Monitoring the effectiveness of the *Galerucella* spp. (Coleoptera: Chrysomelidae) as a biological control agent of purple loosestrife (*Lythrum salicaria*) in Goodyear Swamp Sanctuary, summer 2003

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INTRODUCTION

Purple loosestrife (*Lythrum salicaria*) is a perennial plant, native to Europe, which aggressively invades and dominates wetlands and roadside habitats across North America (Stuckey 1980). Since the introduction of *L. salicaria* to North America in the early 19th century, mainly for ornamental reasons, it has spread rapidly, infesting many wetlands across the continent (Stuckey 1980). It forms dense, monotypic stands, choking out native endemic species in wetland and lakeshore habitats, which in turn degrades food, shelter and nesting sites for native wildlife (Skinner 1996). In its native habitat a diverse arthropod community controls *L. salicaria* (Blossey 1995). These arthropods did not accompany the *L. salicaria* when it was first introduced in North America. The absence of these natural predators has allowed *L. salicaria* to outcompete native species, in part due to the ability of a single adult plant to produce in excess of 2 million seeds per year (Welling and Becker 1990).

Conventional methods of control such as cutting, herbicide treatments, water level manipulation, and burning have generally been unsuccessful (Malecki et al. 1993). As there are no native insects capable of controlling purple loosestrife, extensive research was conducted in Europe in the 1980s to find host-specific, significantly damaging insects (Skinner 1996). The agent had to be an isolated species meeting host-specificity requirements in addition to causing significant damage to *L. salicaria* (Skinner 1996). According to this research four suitable species of insects were identified to combat *L. salicaria* in the United States (Blossey and Hunt 1999).

In June 1997 two of these species, *Galerucella calmariensis* and *G. pusilla*, leaf-eating beetles, were introduced in to the Goodyear Swamp Sanctuary (N42°48.6'W74°53.9'). Beetles were released into cages at sites 1 and 2 (Figure 1), with the intent to monitor the qualitative and quantitative effects of the beetles on purple loosestrife and to examine the extent of recovery, if any, of the native flora (Austin 1997). Sites 3-5 were introduced into the study in 1998 to monitor the spread of *Galerucella* spp. over time (Austin 1998). It was expected that these beetles would lessen the competitive ability of purple loosestrife by feeding upon their meristematic regions, resulting in defoliation, impaired growth, decreased seed production, and increased mortality (Blossey et al. 1994).

Since the introduction of *Galerucella* spp. to Goodyear Swamp Sanctuary monitoring of the beetle herbivory and the recovery of the native flora has been conducted biannually. *Galerucella* spp. have caused severe damage to and repressed the flowering of *L. salicaria* throughout the 2001 and 2002 monitoring season (Meehan and Albright 2003).

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Recent research conducted at Goodyear Swamp has indicated "spillover" of *Galerucella* spp., or the movement to and slight consumption of, adjacent, non-target plants. This occurred after the virtual removal of all above-ground biomass of *L. salicaria* (Meehan and Albright 2003; Albright et al. unpublished). Non-target species were not substantially impacted during these brief periods in summer 2002, with the most heavily damaged non-target species being *Alnus incana* (speckled alder). Following these incidents no *Galerucella* were observed. It was suggested that the lack of appropriate food triggered the onset of early aestivation in the beetles (Albright et. al. unpublished).

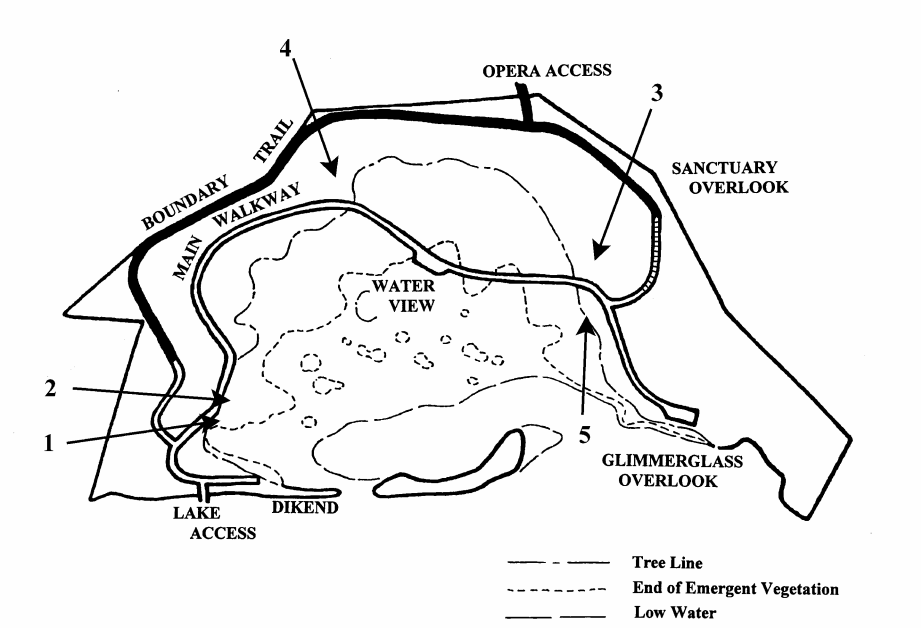

Figure 1. Map of Goodyear Swamp Sanctuary showing sampling sites. Sites 1 and 2 are where *Galerucella* spp. were stocked in 1997; sites 3-5 were to evaluate the spread of *Galerucella* spp. over time.

METHODS

Fifty adult leaf-beetles, *Galerucella calmariensis* and *G. pusilla*, were introduced into each of two sites at Goodyear Swamp Sanctuary in June 1997 (Austin 1998). The monitoring protocols established by Blossey (1997) were followed; five $1m^2$ quadrats were established (Figure 1) in which to assess the success of *Galerucella* spp. in controlling *L. salicaria* (Austin 1998). Quadrats 3, 4, and 5 were established in 1998 initially to serve as control sites and to later prove insight into the movement of *Galerucella* spp. over time (Austin 1999).

Spring monitoring (3 June 03) included an assessment of *Galerucella* spp., *L. salicaria*, and *Typha* spp. The number of *Galerucella* spp eggs, larvae and adults were estimated using abundance categories for each quadrat (Table 1). In addition, observations of other insects in the quadrats were noted. The number of stems of *L.*

salicaria within each quadrat was counted and the five tallest were measured. The percent cover of *L. salicaria* was estimated, as well as the percent damage attributable to *Galerucella* spp. (Table 1). *Typha* spp. was assessed similarly; stems present in each quadrat were counted, the five tallest were measured, and the percent cover was estimated. Fall monitoring (04 August 2003) followed a similar protocol as the spring monitoring, with additional monitoring procedures involving the *L. salicaria* inflorescences. However, this protocol was unnecessary since *L. salicaria* inflorescences were absent within the quadrats.

RESULTS AND DISCUSSION

All monitoring data are represented by abundance and frequency categories defined in Table 1. Changes between these frequency categories can represent a substantial change in abundance.

Abundance Categories		Frequency Categories		
number	category	range	category	mid point
0	1	0%	A	0 %
1-9	2	1-5%	B	2.5 %
10-49	3	5-25%	C	15 %
50-99	4	25-50%	D	37.50 %
100-499	5	50-75%	E	62.50 %
500-1000	6	75-100%	F	87.50 %
> 1000	7	100%	G	100 %

Table 1. Categories prescribed by Blossey's (1997) protocol for abundance and frequency.

Spring Quadrat Sampling: Eggs and larvae of *Galerucella* spp. were not recorded in any of the five quadrats, which is consistent with the 2002 data (Figures 2 and 3). This situation is again assumed to be the result of a harsh and long winter with several late frosts, which in turn would have likely pushed back the emergence of over-wintered adults, throwing off the timing of their mating. Adult *Galerucella* spp. abundance was lower in all five quadrats compared to the 2002 spring data (Figure 4). The reduction in all life stages of *Galerucella* spp. was likely due to the lack of *L. salicaria,* which

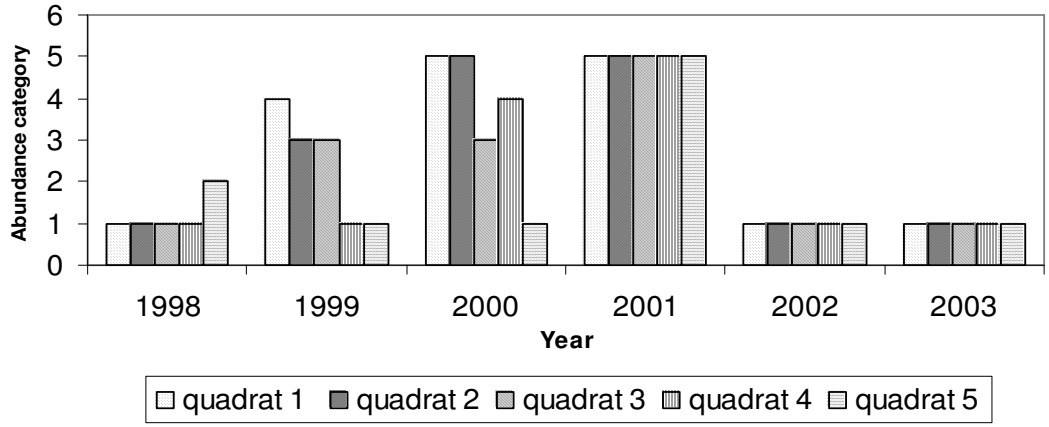

Figure 2. Comparison of Galerucella spp. egg abundance from yearly spring samplings. Abundance categories taken from Table 1.

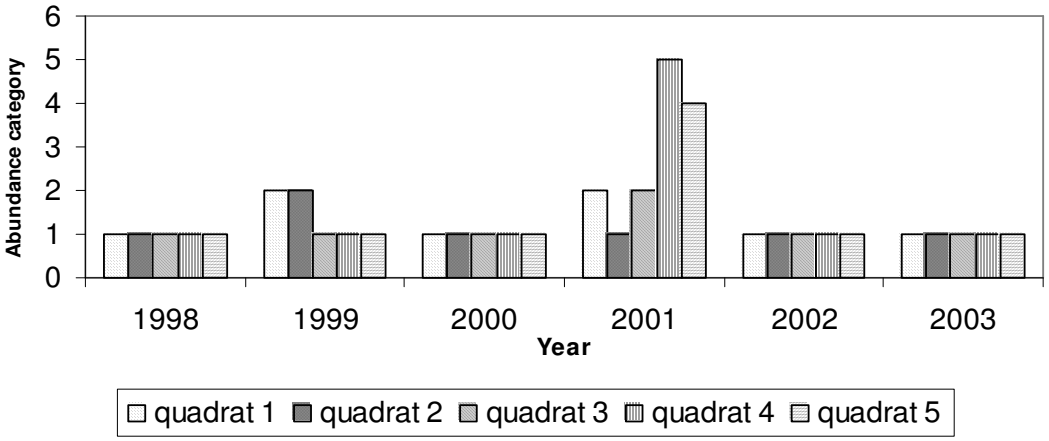

Figure 3. Comparison of Galerucella spp. larval abundance from yearly spring samplings. Abundance categories taken from Table 1.

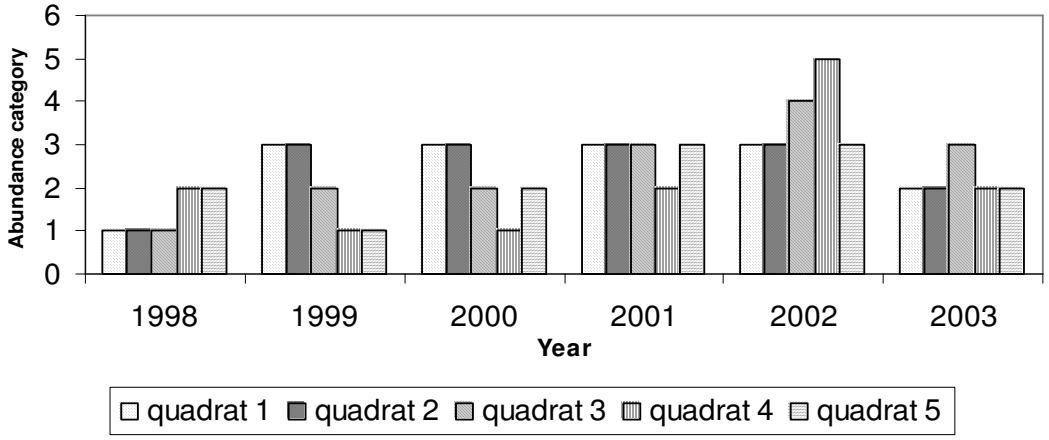

Figure 4. Comparison of Galerucella spp. adult abundance from yearly spring samplings. Abundance categories taken from Table 1.

comprised less than 5% cover in all quadrats (Figure 5), despite there being 20-50 stems per plot (Figure 6). The *L. salicaria* present was largely undamaged by *Galerucella* spp. (Figure 7).

Fall Quadrat Sampling: The presence of a few adult *Galerucella* spp. was noted on *L. salicaria* stands throughout the swamp. *Lythrum salicaria* stems were heavily damaged due to herbivory of the *Galerucella* spp. throughout all five monitored quadrats. The percent cover of *L. salicaria* (Figure 8) and the number of its stems present in each quadrat (Figure 9) were lower than in any year, except 2001 when it was absent (Groff 2002). Cattails (*Typha* spp.) were not present in any of the quadrats.

Corresponding with the decline of *L. salicaria* each summer, species richness in the quadrats, and throughout the Goodyear Swamp Sanctuary, has increased markedly. In August 2000 each quadrat had an average of 6.4 taxa present in addition to *L. salicaria* and *Typha* spp and in August 2002 there was an average of 11.2 taxa per quadrat (Albright et al. unpublished). The monitoring for August 2003 found that on average there were 10 taxa present in each quadrat in addition to *L. salicaria*, however *Typha* spp. was not present in any of the quadrats. These other taxa comprised, on average, a total of 66.5% cover. A total of 20 taxa were identified in addition to *L. salicaria* in 2003 (Table 2), compared to the 16 taxa that were identified in 2002. The rebound of native species indicates that *L. salicaria* is losing its dominance throughout the swamp as a result of the *Galerucella* spp.

It was noted that approximately ten stems of *L. salicaria*, not located within the monitored quadrats, were observed to have produced sizeable inflorescences. This is the first time that *L. salicaria* has flowered in the swamp since the 2000 season.

CONCLUSIONS

Thus far, it appears that *Galerucella* spp. remains in an area provided there is purple loosestrife present for them to feed upon. It has been noted in past years that late in the season when purple loosestrife has been severely decimated by herbivory such that all above-ground material is essentially gone, the beetles seem to disperse in search of new stands of purple loosestrife. It was hypothesized by Meehan and Albright (2003) that if the movement of *Galerucella* spp. from the Sanctuary was complete, purple loosestrife would have the opportunity to rebound. Though present, *Galerucella* spp. abundances in 2003 were lower than those of 2001 or 2002. Continued monitoring will provide insight to the behavior of *Galerucella* spp. and the long-term effectiveness of these beetles as a biological control agent of *L. salicaria.*

In 2001 searches for *Galerucella* spp. were conducted to outside of Goodyear Swamp Sanctuary. Its presence was noted on *L. salicaria* about 1 mile (1.6 km) northeast of the Sanctuary (Groff 2002). In 2002 *Galerucella* spp. were observed in a *L. salicaria* stand at Brookwood Point on Otsego Lake, 9.0 km (5.6 miles) south of the release point. (Meehan and Albright 2003) This summer the stand of *L. salicaria* at Brookwood Point was examined for signs of herbivory and ultimately the presence of *Galerucella* spp. beetles. Moderate herbivory was observed, and three adult *Galerucella* spp. were present.

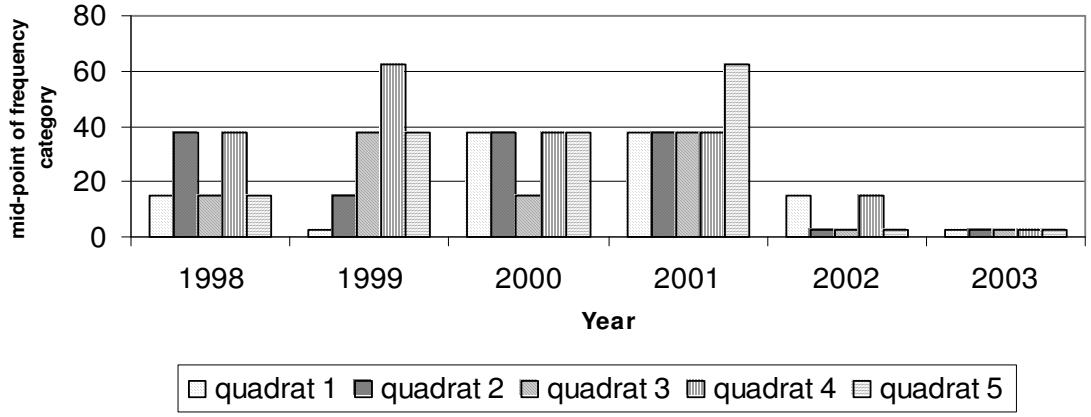

Figure 5. Comparison of percent cover estimations of purple loosestrife plants from yearly spring samplings. Frequency mid-points taken from Table 1.

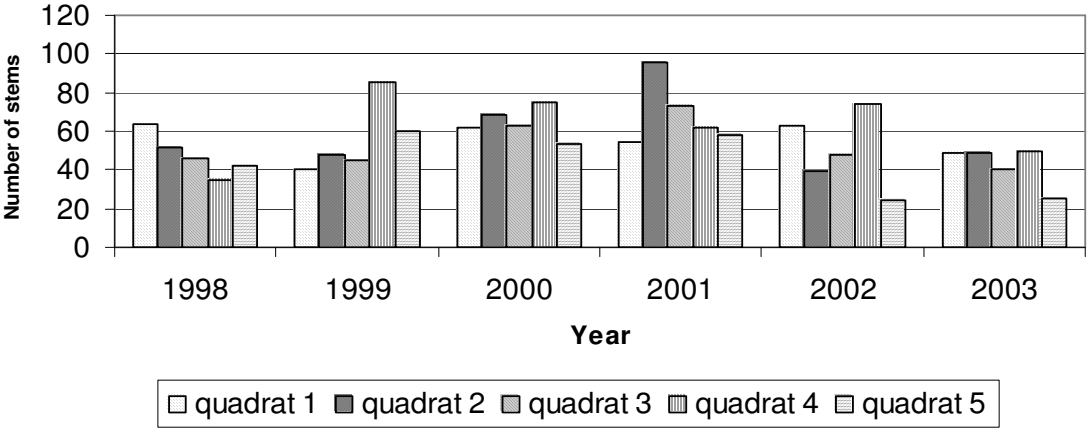

Figure 6. Comparison of the number of purple loosestrife stems from yearly spring samplings.

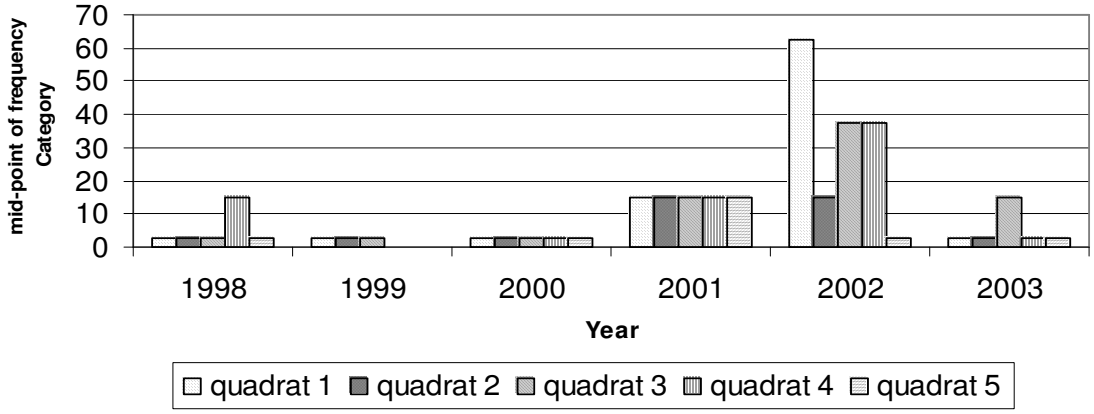

Figure 7. Comparison of percent damage estimations to purple loosestrife leaves from yearly spring samplings. Frequency mid-points taken from Table 1.

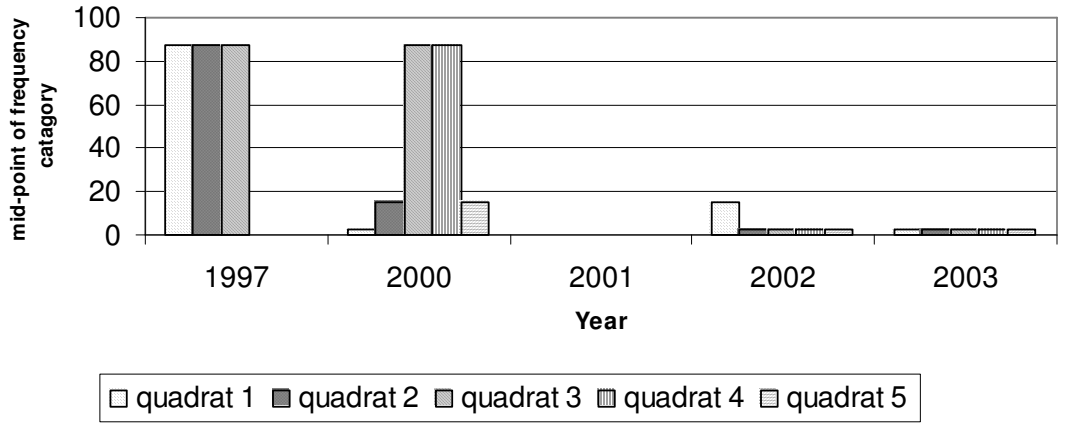

Figure 8. Comparison of percent cover estimations of purple loosestrife plants from yearly fall samplings. Frequency mid-points taken from Table 1.

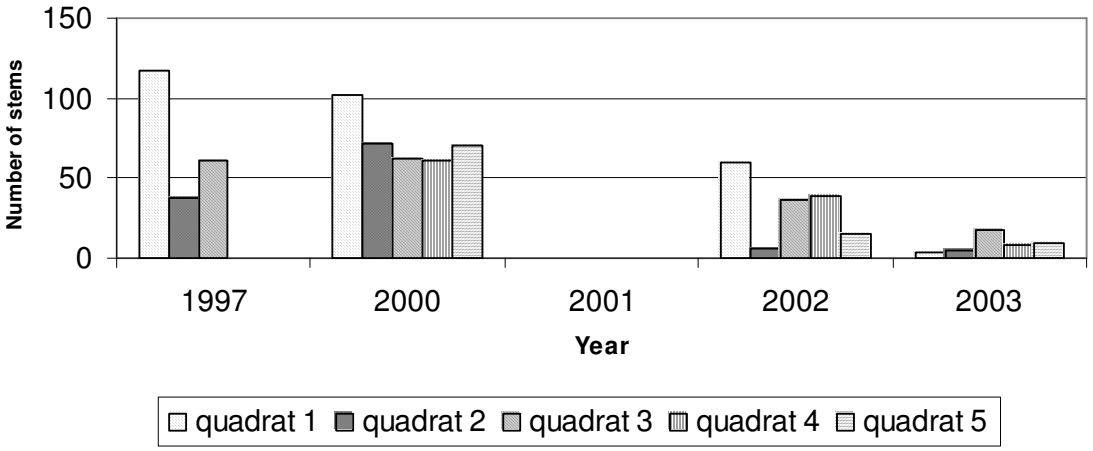

Figure 9. Comparison of number of purple loosestrife stems from yearly fall sampling surveys.

Taxa	quadrat 1	quadrat 2	quadrat 3	quadrat 4	quadrat 5
Forget-me-not (*Myosotis* spp.)	**B**	**C**	**B**	**B**	**C**
Fragrant water lilly (*Nymphaea spp.)*	A	A	**B**	**B**	**B**
Bur reed (*Sparganium* spp.)	**C**	A	**B**	**C**	**B**
Skullcap (*Scutellaria* spp.)	A	**B**	**B**	**B**	**B**
Bedstraw (*Galium* spp.)	**B**	**B**	**B**	**B**	**B**
Speedwell (*Veronica* spp.)	A	**B**	A	**B**	**C**
Cut grass (*Leersia* spp.)	A	A	**B**	A	**C**
Unidentified Rush (*Juncus* spp.)	A	A	**C**	**D**	**C**
Swamp candles (*Lysimachia terrestris*)	A	**B**	**B**	A	A
Water Purslane (*Ludwigia palustris*)	**D**	**B**	**C**	A	A
Bugleweeds *(Lycopus* spp.)	**B**	**B**	**B**	**B**	A
Bulb-bearing water hemlock (Cicuta bulbifera)	A	**B**	**B**	A	A
Hardstem bulrush (*Juncus acutus*)	A	A	A	**B**	A
Water Plantain (*Alisma trivale*)	A	A	A	**B**	A
Willow (*Salix* spp.)	A	**C**	A	A	A
Bur-Marigolds (*Bidens* spp.)	A	**B**	A	A	A
Unknown grass	A	**B**	A	A	A
Watercress *(Rorippa nasturtium-aquaticum*)	A	**C**	A	A	A
Smartweed (*Polygonum hydropiper)*	**B**	**B**	A	A	A
Impatiens (*Impatiens capensis)*	A	**B**	A	**B**	A
TOTAL number of taxa	**6**	**14**	**11**	**11**	**8**

Table 2. Taxa list for the plants identified in each quadrat in the Goodyear Swamp Sanctuary. Percent cover in each quadrat is represented by abundance categories from Table 1.

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