


Figure 3

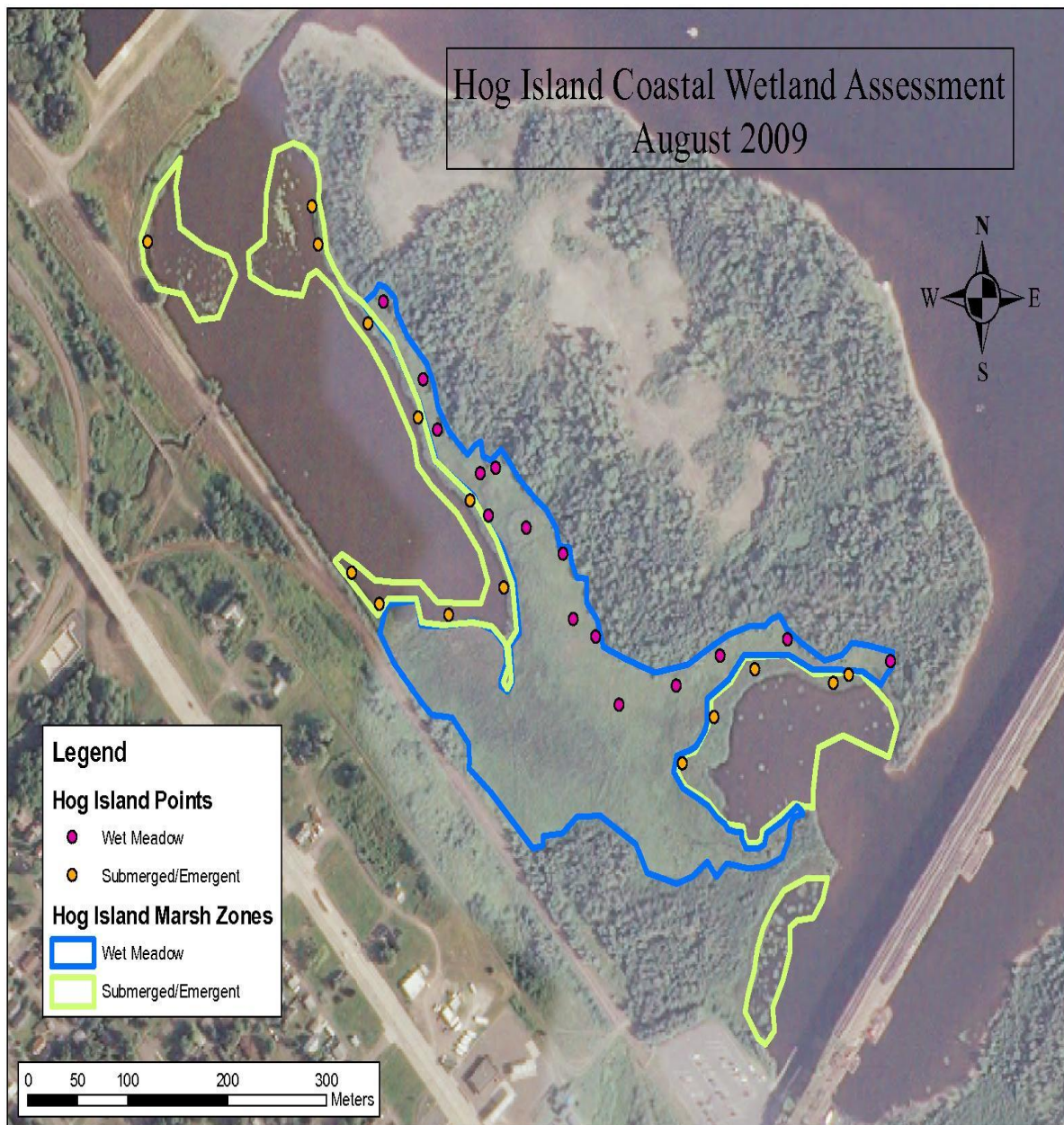


Figure 4

The next step was collecting and rearing the beetles. This was accomplished very similarly to the methods described in the Biology and Biological Control of Purple loosestrife manual by Wilson et al. In early May 2010, approximately fifty purple loosestrife root crowns were harvested from the Wisconsin Point area. Large crowns were potted individually and small

crowns were potted together (the goal being about a softball sized crown) in an inorganic potting mix. The potted crowns were then placed in wading pools. The wading pools were filled with water to a depth of five inches. The water level was maintained at this depth for the duration of the growing period. A 4 foot tomato cage was then placed in each pot and a sleeve made of no-see-um proof mesh was slipped over the cages and attached to the top of the pots using duct tape. The plants were allowed to grow until approximately 12-15 inches tall. At this point the apical buds were pinched to inhibit vertical growth and promote lateral growth. Approximately one month later adult beetles were captured near Ashland WI. The beetles were captured in collection jars made from soda bottles. To make the jars the top of a one liter soda bottle was cut off two inches from the top. The top was then inverted, placed inside the bottom part of the bottle, and secured with duct tape. Once at the collection site fresh plant matter was placed in the collection jars to give the beetles shade, moisture and anchor points. Next, the tops of purple loosestrife plants were bent over the lid of the collection jar and lightly tapped to knock the beetles into the jar. It was assumed that only *Galerucella spp.* would be captured with this method as they are the only insect feeding on purple loosestrife and they tend to accumulate in the buds. This turned out to be an accurate assumption as only *Galerucella* beetles, a spider, and several ants were found in the collection jar. Identification was done by site as these beetles are visibly distinct being gold or brown with dark markings on the elytra. When a sufficient number of beetles were collected the jars were stored in a cooler with ice and transported back to Superior WI to be placed on the purple loosestrife plants. Ten to twelve beetles were placed on each plant and then the tops of the mesh sleeves were zip-tied shut to prevent escape. Approximately five weeks later the pots were brought to approximately 40 sites in the treatment

area. The coordinates of purple loosestrife stands on Hog Island were recorded with a GPS when the initial purple loosestrife density was first estimated (Figure 5) (Table1).

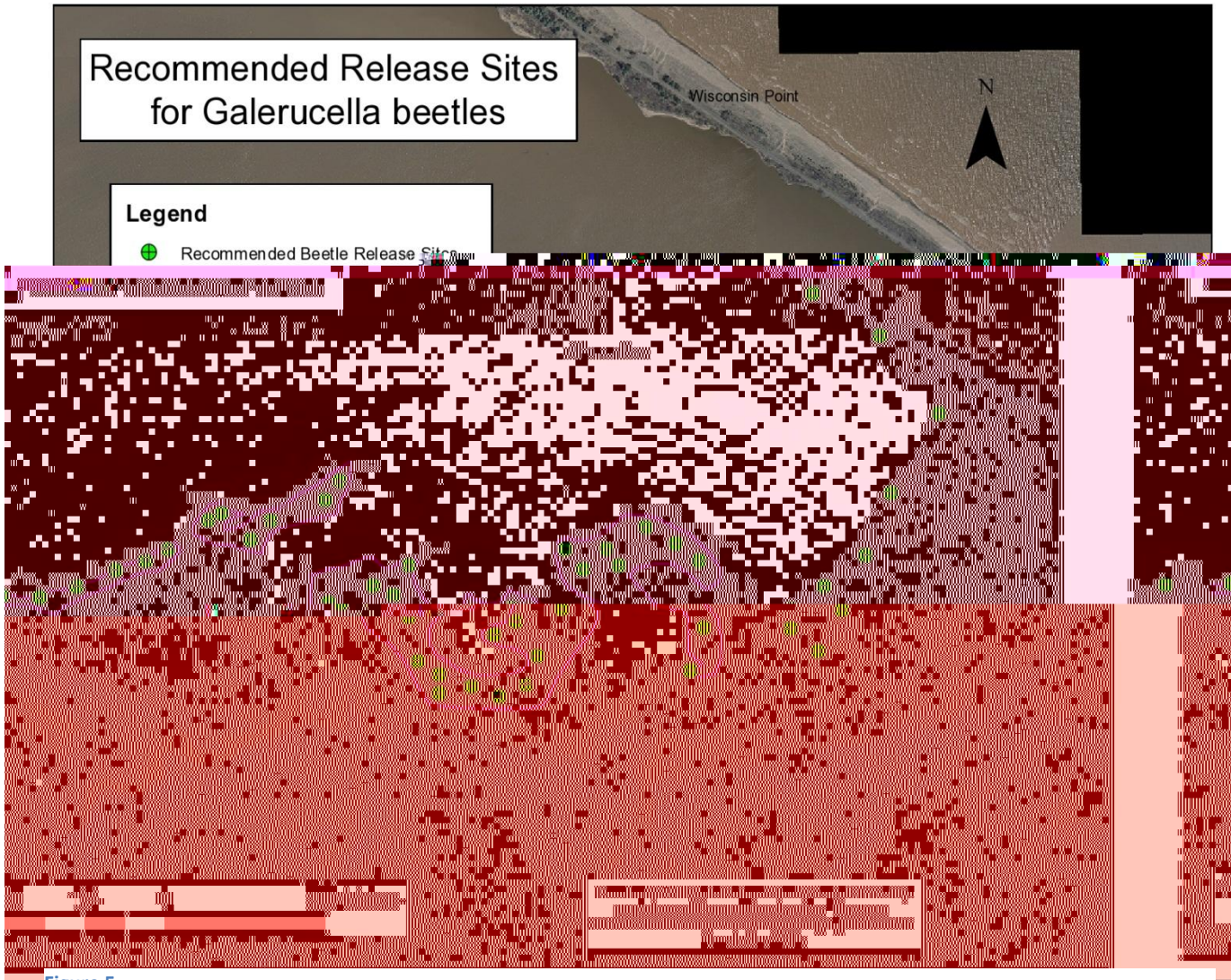


Figure 5

Plot #	COMMENT	POINT_X	POINT_Y
PL3	Wet Meadow	578229.4	5170148
PL4	Wet Meadow	578227.4	5170184
PL6	Submerged/Emergent	578219.8	5170301
PL7	Submerged/Emergent	578213.4	5170261
PL8	Submerged/Emergent	578182.5	5170228
PL9	Submerged/Emergent	578183.1	5170182
PL10	Submerged/Emergent	578152.8	5170160
PL20	Wet Meadow	576146.7	5172240
PL25	Submerged/Emergent	577082.5	5170159

Table 1

These sites were located on the release day. Once at a site one or more pots were placed adjacent to the stand, the cages and sleeves were removed, and the stems of the potted purple loosestrife plants were bent and secured to an existing purple loosestrife plant to ensure larval instars would be able to migrate to fresh food and complete their life cycle. After several weeks the pots were emptied and collected. The soil and plant remnants from the pots were left at the release sites to allow developing beetles time to pupate (B. Woods, email April 24, 2010).

In the summer of 2011, another survey was done to determine the change, if any, in the density of purple loosestrife in the areas where beetles were released. The 2011 survey differed from the 2009 survey in several ways. First, only purple loosestrife was measured. Second, instead of a transect, a 2010 beetle release site was located using a GPS unit. Then a one meter by one meter grid was placed randomly within an eleven foot radius of the release site. Eleven feet was chosen as an appropriate radius for sampling because the GPS unit used was accurate to within eleven feet on the first day used. The process was repeated three times at each site with a total of 10 sites sampled. Cover was estimated by measuring the leaf area of each plant/stem, averaging the sum of the leaf area for each site, and dividing by the total area surveyed.. Frequency was calculated by counting the number of plots purple loosestrife was found in and dividing by three (the number of replicates for each site). Observations on leaf damage, insect presence and life stage, and surrounding purple loosestrife plants were also recorded. Leaf damage was assessed using a scale and observations of plant damage type. The damage scale ranged from zero, being no damage, to three, being nearly defoliated, in intervals of one half. Thus each replicate would be placed in one of seven categories, 0.0 to 3.0 The final damage code was the average of the replicates rounded to the nearest multiple of one half. Leaf damage type

was categorized as shotgun pattern (adult beetle damage), window pane pattern (larval beetle damage) or both.



Example of level 1 damage



Example of level 3 damage

Shotgun feeding pattern



Window pane feeding pattern

Results:

Historically, *Galerucella* bio-control efforts have been successful. In a study done by the University of Minnesota and the Minnesota Department of Natural Resources (MN DNR), two sites in Mendota Heights, MN were inoculated with approximately 7,000 *Galerucella spp.* individuals (Table 2) (Stamm-Katovich et al, 2001). The first year after release showed only

isolated feeding near the release site for the sedge meadow site and no visible indication of feeding at the wet meadow site. After two years both sites saw feeding near the release sites. Purple loosestrife plants fed on by the beetles had dramatic decreases in the number of seed pods produced. By the third year the sedge meadow site reportedly saw only scattered flowers in a 40m area around the release site. The wet meadow area was inexplicably less successful after three years. A decrease in overall purple loosestrife height was also documented (Stamm-Katovich et al, 2001).

Table 2 Effect of *Galerucella* on Purple Loosestrife Growth

Treatment	Inflorescence length				Axillary inflorescences		Seed capsules				Plant height	
	Main		Axillary		1996	1997	Main		Axillary		1996	1997
	1996	1997	1996	1997			1996	1997	1996	1997		
	cm		cm		No. branch ⁻¹				cm			
Wet meadow site												
Control	19	30	10	6	6	2	110	166	49	18	174	153
With <i>Galerucella</i> spp.	3	7	3	4	2	2	6	35	5	12	108	135
LSD (0.05)	7	11	5	NS	3	NS	61	62	30	NS	18	14
Sedge meadow site												
Control	19	13	12	11	27	15	146	47	60	33	185	167
With <i>Galerucella</i> spp.	17	0.2	12	4	19	0.4	84	0	56	6	180	131
LSD (0.05)	NS	2	NS	5	NS	4	61*	14	NS	13	NS	10

* Significant at the 0.10 level.

In New York, more than 7,000 *Galerucella* beetles were introduced to a 50 acre area that had been infested with purple loosestrife (Carroll, 2000). Within six years, 50% of the treatment area had come under control. In another year, the remaining 50% had come under control. For the purposes of this study, under control meant a 75-80% reduction in purple loosestrife density with remaining individuals stunted and allowing for the growth of native species (Carroll, 2000). In Goodyear Swamp Sanctuary, Ostego County, NY, only 100 beetles were released into the purple loosestrife dominated area. Within five years, beetle density increased significantly (Figure 2).

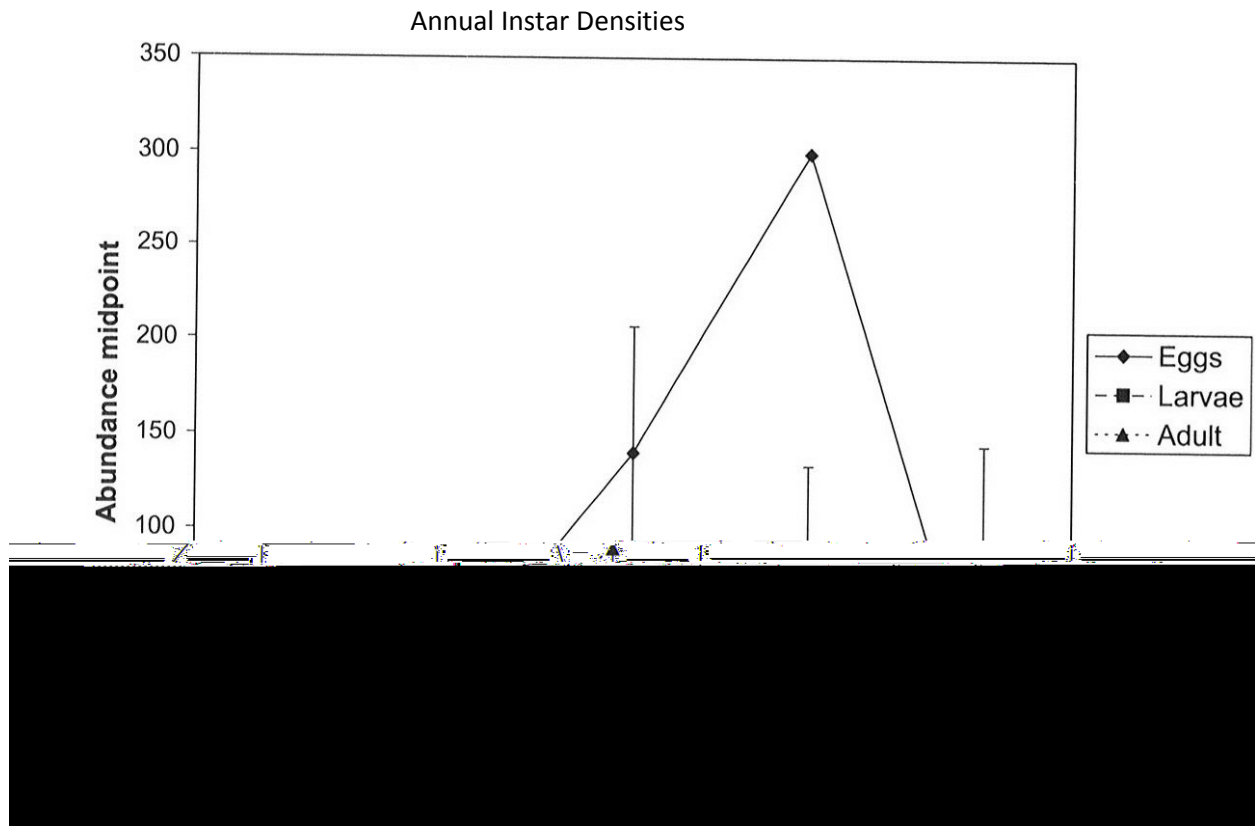


Figure 2

The increase in beetle density led to increased predation of purple loosestrife. The damage to the plants had a significant impact on purple loosestrife population (Figure 3).

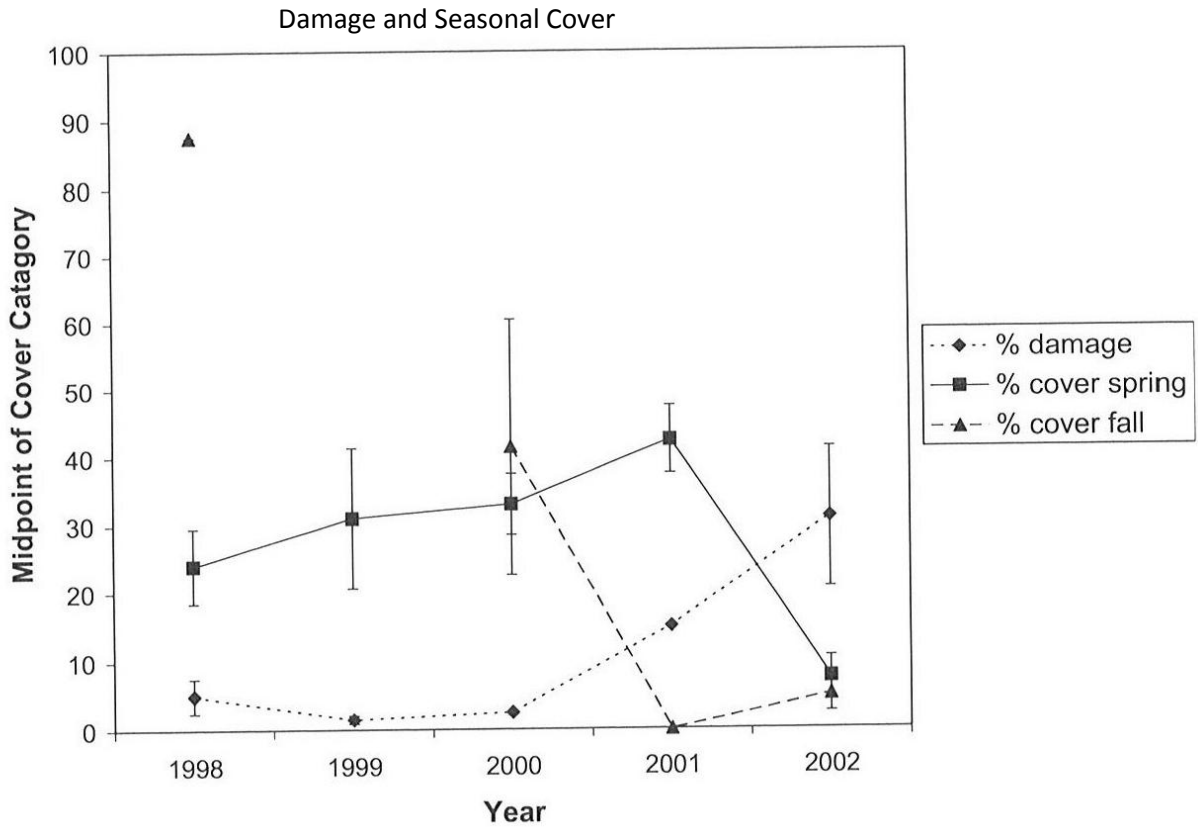


Figure 3

Also, *Galerucella* beetles were observed to have left the initial site to find neighboring purple loosestrife stands (Albright, Harman, Fickbom, 2004).

The initial survey of Hog Island showed purple loosestrife had an average relative cover of almost five percent with a range between zero and over eight percent (Table 1). Allouez Bay had an average relative cover of almost two percent with ranges from nearly zero to over four percent. The average frequency of purple loosestrife at both sites was about 23%.

Discussion

1992 was the first year that *Galerucella* beetles were released in the U.S. (Schooler, Coombs, & McEvoy, 2003). The success of bio-control efforts can be measured two main ways including long and short term efficacy and the impact a bio-control agent has on non-target elements of an ecosystem. In the first 1-3 years, *Galerucella spp.* tend to have little impact on purple loosestrife densities as the beetles must reach a critical density. When this critical density is reached, the plants will be defoliated or they will lose so much tissue that they will use starch stores to grow new tissue. This reduction in stored calories will eventually lead to plant death. The cool climate in the treatment areas will also slow the population growth of the beetles. This slow start is demonstrated by the study done by Stamm-Katovich et al in Mendota Height, MN. In this study, *Galerucella* beetles were released at two sites. Within two years the beetles significantly decreased the seed producing abilities and overall size of the purple loosestrife. The results of the studies performed directly apply to the Hog Island/Allouez Bay restoration project because of the similar methodologies used as well as the similarities in the climate of the sites in Mendota Heights and Superior. Figures two and three from the Carroll study in New York also show a slow start to beetle population growth. In fact, in Figure 2 there is almost no increase in the adult population until the third year. The larval population, paradoxically, did not appear to exceed the adult population for more than a year. The number of eggs, however, increased dramatically almost immediately. This might be explained by predators that feed on non-specific prey. Also, a weather event could have killed eggs early in the season. From the literature it is clear that the larvae are very difficult to see until their third and final instar. Individuals not used to these insects may have had a difficult time locating larvae.

The data collected on Hog Island and Allouez Bay seem to follow the same pattern as the data from the New York study published by Carroll in 2000. In Carroll's study, the fall ground cover of purple loosestrife is non-decreasing for the first three years as seen in Figure 3. This correlates with the Allouez Bay data collected in 2009 and 2011. The relative cover seems to have increased from two percent to ten percent and the frequency seems to have increased from 23% to 60%. This is explained by the near absence of *Galerucella* beetles prior to summer 2010. Even after the initial release, seed production would not have been impaired because the plants would have had an entire season to store starch before the beetles were introduced. The apparent increase could also be caused by having different surveyors and different survey methods.

There are signs that the beetle population is growing. Observations of the sample plots and surrounding area showed eggs in more than half of the plots sampled. Also, many more adults were present in 2011 compared to 2010 when beetle collection was attempted in and near the treatment areas. Damage was also present in the vicinity of all plots sampled. This was not true when root crowns were harvested or, again, when beetle collection was attempted in the treatment area in spring 2010.

Further surveys will be conducted in the late summer 2011 using the same methods as in early summer 2011. This should help to see if an increase really did occur between 2009 and 2011. Further surveys will also indicate if plant damage is increasing over time.

If the introduction of *Galerucella* beetles into Hog Island and Allouez Bay follows the trends of similar releases, in the next two years it is expected that purple loosestrife densities will start to decline. Within the next 5 to 7 years, purple loosestrife densities should either be eradicated or be present at densities that allow native communities to thrive.

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