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The Wildlife Value of Reed Canarygrass Infested Wetlands in Minnesota

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Diversity and complexity of vegetation in native sedge wetlands of southern Minnesota have become threatened by reed canarygrass (*Phalaris arundinacea*). The consequences for wildlife of widespread conversion of diverse sedge communities to reed canarygrass dominated communities are largely unknown. We conducted a study to determine the effects of reed canarygrass on the plant and wildlife (birds, mammals, and invertebrates) communities. We hypothesized that wildlife would be negatively affected by the invasion of reed canarygrass. To test our hypothesis, we selected 4 sites that had native vegetation (native) and paired those sites with sites invaded by reed canarygrass (invaded). We determined the characteristics of the plant and animal communities at all or a subset of the paired sites during 2006-2007. The plant community at invaded wetlands had lower richness and diversity of species than native wetlands. However, richness and diversity of the bird community was not different during 2007 and greater at invaded sites than at native sites during 2006. In contrast, diversity of mammals was lower at invaded sites during 2006, but no differences were detected during 2007. Similarly, richness and diversity of invertebrate families was lower at invaded sites than at native sites. Our results did not consistently support the hypothesis that there is a clear negative impact of reed canarygrass on wildlife.

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The Wildlife Value of Reed Canarygrass Infested Wetlands in Minnesota

Final Report

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EXECUTIVE SUMMARY

The relationship between diversity of wildlife and complexity of vegetation has been well documented. During the past few decades, diversity and complexity of vegetation in native wetlands of southern Minnesota have become threatened by reed canarygrass (*Phalaris arundinacea*). Reed canarygrass is a perennial, cool season grass that out-competes native vegetation and appears to form dense monocultures. The consequences for wildlife of widespread conversion of diverse sedge communities to reed canarygrass monocultures are largely unknown. We conducted a two-year study to determine the effects of reed canarygrass on the plant, bird, mammal, and invertebrate communities. We hypothesized that reed canarygrass would negatively affect the richness and diversity of the plant community. Consequently, we hypothesized that the animal groups at higher trophic levels would likewise be negatively affected by the invasion of reed canarygrass.

We selected four sites that had native vegetation and paired those sites with sites invaded by reed canarygrass. Paired sites were close in proximity and similar in size and landscape position. We determined the characteristics of the plant and animal communities at all or a subset of the paired sites during 2006 and 2007. Consistent with our hypotheses, the plant community at wetlands invaded by reed canarygrass had lower richness and diversity of species. However, richness and diversity of the bird community was not different during 2007 and greater at sites invaded by reed canarygrass than at native sites during 2006. In contrast, diversity of mammals was lower at sites invaded by reed canarygrass during 2006, but no differences were detected during 2007. Similarly, richness and diversity of invertebrate families was lower at sites invaded by reed canarygrass than at native sites.

Although there was a reduction in richness and diversity of the plant community related to reed canarygrass, our data do not consistently support the hypothesis that there is a clear negative impact of reed canarygrass on wildlife. In fact, the only significant relationship in the analyses of the bird community was a positive effect of reed canarygrass. In contrast, diversity of mammals was lower in invaded sites during one year and diversity of invertebrate was lower at invaded sites than at native sites. Because there were no clear results, we recommend a more rigorous study of the vertebrate and invertebrate communities in wetlands invaded by reed canarygrass to determine whether our results are indicative of the invasion in general or our results are inconsistent with the general effects of a reduction in structure and diversity of the plant community associated with the invasion of reed canarygrass.

INTRODUCTION

The diversity of animals in any habitat is related to the structure, complexity, and diversity of vegetation (MacArthur 1957, MacArthur and MacArthur 1961, MacArthur et al. 1962, Karr and Roth 1971, Roth 1976). Specific characteristics of vegetation related to diversity of animals include diversity of foliage height (MacArthur and MacArthur 1961), spatial heterogeneity (MacArthur et al. 1962, Karr and Roth 1971, Roth 1976), and diversity of plant species (MacArthur 1957, MacArthur and MacArthur 1961). Diversity of foliage height, or vertical layering of vegetation, is thought to be one of the most important aspects of vegetation for birds. For example, greater diversity of birds is expected in habitats with a greater number of layers of vegetation (MacArthur and MacArthur 1961). Secondly, as spatial heterogeneity, or horizontal patchiness, increases, the diversity of both birds and mammals is expected to increase (MacArthur et al. 1962, Karr and Roth 1971, Roth 1976). Lastly, diversity of plant species typically is high when diversity of foliage height is high. Therefore, diversity of plants may directly or indirectly (by influencing the diversity of foliage height profile) influence the diversity of animals in an ecosystem (MacArthur 1957, MacArthur and MacArthur 1961).

Invasive species of plants have the potential to greatly influence the structure, composition, and diversity of vegetation. In fact, invasive species pose a serious threat to native communities and have been described as a leading contributor (second only to habitat destruction) to loss of biodiversity (Vitousek et al. 1996). In some cases, invasive plants displace native species, thereby altering the structure and composition, and decreasing the diversity of native plant communities. Ultimately, these changes can lead to alteration of ecosystem function. Furthermore, such changes in the plant community may lead to changes in the structure and composition of higher trophic levels (Wilson and Belcher 1989, Vitousek et al. 1996).

Wetlands are known for their susceptibility to invasive plants (Zedler and Rea 1998, Galatowitsch et al. 1999). Even small changes to the physio-chemical environment of these shallow-water communities can result in major changes to their plant community. If these changes are beyond the natural range of variation and sources of invasive plants are available, natural vegetation may be displaced by invasive plants. When invasive plants possess rapid growth rates, high reproductive potential, and wide tolerance to the physical environment, invasion is especially enhanced (Zedler and Rea 1998).

During the past few decades, diversity and complexity of native plant communities in wetlands of southern Minnesota have become threatened by reed canarygrass (*Phalaris arundinacea*). Reed canarygrass is a perennial, cool season grass that, once established, appears to rapidly out-compete native wetland vegetation, thereby altering structure and complexity of the plant community. Habitats that contain reed canarygrass generally have lower diversity of traditionally native plants and lower spatial heterogeneity of vegetation (Apfelbaum and Sams 1987, Lavergne and Molofsky 2004). While the relationship between diversity of animals and diversity/complexity of vegetation has been well documented (MacArthur 1957, MacArthur and MacArthur 1961, MacArthur et al. 1962, Karr and Roth 1971, Roth 1976) and the effects of invasive species on plant communities have been studied (Wilson and Belcher 1989, Vitousek et al. 1996), the consequences for wildlife of the widespread conversion of diverse sedge communities to reed canarygrass are largely unknown.

The purpose of this study was to determine the effects of reed canarygrass on animal population and community dynamics. More specifically, the objectives were to determine the effects of invasion by reed canarygrass on 1) species richness and diversity of the plant community, 2) species richness, diversity, and composition of the bird community, 3) species richness, diversity, and composition of the mammal community, and 4) species richness, diversity, and composition of the invertebrate community. We hypothesized that all four communities would be negatively affected by the invasion of reed canarygrass. In addition, we hypothesized that the effects would be more evident at the lower trophic levels (primary producers and primary consumers) than at higher trophic levels (e.g., secondary and tertiary consumers).

METHODS

Study areas

We conducted this study during spring 2006-fall 2007 in the farmland region of southern Minnesota. We established sampling plots at 8 paired sites spanning five counties (four diverse sedge wetlands with four wetlands dominated by reed canarygrass that were similar in size and landscape juxtaposition; Table 1). Sites with native vegetation were rare. Therefore, we used all four sites that we were able to locate with native vegetation (Fig. 1 picture examples of native and invaded sites). Once a native site was located, sites dominated by reed canarygrass that were close in proximity, similar in size, and similar in landscape juxtaposition we relatively easy to locate. Dominant plants at the native sites included sedges (*Carex* spp.), reed canarygrass, cattail (*Typha* spp.), goldenrod (*Solidago* spp.), and bulrush (*Scirpus* spp).

Plant community

Survey methods

We conducted plant sampling at each site during both the 2006 and 2007 growing seasons. During 2006, we randomly located plots at each study site until no new species were identified. This method is effective at estimating total richness and diversity within a site, but not good for comparison among sites. Therefore, we modified the design for 2007 to enhance our ability to compare richness and diversity of plants among the treatments. For 2007, we used a stratified-systematic design to establish a series of randomly-located transects to sample the same number of plots at each site for composition and percent cover of plant species. More specifically, we sampled vegetation in plots located at 20-m intervals along 4 randomly located 100-m transects. We used hybrid Daubenmire-Releve methodology to estimate plant species composition and percent cover of each species present within sampling plots during both years (Mueller-Dombois D., and H. Ellenberg, 1974). Specifically, plant species composition data were collected using a 1-m^2 rectangular quadrat with absolute coverage estimated for each species.

Aboveground net primary production (ANPP hereafter) of grasses and forbs was estimated by harvesting all vegetation within 0.1-m^2 circular quadrats to ground level at the time of peak aboveground biomass (early September 2007). Clipped vegetation was sorted by functional group into graminoid and forb biomass produced during the 2007 growing season and dead biomass from previous years, dried at 60°C to constant mass, and weighed. Ten plots were randomly collected from each site.

Data for species composition of the plant community were averaged to estimate mean absolute coverage per species at each wetland. The mean absolute coverage data for the four native sites were averaged together to determine mean native coverage for each species. This was repeated for the four invaded sites. Shannon-Wiener diversity was calculated using the final native and invaded coverage means. The final diversity values for the native and invaded sites from the 2006 and 2007 growing seasons were compared using a two-way analysis of variance (ANOVA) and Tukey's *post-hoc* comparison of means.

Data used for the determination of species richness were collected at each wetland. Species richness estimates for the four native wetlands were averaged to estimate mean species richness for the native sites. This was repeated for the four invaded sites. Mean native and invaded species richness from the 2006 and 2007 growing seasons was compared using a two-way analysis of variance (ANOVA) and Tukey's *post-hoc* comparison of means.

Estimates of ANPP for each site were determined by averaging the values for the ten plots sampled at each wetland. Estimates of ANPP for native and invaded wetlands were determined by averaging the mean ANPP values for the four native and invaded sites respectively. The final native and invaded ANPP means for both grasses and forbs were compared using a two-way analysis of variance (ANOVA) and Tukey's *post-hoc* comparison of means.

Bird community

To determine the effects of invasion by reed canarygrass on birds, we established one to three survey plots at each study site. Potential locations of survey points were determined by the creation of a numbered grid that we placed over aerial photos of the study sites (Buckland et al. 1993, Bibby et al. 2000) using ArcMap 9.1 Geographic Information System (GIS). We then randomly selected survey points from the numbered grid that were located at least 200 m apart to minimize the likelihood of counting birds twice (Reynolds et al. 1980). At each of the selected points, we established a fixed circular-plot with a radius of 50 meters to determine composition and diversity of the bird community (Fowler and McGinnes 1973, Reynolds et al. 1980, Buckland et al. 1993). The edge of each plot was located >25 m from the nearest habitat transition when possible to reduce edge effects.

We conducted fixed circular-plot surveys to determine composition and diversity of the bird community (Fowler and McGinnes 1973, Reynolds et al. 1980, Buckland et al. 1993). During the breeding season (mid-May through July), we completed weekly surveys on all paired sites. During the non-breeding season, August-April, we conducted surveys monthly at each point. Additionally, we completed surveys of paired sites on the same day to minimize temporal bias and alternated weekly surveys on paired sites between observers to minimize observer bias (Bibby et al 2000).

All surveys were conducted from sunrise to four hours after sunrise (Fowler and McGinnes 1973, Robbins 1981) on days with little or no precipitation or fog and winds less than 12 mph (North American Breeding Bird Survey 2001). Furthermore, we reversed the order of points within sites each survey period. From May-October 2007, we used two-foot stepladders during surveys to facilitate ease of detections.

We commenced surveys upon arrival at the point and, thus, had no waiting period (Ralph et al. 1995). Each survey lasted for 5 minutes. We recorded all birds seen and heard actively utilizing the site during the survey period (Reynolds et al. 1980) including birds that foraged in flight, such as swallows and raptors, if they foraged over the survey plot (Bryan and Best 1991). We also recorded birds that flushed from within a plot upon approach to the survey point and used the distance from the survey point to where they were first observed as the detection distance (Fowler and McGinnes 1973, Reynolds et al. 1980).

We used Simpson's Reciprocal Index (1/D) to calculate species diversity of birds by season for each site. We compared species richness and diversity between paired sites with a two-tailed, paired t-test, using a $P \leq 0.05$ level of significance to identify differences between treatments. In addition, we computed relative abundance of birds by season to model community composition. For breeding season calculations, we used the highest number of each species recorded per point at each study site because breeding birds defend territories and detections, therefore, would not be additive. For the remaining seasons when birds do not hold territories, we summed detections.

Finally, we subdivided birds into subgroups consisting of native and non-native species. Native species were divided further into subgroups consisting of species that are considered specialists and species that are considered generalists. We compared the subgroups for patterns between treatments.

Mammal community

Small mammal communities were sampled at three of the pairs of native and invaded sites. We randomly located a trapping grid near the center of each site to minimize edge effect. Each trapping grid was comprised of a 7X11 or 9X9 trap grid with 77 or 81 traps with a spacing of 15 meters between trapping station. Due to the shape of each wetland, we were not able to maintain a similar shape of trapping grid at all sites. However, grid dimensions were similar between site pairs.

Small mammals were sampled during monthly sampling periods between June and December 2006. It was our intent to trap alternating months throughout the winter, however; sub-zero temperatures in February and March 2007 would have been detrimental to the survival of trapped individuals. Seasonal flooding also prevented trapping in April 2007. Sampling periods for 2007 occurred monthly during May through September 2007. Each pair of native and invaded sites was sampled simultaneously to minimize environmental influences on small mammal activities. Small mammals were sampled by placing one Sherman live traps baited with peanut butter and oats at each station on the sampling grid. Traps were set and checked each morning for the following three mornings. Traps were checked by 10:00 am each morning to minimize heat stress on the animals, especially in the warmer summer months. In colder temperatures (nighttime temperature ≤ 40°C), insulation was added to each trap to reduce cold stress of captured individuals.

For each animal captured, we collected general livetrap data including: site, species, grid location, sex, reproductive condition (mammae conspicuous, testes descended, etc.), mass, and age (based on pelage for those species that molt between age classes). In addition, each individual was given an ear tag stamped with a unique personal identification number that could be used to identify individuals during subsequent sampling periods.

We determined the relative density (number of individuals per number of trapping stations) of each species at each site. Similarity in composition of the small mammal community between treatments was determined by comparing the relative densities of each species. A difference in composition between treatments was determined using a contingency table analysis and performing a G-log likelihood ratio test. Species richness of the small mammal community for native and invaded sites was calculated by taking the mean (among treatment) of the total number of species captured at each site during each year. Species richness between native and invaded sites was compared using a paired t-test. Mean species diversity was calculated using the Shannon Wiener diversity index. The mean species diversity for native and invaded sites was calculated for each year. Species diversity between native and invaded sites was compared using a paired t-test. For all tests, we considered there to be a significant difference between treatments if P was less than or equal to 0.05.

Invertebrate community

Survey methods

To determine the effects of invasion by reed canarygrass on invertebrates, we conducted invertebrate sampling at each of the eight sites. Sampling was conducted twice (once during June and once during July) during the 2007 growing season. Each sampling effort consisted of randomly selecting two or three starting points at each site, walking in a random direction from the starting point, and taking 25 sweeps with a sweep net while walking in a straight line. All insects collected in the 25 sweeps were combined to comprise one sample. Therefore, we collected 4 or 6 samples of invertebrates from each site during the 2007 growing season.

Processing samples consisted of identifying each individual in each sample to the family level (order level when family was not possible). Once identified, we counted the number of individuals comprising each family in each sample. In this manner, we were able to determine abundance at the family and order levels of taxonomic hierarchy.

We used Shannon-Wiener Diversity Index (H') to calculate family diversity of invertebrates each site. We compared family richness and diversity between paired sites with a one-tailed, paired t-test, using a $P \leq 0.05$ level of significance to identify differences between treatments.

RESULTS

Plant Community

Species composition of the plant community for the 2006 and 2007 growing seasons are itemized and summarized in Tables 2 and 3, respectively. Diversity of plant species was greater at native sites than at invaded sites ($F = 6.16$, d.f. = 1, 15, $P = 0.024$; Fig. 2). However, plant diversity was only significantly greater in native sites than invaded sites during summer 2007 ($P = 0.036$; Fig. 1). Plant diversity was not significantly different during summer 2006 ($P = 0.229$; Fig. 1). Plant species richness was not greater in native sites than invaded sites during summer 2006 ($P = 0.481$; Fig. 2). Similar to results on diversity, plant species richness was significantly greater at native sites during summer 2007 ($P = 0.05$; Fig. 3).

Aboveground Net Primary Production was significantly different between native and invaded sites ($F = 25.588$, d.f. = 1, 15, $P < 0.001$; Fig. 4). Grass production was 35.6% less in native sites than in invaded sites (510.64 vs. 792.90 g/m² respectively, $P < 0.001$; Fig. 4). Grass production also accounted for >90% of total aboveground production for both native and invaded sites (Fig. 4). Forb production was not significantly different between native and invaded sites (17.02 vs. 22.79 g/m² respectively, $P = 0.884$; Fig. 4).

Bird Community

Composition of the bird community did not differ significantly between treatments or years (Tables 4-9). In contrast, we found that wetlands invaded by reed canarygrass had significantly greater species richness of birds than diverse sedge wetlands during the 2006 breeding season ($P=0.003$, Fig. 5). However, we found no differences between treatments in species richness or diversity during any other season. Species diversity was not different between treatments for the 2006 breeding season ($P=0.34$, Fig. 6). For fall migration 2006, we found no differences in species richness ($P=0.25$, Fig. 7) or diversity ($P=0.11$, Fig.8) between treatments. Similarly, we found no differences in richness or diversity, respectively, between treatments for winter 2006-2007 (P=0. 89, Fig. 9; $P=0.82$, Fig. 10), spring migration 2007 ($P=0.49$, Fig. 11; $P=0.35$, Fig. 12), breeding season 2007 ($P=0.42$, Fig. 13; $P=0.38$, Fig. 14), or fall migration 2007 ($P=0.32$, Fig. 15; $P=0.63$, Fig. 16).

There were no significant differences between treatments among the native, non-native, specialist, and generalist subgroups ($P > 0.05$).

Mammal community

We captured 243 individual small mammals 324 times. Captures were comprised of 11 species of small mammals. In decreasing order of abundance, species captured included the meadow vole (*Microtus pennsylvanicus*), the northern short-tailed shrew (*Blarina brevicauda*), the deer mouse (*Peromyscus maniculatus*), the arctic shrew (*Sorex articus*), the meadow jumping mouse (*Zapus hudsonius),* the short-tailed weasel (*Mustela ermine),* the masked shrew *(Sorex cinereus)*, the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), the house mouse (*Mus musculus*), the long-tailed weasel (*Mustela frenata),* and the eastern chipmunk (*Tamias striatus;* Tables 10 &11.).

In 2006, there was a difference in composition of species between native and invaded wetlands ($G = 26.6$, d.f. = 15, $P < 0.05$). This was also the same when considering only the five most abundant species ($G = 24.4$, d.f. = 9, $P < 0.05$). In 2007, there was no difference in composition of species when examining all species ($G = 14.2$, d.f. = 19, $P > 0.05$) or when limiting the analysis to the five most abundant species ($G = 5.4$, d.f. = 9, $P > 0.05$).

There was no difference in richness of species during 2006 (d.f. 2, $P = 0.19$; Fig. 17) or 2007 (d.f., = 2, $P = 1.0$; Fig. 18). However, diversity of small mammals was lower at invaded site than at native sites during 2006 (d.f. = 2, $P < 0.01$; Fig. 19), but there was no difference between treatments in 2007 (d.f. = 2, $P = 0.08$, Fig. 20).

Invertebrate Community

We identified 6137 individual insects comprising 123 Families and 11 Orders (Table 12). Richness of families of invertebrates was greater at native sites than at sites invaded by reed canarygrass (d.f. = 3; $P = 0.05$; Fig. 21). Likewise, diversity of invertebrates was greater at native sites than at sites invaded by reed canarygrass (d.f. = 3; $P = 0.02$; Fig. 22).

DISCUSSION

Invasion by reed canarygrass significantly influenced both species richness and diversity of the plant community at our study sites during summer 2007, but not during summer 2006. The lack of detecting a difference during 2006 was likely a result of sampling methods (designed to sample total diversity during 2006, whereas the design was altered during 2007 to detect differences among sites). Therefore, we suggest that 2007 is a more accurate depiction of the plant community and conclude that there was lower richness and diversity of plant species at sites invaded by reed canarygrass. We hypothesized that a reduction in richness and diversity of the plant community would negatively affect the animal communities of these wetlands. However, our results did not consistently support our hypotheses.

There was no evidence that the bird community was negatively influenced by the invasion of reed canarygrass. In fact, the only significant analysis demonstrated that species richness of birds was greater at sites invaded by reed canarygrass than at sites with native vegetation. However, this relationship was significant during one year only and there was no difference in diversity of birds during either year. It is possible that the lack of influence on the bird community is a function of the size of bird territories or home ranges relative to the size of our study sites (i.e., bird home ranges could be largely outside of the study site). However, we made every effort to match our paired study sites in size and landscape juxtaposition. Therefore, we cannot dismiss the result that during one year, richness of birds was actually greater at sites invaded by reed canarygrass. Studies have demonstrated a positive relationship between characteristics of bird communities and structural height of the vegetation (MacArthur and MacArthur 1961). Therefore, it is possible that sites invaded by reed canarygrass with greater vegetative height actually provide better habitat for birds. However, we are unwilling to make such a broad statement based on the results of one analysis when several other analyses demonstrated no significant difference.

Similar to our results for birds, there was only one measure of a community parameter that demonstrated a significant difference in the small mammal community between sites invaded by reed canarygrass and sites with native vegetation. In contrast to birds, diversity of mammals was lower at sites invaded by reed canarygrass than at sites with native vegetation during 2006. This was not unexpected as richness and diversity of small mammals communities have been shown to be influenced by richness and diversity of vegetation. However, a single difference during a single year suggests that this relationship may not be strong in the wet meadow sites of southern Minnesota.

Consistent with our hypotheses, the effects of invasion by reed canary grass was more evident at lower trophic levels. In addition to a negative influence on the diversity of vegetation, richness and diversity of invertebrates was lower at sites invaded by reed canarygrass than at sites dominated by native vegetation.

Management implications

During the past few decades, reed canarygrass has threatened the diversity and complexity of plant communities in wetlands of southern Minnesota. Communities invaded by reed canarygrass generally have lower diversity of traditionally native species of plants and lower spatial heterogeneity of vegetation (Apfelbaum and Sams 1987, Lavergne and Molofsky 2004), an alteration to structure and complexity of the plant community. These changes in structure and complexity of the plant community appear to have inconsistent effects on communities at higher trophic levels. In some cases, communities may benefit, whereas there is a negative effect or neutral effect for other communities.

While our data do not support the assertion that there is a clear negative impact of reed canarygrass at higher trophic levels, it was clear that invasion of reed canarygrass negatively influenced the plant community and the invertebrate community. It seems likely that these likely that changes in the community of primary producers (plants) and primary consumers (invertebrates) would have cascading effects at higher trophic levels. However, we were unable to demonstrate a clear and consistent effect. Therefore, we recommend a more rigorous study of vertebrate community in wetlands invaded by reed canarygrass to determine whether our results are indicative of the invasion in general or our results are inconsistent with the general effects of a reduction in structure and diversity of the plant and invertebrate communities associated with the invasion of reed canarygrass.

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APPENDIX A - TABLES

Table 1. Locations for eight paired study sites (four sites dominated by native sedge vegetation and four sites invaded and dominated by reed canarygrass) used to evaluate the influence of invasion by reed canarygrass on wildlife during 2006-2007.

Site	Pair	Trt	County	Latitude	Longitude
Rasmussen	1	Invaded	Blue Earth	419151 N	4888823 E
Ottawa	1	Native	Le Sueur	426698 N	4910629 E
Swan Lake	2	Invaded	Nicollet	403049 N	4896197 E
Judson	2	Native	Blue Earth	407790 N	4894057 E
Cannon River	3	Invaded	Rice	466405 N	4898570 E
Cannon River	3	Native	Rice	466580 N	4898546 E
Oak Glen	4	Invaded	Steele	491719 N	4864682 E
Pogones	4	Native	Steele	487784 N	4860628 E

Table 2. Composition (mean percent cover ± SE) of plants in wetlands comprised of native vegetation and wetlands invaded by reed canary grass in southern Minnesota during summer 2006.

Species		Native Wetlands			Invaded Wetlands		
Latin Name	**Common Name**						
*Acer saccharum**	Sugar Maple	0.00	±	0.00	0.06	±	0.06**
Ambrosia artemisifolia	Common Ragweed	0.01	±	0.01**	0.00	±	0.00
Amorpha Fruiticosa	Indigo Bush	0.00	±	0.00	0.11	±	0.11**
Apocynum sibiricum	Prairie Dogbane	0.39	±	0.39**	0.00	±	0.00
Arisaema triphyllum	Jack in the Pulpit	0.08	±	0.08**	0.04	±	0.04**
Asclepias syrica	Common Milkweed	0.24	±	0.17	0.11	±	0.07
Asclepias verticillata	Narrow-leaved Milkweed	0.16	±	0.10	0.56	±	0.44
Aster puniceus	Purple Stemmed Aster	0.14	±	0.14**	0.14	±	0.14**
Bromus inermis	Brome Grass	0.84	±	0.70	3.56	±	2.26
Calamagrostis canadensis	Canada Bluejoint	0.11	±	0.11**	0.11	±	0.11**
Caltha palustris	Marsh Marigold	2.26	±	1.25	0.56	±	0.41
Calystegia sepium	Bindweed	0.00	±	0.00	0.07	±	0.03
Cardamine rhomboidea	Spring Cress	0.06	±	0.06**	0.00	±	0.00
Carex aquatilis	Water Sedge	0.39	±	0.39**	0.00	±	0.00
Carex hysternica	Porcupine Sedge	2.65	±	2.55	1.11	±	0.65
Carex lacustris	Lake Sedge	7.47	±	7.47**	0.00	±	0.00
Carex rostrata	Beaked Sedge	0.00	±	0.00	1.11	±	1.11**
Carex sterilis	Sterile Sedge	3.29	±	1.70	2.06	±	1.70
Carex stricta	Tussock Sedge	27.34	±	8.52	14.30	±	10.04
Carex vulpinoidea	Fox Sedge	9.74	±	5.03	7.30	±	4.79
Chenopodium sp	Goosefoot	0.00	±	0.00	0.01	±	0.01**
Cirsium discolor	Field Thistle	0.32	±	0.32**	0.00	±	0.00
Cirsium muticum	Swamp Thistle	0.12	±	0.08	0.69	±	0.48
Cirsium vulgare	Bull Thistle	0.09	±	0.09**	0.04	±	0.04**
Conzya canadensis	Horseweed	0.42	±	0.42**	0.00	±	0.00
*Cornus sericea**	Red-Osier Dogwood	2.89	±	2.86	4.31	±	4.28
Cryptotaenia canadensis	Honewort	0.14	±	0.14**	0.00	±	0.00
Daucus carota	Queen Anne's Lace	0.85	±	0.82	0.03	±	0.03**
Eleocharis rostella	Beaked Spike Rush	1.91	±	1.91**	2.86	±	2.86**
Equisetum arvense	Common Horsetail	0.55	±	0.11	1.42	±	1.11
Equisetum palustre	Marsh Horsetail	0.10	±	0.10**	0.00	±	0.00
Erigeron annuus	Daisy Fleabane	0.01	±	0.01**	0.07	±	0.07**
Eupatorium maculatum	Joe-Pye Weed	0.71	±	0.28	0.39	±	0.24
Eupatorium perfoliatum	Boneset	0.17	±	0.09	0.16	±	0.12
Galium boreale	Northern Bedstraw	0.07	±	0.07**	0.01	±	0.01**
Galium triflorum	Fragrant Bedstraw	0.11	±	0.11**	0.00	±	0.00
Glechoma hederaceae	Ground Ivy	0.50	±	0.5**	0.51	±	0.50
Glyceria grandis	Manna Grass	1.41	±	1.27	0.11	±	0.11
Helianthus sp	Sunflower	1.18	±	0.88	0.96	±	0.94
Helianthus maximillian	Maximillian's Sunflower	0.18	±	0.18**	0.00	±	0.00
Heracleum maximum	Cow Parsnip	0.00	±	0.00	0.01	±	0.01**
Hesperis matronalis	Dame's Rocket	0.00	±	0.00	0.01	±	0.01**
Hierochloe odorata	Purple Phlox	0.13	±	0.13**	0.13	±	0.13**
Hydrophyllum virgininum	Waterleaf	0.04	±	0.04**	0.00	±	0.00

Impatiens capensis	Jewel Weed	2.78	±	1.15	4.03	±	1.61
Iris versicolor	Blueflag Iris	0.02	±	0.02**	0.00	±	0.00
Juncus effusus	Common Rush	2.87	±	2.03	0.91	±	0.62
Juncus tenuis	Poverty Rush	0.23	±	0.23**	0.00	±	0.00
*Juniperus virginiana**	Red Cedar	0.02	±	0.02**	0.00	±	0.00
Lemna minor	Duckweed	0.00	±	0.00	0.29	±	0.29**
Lepidium virginicum	Poor Man's Pepper	0.02	±	0.02**	0.00	±	0.00
Lonicera murrowi	Honeysuckle	0.00	±	0.00	0.03	±	0.03**
Lysimachia punctata	Yellow Alexander	0.03	±	0.03**	0.03	±	0.03**
Melilotus officinales	Yellow Sweetclover	0.16	±	0.11	0.06	±	0.04
Onoclea sensibilis	Sensitive Fern	0.02	±	0.02**	0.02	±	0.02**
Oxalis stricta	Yellow Oxalis	0.00	±	0.00	0.06	±	0.06**
Packera pseudaurea	False Groundsel	0.04	±	0.04**	0.00	±	0.00
Parthenocissus cinquefolia	Virginia Creeper	0.02	±	0.02**	0.04	±	0.04**
Pedicularis canadensis	Canadian Lousewort	0.04	±	0.04**	0.00	±	0.00
Phalaris arundinacea	Reed canary grass	17.87	±	4.00	67.15	±	6.59
Phlox pilosa	Purple Phlox	0.07	±	0.07**	0.07	±	0.07**
Phragmites australis	Giant Reed	3.89	±	2.42	6.03	±	2.21
Poa pratensis	Kentucky Bluegrass	2.33	±	2.33**	0.42	±	0.26
Polygonatum biflorum	Solomon's Seal	0.00	±	0.00	0.04	±	0.04**
Polygonum	Smartweed	0.00	±	0.00	0.38	±	0.38**
*Populus deltoides**	Cottonwood	0.03	±	0.03**	0.00	±	0.00
*Populus tremuloides**	Quaking Aspen	0.01	±	0.01**	0.13	±	0.12
Pycnanthemum sp	Mountain Mint	0.51	±	0.51**	0.00	±	0.00
Ranunculus bulbosus	Bulbous Buttercup	0.04	±	0.04**	0.00	±	0.00
*Rhus typhina**	Staghorn Sumac	0.00	±	0.00	0.64	±	0.64**
Rumex crispus	Curly Dock	0.06	±	0.06**	0.04	±	0.04**
Sagittaria latifolia	Broad-leaved Arrowhead	0.28	±	0.26	1.74	±	1.71
*Salix alba**	White Willow	0.00	±	0.00	0.39	±	0.27
*Salix exigua**	Sandbar Willow	2.66	±	1.54	2.86	±	1.65
*Salix nigra**	Black Willow	0.00	±	0.00	0.01	±	0.01**
*Salix pentandre**	Bay Willow	0.06	±	0.06**	0.06	±	0.06**
Saxifraga pensylvanica	Swamp Saxifrage	0.17	±	0.10	0.00	±	0.00
Scirpus atrovirens	Green Bulrush	4.59	±	1.88	1.90	±	1.56
Scirpus fluviatilis	River Bulrush	2.28	±	1.50	4.73	±	3.86
Senecio pseudaureus	Ragwort	0.32	±	0.32**	0.00	±	0.00
Solanum dulcamora	Bittersweet Nightshade	0.00	±	0.00	0.11	±	0.11**
Solidago sp 1	Goldenrod	3.54	±	2.03	1.98	±	1.39
Solidago sp 2	Goldenrod	1.82	±	1.81	0.01	±	0.01**
Sparganium angustifolium	Narrow-leaved Bur-Reed	0.00	±	0.00	0.09	±	0.09**
Sphagnum sp	Moss	0.00	±	0.00	0.63	±	0.63**
Taraxcum officinale	Dandelion	0.12	±	0.12**	0.01	±	0.01**
Thalictrum venulosm	Northern Meadow Rue	0.19	±	0.09	0.13	±	0.11
Thelypteris palustris	Marsh Fern	0.39	±	0.39**	0.00	±	0.00
Toxicodendron radicans	Poison Ivy	0.04	±	0.04**	0.25	±	0.10
Toxicodendron vernix	Poison Sumac	0.07	±	0.07**	0.78	±	0.78**
Triglochin palustre	Arrow Grass	0.16	±	0.16**	0.00	±	0.00
Typha angustifolia	Narrow-leaved Cattail	7.30	±	3.15	16.49	±	3.22
Typha latifolia	Wide-leaved Cattail	1.66	±	0.12	1.45	±	0.66
Typha x glauca	Hybrid Cattail	2.17	±	1.26	10.90	±	1.90

Unknown 1		0.12	±	0.12**	0.00	±	0.00
Unknown 2		0.93	±	0.93**	0.00	±	0.00
Unknown 3		0.80	±	0.80**	0.00	±	0.00
Urtica dioica	Stinging Nettle	0.05	±	0.05**	3.03	±	2.63
Verbascum thapsis	Mullein	0.07	±	0.04	0.00	±	0.00
Vicia americana	Purple Vetch	0.26	±	0.11	0.32	±	0.17

*Tree and shrub data for seedlings < 20 cm in height.

** Plant species only found on one site.

Table 3. Composition (mean percent cover ± SE per site) of plants in wetlands comprised of native vegetation and wetlands invaded by reed canary grass in southern Minnesota during summer 2007.

Species		Native Wetlands			Invaded Wetlands		
Latin Name	**Common Name**						
Ambrosia artemisifolia	Common Ragweed	0.02	±	0.02*	0.00	±	0.00
Apocynum sibiricum	Prairie Dogbane	0.49	±	0.49*	0.00	±	0.00
Asclepias sullivantii	Sullivan's Milkweed	0.24	±	0.11	0.00	±	0.00
Asclepias syrica	Common Milkweed	0.49	±	0.32	0.20	±	0.12
Asclepias verticillata	Narrow-leaved Milkweed	0.31	±	0.18	0.70	±	0.47
Aster lucidulus	Swamp Aster	0.45	±	0.23	0.06	±	0.06*
Aster puniceus	Purple Stemmed Aster	0.49	±	0.18	0.23	±	0.21
Aster simplex	Marsh Aster	1.36	±	1.02	0.03	±	0.03*
Calamagrostis canadensis	Canada Bluejoint	0.21	±	0.21*	0.21	±	0.21*
Caltha palustris	Marsh Marigold	2.56	±	1.53	0.71	±	0.50
Cardamine rhomboidea	Spring Cress	0.12	±	0.12*	0.00	±	0.00
Carex aquatilis	Water Sedge	0.38	±	0.38*	0.00	±	0.00
Carex hysternica	Porcupine Sedge	2.98	±	1.91	1.30	±	0.64
Carex lacustris	Lake Sedge	6.97	±	6.97*	0.00	±	0.00
Carex rostrata	Beaked Sedge	1.07	±	0.96	0.93	±	0.89
Carex sterilis	Sterile Sedge	3.83	±	1.58	2.08	±	1.83
Carex stricta	Tussock Sedge	26.73	±	7.92	13.59	±	9.42
Carex vulpinoidea	Fox Sedge	10.07	±	4.58	7.70	±	4.91
Chenopodium album	Goosefoot	0.05	±	0.05*	0.03	±	0.03*
Cirsium discolor	Field Thistle	0.37	±	0.29	0.03	±	0.03*
Cirsium muticum	Swamp Thistle	0.38	±	0.20	1.14	±	0.75
Cirsium vulgare	Bull Thistle	0.27	±	0.14	0.10	±	0.06
Conzya canadensis	Horseweed	0.51	±	0.51*	0.00	±	0.00
Cryptotaenia canadensis	Honewort	0.18	±	0.18*	0.00	±	0.00
Daucus carota	Queen Anne's Lace	1.08	±	0.98	0.08	±	0.08*
Eleocharis rostella	Beaked Spike Rush	2.12	±	2.12*	0.71	±	0.71*
Equisetum arvense	Common Horsetail	0.80	±	0.16	0.62	±	0.33
Equisetum palustre	Marsh Horsetail	0.18	±	0.18*	0.00	±	0.00
Erigeron annuus	Daisy Fleabane	0.03	±	0.03*	0.16	±	0.16*
Eupatorium maculatum	Joe-Pye Weed	1.19	±	0.40	0.71	±	0.41
Eupatorium perfoliatum	Boneset	0.37	±	0.16	0.23	±	0.14
Galium boreale	Northern Bedstraw	0.15	±	0.15*	0.03	±	0.02
Galium triflorum	Fragrant Bedstraw	0.15	±	0.15*	0.00	±	0.00
Glyceria grandis	Manna Grass	1.46	±	1.26	0.16	±	0.16*
Helenium autumnale	Sneezeweed	1.14	±	1.04	0.00	±	0.00
Helianthus grosseserratus	Sawtooth Sunflower	1.13	±	0.68	0.80	±	0.78
Helianthus maximillian	Maximillian's Sunflower	0.28	±	0.22	0.00	±	0.00
Heracleum maximum	Cow Parsnip	0.00	±	0.00	0.03	±	0.03*
Hesperis matronalis	Dame's Rocket	0.00	±	0.00	0.01	±	0.01*
Hierochloe odorata	Purple Phlox	0.15	±	0.15*	0.15	±	0.15*
Hydrophyllum virgininum	Waterleaf	0.06	±	0.06*	0.00	±	0.00
Impatiens capensis	Jewel Weed	3.28	±	1.25	3.85	±	1.33
Iris versicolor	Blueflag Iris	0.03	±	0.03*	0.00	±	0.00
Juncus effusus	Common Rush	1.05	±	0.72	0.11	±	0.06

Juncus tenuis	Poverty Rush	0.34	±	0.31	0.00	±	0.00
Lemna	Duckweed	0.15	±	0.15*	0.00	±	0.00
Lepidium virginicum	Poor Man's Pepper	0.05	±	0.05*	0.00	±	0.00
Liatris spicata	Blazing Star	0.13	±	0.08	0.03	±	0.03
Lysimachia punctata	Yellow Alexander	0.06	±	0.06*	0.06	±	0.06*
Melilotus officinales	Yellow Sweetclover	0.20	±	0.13	0.08	±	0.06
Onoclea sensibilis	Sensitive Fern	0.04	±	0.04*	0.04	±	0.04*
Packera pseudaurea	False Groundsel	0.05	±	0.05	0.00	±	0.00
Parthenocissus cinquefolia	Virginia Creeper	0.12	±	0.12*	0.04	±	0.04*
Pedicularis canadensis	Canadian Lousewort	0.06	±	0.06*	0.00	±	0.00
Phalaris arundinacea	Reed Canarygrass	18.55	±	3.06	56.85	±	13.46
Phlox pilosa	Purple Phlox	0.09	±	0.09*	0.09	±	0.09*
Phragmites australis	Giant Reed	3.69	±	2.53	2.88	±	1.81
Poa pratensis	Kentucky Bluegrass	3.17	±	3.10	1.11	±	0.67
Polygonatum biflorum	Solomon's Seal	0.00	±	0.00	0.02	±	0.02*
Polygonum amphibium	Water Smartweed	0.00	±	0.00	0.13	±	0.13*
Pycnanthemum virginianum	Virginia Mountain Mint	0.66	±	0.66*	0.00	±	0.00
Ranunculus bulbosus	Bulbous Buttercup	0.06	±	0.06*	0.00	±	0.00
Rumex crispus	Curly Dock	0.13	±	0.13*	0.07	±	0.07*
Sagittaria latifolia	Broad-leaved Arrowhead	0.37	±	0.30	1.77	±	1.70
Saxifraga pensylvanica	Swamp Saxifrage	0.32	±	0.23	0.00	±	0.00
Scirpus atrovirens	Green Bulrush	5.21	±	2.25	1.86	±	1.41
Scirpus fluviatilis	River Bulrush	1.91	±	1.38	4.48	±	3.91
Scirpus validus	Soft Stem Bulrush	2.99	±	1.98	0.91	±	0.62
Senecio pseudaureus	Ragwort	0.35	±	0.35*	0.00	±	0.00
Solanum dulcamora	Bittersweet Nightshade	0.00	±	0.00	0.09	±	0.09*
Solidago altissima	Tall Goldenrod	1.90	±	1.20	0.79	±	0.55
Solidago gigantea	Giant Goldenrod	3.72	±	1.86	1.95	±	1.14
Solidago ohioensis	Ohio Goldenrod	1.90	±	1.73	0.22	±	0.18
Sparganium angustifolium	Narrow-leaved Bur-Reed	0.15	±	0.15*	0.06	±	0.06*
Sphagnum	Moss	0.71	±	0.71*	0.59	±	0.59*
Thalictrum venulosm	Northern Meadow Rue	0.32	±	0.13	0.14	±	0.14*
Thelypteris palustris	Marsh Fern	0.46	±	0.46*	0.00	±	0.00
Toxicodendron radicans	Poison Ivy	0.18	±	0.11	0.71	±	0.39
Triglochin palustre	Arrow Grass	0.22	±	0.22*	0.00	±	0.00
Typha angustifolia	Narrow-leaved Cattail	6.21	±	3.20	3.59	±	1.47
Typha latifolia	Wide-leaved Cattail	0.95	±	0.22	0.83	±	0.39
Typha x glauca	Hybrid Cattail	1.30	±	0.80	0.95	±	0.91
Urtica dioica	Stinging Nettle	0.05	±	0.05*	1.79	±	1.25
Verbascum thapsis	Mullein	0.14	±	0.08	0.00	±	0.00
Vicia americana	Purple Vetch	0.25	±	0.11	0.22	±	0.13

* Plant species only found on one site.

Table 4. Composition and mean abundance of breeding birds (+ SE) in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-May-July 2006.

COMPOSITION AND MEAN ABUNDANCE OF BREEDING BIRDS + SE - 2006			
	Species	**Native wetlands**	**Invaded wetlands**
AMGO	American goldfinch	0.07 ± 0.01	0.06 ± 0.01
AMRO	American robin	0.03 ± 0.02	0.05 ± 0.02
BAOR	Baltimore oriole	0.0 ± 0	0.01 ± 0.01
BARS	Barn swallow	0.08 ± 0.04	0.06 ± 0.04
BCCH	Black-capped chickadee	0.0 ± 0	0.02 ± 0.02
BEKI	Belted kingfisher	0.0 ± 0	0.01 ± 0.01
BHCO	Brown-headed cowbird	0.01 ± 0.01	0.05 ± 0.03
BOBO	Bobolink	0.04 ± 0.04	0.0 ± 0
CHSW	Canada goose	0.0 ± 0	0.0 ± 0.00
COGR	Common grackle	0.01 ± 0.01	0.01 ± 0.01
COYE	Common yellowthroat	0.13 ± 0.06	0.13 ± 0.02
DICK	Dickcissel	0.03 ± 0.03	0.02 ± 0.02
DOWO	Downy woodpecker	0.01 ± 0.01	0.01 ± 0.01
EAKI	Eastern kingbird	0.0 ± 0	0.02 ± 0.02
EAME	Eastern meadowlark	0.03 ± 0.03	0.0 ± 0
EAPH	Eastern phoebe	0.0 ± 0	0.01 ± 0.01
EWPE	Eastern wood-pewee	0.0 ± 0	0.01 ± 0.01
FISP	Field sparrow	0.0 ± 0	0.0 ± 0
GRCA	Gray catbird	0.02 ± 0.01	0.04 ± 0.02
GRSP	Grasshopper sparrow	0.0 ± 0	0.0 ± 0
HAWO	Hairy woodpecker	0.01 ± 0.01	0.01 ± 0.01
HOWR	House wren	0.0 ± 0.01	0.03 ± 0.02
INBU	Indigo bunting	0.0 ± 0	0.02 ± 0.01
LEFL	Least flycatcher	0.0 ± 0	0.01 ± 0.01
MALL	Mallard	0.0 ± 0	0.0 ± 0.00
MAWR	Marsh wren	0.0 ± 0.01	0.01 ± 0.01
MODO	Mourning dove	0.01 ± 0.01	0.01 ± 0.01
NOCA	Northern cardinal	0.00 ± 0.00	0.01 ± 0.01
NOFL	Northern flicker (yellow-shafted)	0.01 ± 0.01	0.0 ± 0
OROR	Orchard oriole	0.01 ± 0.01	0.01 ± 0.01
RBGR	Rose-breasted grosbeak	0.0 ± 0	0.02 ± 0.01
RNPH	Ring-necked pheasant	0.01 ± 0.01	0.0 ± 0.00
ROPI	Rock pigeon	0.01 ± 0.01	0.0 ± 0
RTHU	Ruby-throated hummingbird	0.0 ± 0	0.0 ± 0
RWBB	Red-winged blackbird	0.21 ± 0.04	0.16 ± 0.07

SEWR	Sedge wren	0.04 ± 0.04	0.06 ± 0.03
SORA	Sora	0.0 ± 0	0.0 ± 0
SOSP	Song sparrow	0.03 ± 0.02	0.04 ± 0.02
SSHA	Sharp-shinned hawk	0.0 ± 0	0.0 ± 0
SWSP	Swamp sparrow	0.06 ± 0.02	0.02 ± 0.01
TEWA	Tennessee warbler	0.0 ± 0	0.01 ± 0.01
TRSW	Tree swallow	0.04 ± 0.02	0.04 ± 0.02
WAVI	Warbling vireo	0.0 ± 0	0.01 ± 0.01
WBNU	White-breasted nuthatch	0.0 ± 0	0.0 ± 0
WIFL	Willow flycatcher	0.03 ± 0.02	0.01 ± 0.01
WODU	Wood duck	0.0 ± 0	0.01 ± 0.01
YBSA	Yellow-bellied sapsucker	0.0 ± 0	0.0 ± 0
YEWA	Yellow warbler	0.02 ± 0.02	0.03 ± 0.02

Table 5. Composition and mean abundance of birds ± SE during fall migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from August-mid-November 2006.

COMPOSITION AND MEAN ABUNDANCE OF BIRDS ± SE - FALL MIGRATION 2006			
	Species	**Native wetlands**	**Invaded wetlands**
AMGO	American goldfinch	0.20 ± 0.03	0.14 ± 0.05
AMRO	American robin	0.03 ± 0.03	0.03 ± 0.03
BARS	Barn swallow	0.15 ± 0.15	0.02 ± 0.01
BCCH	Black-capped chickadee	0.03 ± 0.02	0.04 ± 0.03
BLJA	Blue jay	0.01 ± 0.01	0.03 ± 0.01
CEWA	Cedar waxwing	0.00 ± 0.00	0.01 ± 0.01
CHSW	Chimney swift	0.01 ± 0.01	0.00 ± 0.00
CONI	Common nighthawk	0.00 ± 0.00	0.01 ± 0.01
COYE	Common yellowthroat	0.02 ± 0.02	0.04 ± 0.02
DEJU	Dark-eyed junco	0.00 ± 0.00	0.11 ± 0.07
DOWO	Downy woodpecker	0.01 ± 0.01	0.00 ± 0.00
EAKI	Eastern kingbird	0.03 ± 0.03	0.01 ± 0.01
EAME	Eastern meadowlark	0.03 ± 0.03	0.00 ± 0.00
EUST	European starling	0.01 ± 0.01	0.00 ± 0.00
EWPE	Eastern wood-pewee	0.00 ± 0.00	0.01 ± 0.01
FISP	Field sparrow	0.03 ± 0.03	0.00 ± 0.00
GCKI	Golden-crowned kinglet	0.00 ± 0.00	0.01 ± 0.01
GRCA	Gray catbird	0.02 ± 0.01	0.01 ± 0.01
HOWR	House wren	0.00 ± 0.00	0.02 ± 0.01
NAWA	Nashville warbler	0.00 ± 0.00	0.01 ± 0.01
NOCA	Northern cardinal	0.00 ± 0.00	0.01 ± 0.01
RBGR	Rose-breasted grosbeak	0.00 ± 0.00	0.01 ± 0.01
RTHA	Red-tailed hawk	0.00 ± 0.00	0.01 ± 0.01
RTHU	Ruby-throated hummingbird	0.00 ± 0.00	0.09 ± 0.06
RWBB	Red-winged blackbird	0.18 ± 0.08	0.06 ± 0.06
SEWR	Sedge wren	0.05 ± 0.04	0.07 ± 0.04
SOSP	Song sparrow	0.01 ± 0.01	0.03 ± 0.02
SWSP	Swamp sparrow	0.15 ± 0.06	0.19 ± 0.11
WIWA	Wilson's warbler	0.01 ± 0.01	0.00 ± 0.00
WOODP	Unknown woodpecker	0.00 ± 0.00	0.01 ± 0.01
WTSP	White-throated sparrow	0.04 ± 0.03	0.00 ± 0.00

Table 6. Composition and mean abundance of birds ± SE during winter in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-November 2006-February 2007.

COMPOSITION AND MEAN ABUNDANCE OF BIRDS ± SE - WINTER 2006-2007			
	Species	**Native wetlands**	**Invaded wetlands**
AMGO	American goldfinch	0.00 ± 0.00	0.06 ± 0.06
ATSP	American tree sparrow	0.00 ± 0.00	0.19 ± 0.19
BCCH	Black-capped chickadee	0.10 ± 0.10	0.32 ± 0.24
BLJA	Blue jay	0.19 ± 0.16	0.11 ± 0.11
COHA	Cooper's hawk	0.03 ± 0.03	0.00 ± 0.00
DEJU	Dark-eyed junco	0.04 ± 0.04	0.00 ± 0.00
DOWO	Downy woodpecker	0.07 ± 0.04	0.05 ± 0.05
FISP	Field sparrow	0.08 ± 0.08	0.00 ± 0.00
WBNU	White-breasted nuthatch	0.00 ± 0.00	0.02 ± 0.02

Table 7. Composition and mean abundance of birds ± SE during spring migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from March-mid-May 2007.

COMPOSITION AND MEAN ABUNDANCE OF BIRDS ± SE - SPRING MIGRATION 2007			
	Species	**Native wetlands**	**Invaded wetlands**
AMGO	American goldfinch	0.03 ± 0.03	0.00 ± 0.00
AMRO	American robin	0.00 ± 0.00	0.10 ± 0.06
ATSP	American tree sparrow	0.05 ± 0.05	0.01 ± 0.01
BCCH	Black-capped chickadee	0.02 ± 0.02	0.00 ± 0.00
BHCO	Brown-headed cowbird	0.00 ± 0.00	0.02 ± 0.02
BLJA	Blue jay	0.04 ± 0.04	0.00 ± 0.00
CAGO	Canada goose	0.00 ± 0.00	0.14 ± 0.14
COGR	Common grackle	0.03 ± 0.03	0.04 ± 0.02
COSN	Common snipe	0.03 ± 0.03	0.04 ± 0.04
COYE	Common yellowthroat	0.02 ± 0.02	0.05 ± 0.05
EABL	Eastern bluebird	0.06 ± 0.06	0.00 ± 0.00
EUST	European starling	0.08 ± 0.08	0.00 ± 0.00
GRCA	Gray catbird	0.00 ± 0.00	0.02 ± 0.02
HOWR	House wren	0.00 ± 0.00	0.05 ± 0.05
MALL	Mallard	0.00 ± 0.00	0.14 ± 0.08
NOCA	Northern cardinal	0.04 ± 0.04	0.00 ± 0.00
NOFL	Northern flicker	0.02 ± 0.02	0.00 ± 0.00
RBGR	Rose-breasted grosbeak	0.00 ± 0.00	0.02 ± 0.02
RNPH	Ring-necked pheasant	0.00 ± 0.00	0.03 ± 0.02
RWBB	Red-winged blackbird	0.37 ± 0.11	0.15 ± 0.09
SOSP	Song sparrow	0.15 ± 0.12	0.15 ± 0.08
SWSP	Swamp sparrow	0.02 ± 0.02	0.00 ± 0.00
TRSW	Tree swallow	0.03 ± 0.03	0.00 ± 0.00
WBNU	White-breasted nuthatch	0.00 ± 0.00	0.05 ± 0.05
YEWA	Yellow warbler	0.02 ± 0.02	0.00 ± 0.00

Table 8. Composition and mean abundance of breeding birds ± SE in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-May-July 2007.

COMPOSITION AND MEAN ABUNDANCE OF BREEDING BIRDS ± SE - 2007			
	Species	**Native wetlands**	**Invaded wetlands**
AMCR	American crow	0.00 ± 0.00	0.00 ± 0.00
AMGO	American goldfinch	0.08 ± 0.02	0.09 ± 0.03
AMRE	American redstart	0.00 ± 0.00	0.01 ± 0.01
AMRO	American robin	0.07 ± 0.04	0.03 ± 0.01
AMWO	American woodcock	0.00 ± 0.00	0.00 ± 0.00
BAEA	Bald eagle	0.00 ± 0.00	0.00 ± 0.00
BAOR	Baltimore oriole	0.02 ± 0.01	0.03 ± 0.01
BARS	Barn swallow	0.05 ± 0.03	0.06 ± 0.03
BBCU	Black-billed cuckoo	0.00 ± 0.00	0.00 ± 0.00
BCCH	Black-capped chickadee	0.00 ± 0.00	0.00 ± 0.00
BEKI	Belted kingfisher	0.00 ± 0.00	0.00 ± 0.00
BGGN	Blue-gray gnatcatcher	0.00 ± 0.00	0.00 ± 0.00
BHCO	Brown-headed cowbird	0.02 ± 0.01	0.06 ± 0.03
BLJA	Blue jay	0.00 ± 0.00	0.00 ± 0.00
BOBO	Bobolink	0.01 ± 0.01	0.00 ± 0.00
CCSP	Clay-colored sparrow	0.00 ± 0.00	0.00 ± 0.00
CEWA	Cedar waxwing	0.00 ± 0.00	0.00 ± 0.00
CHSW	Chimney swift	0.00 ± 0.00	0.00 ± 0.00
CLSW	Cliff swallow	0.06 ± 0.03	0.00 ± 0.00
COGR	Common grackle	0.03 ± 0.01	0.12 ± 0.06
COYE	Common yellowthroat	0.08 ± 0.04	0.09 ± 0.01
DICK	Dickcissel	0.01 ± 0.01	0.01 ± 0.01
DOWO	Downy woodpecker	0.00 ± 0.00	0.01 ± 0.01
EAKI	Eastern kingbird	0.00 ± 0.00	0.01 ± 0.01
EAME	Eastern meadowlark	0.01 ± 0.01	0.00 ± 0.00
EAPH	Eastern phoebe	0.00 ± 0.00	0.00 ± 0.00
EUST	European starling	0.09 ± 0.08	0.00 ± 0.00
EWPE	Eastern wood-pewee	0.00 ± 0.00	0.01 ± 0.01
FISP	Field sparrow	0.01 ± 0.01	0.00 ± 0.00
GRCA	Gray catbird	0.01 ± 0.01	0.02 ± 0.01
GRSP	Grasshopper sparrow	0.00 ± 0.00	0.00 ± 0.00
HAWO	Hairy woodpecker	0.00 ± 0.00	0.00 ± 0.00
HOWR	House wren	0.00 ± 0.00	0.02 ± 0.01
INBU	Indigo bunting	0.00 ± 0.00	0.01 ± 0.01
LEFL	Least flycatcher	0.00 ± 0.00	0.01 ± 0.01

MALL	Mallard	0.00 ± 0.00	0.00 ± 0.00
MAWR	Marsh wren	0.00 ± 0.00	0.01 ± 0.01
MODO	Mourning dove	0.01 ± 0.01	0.02 ± 0.01
NOCA	Northern cardinal	0.00 ± 0.00	0.01 ± 0.01
NOFL	Northern flicker (yellow-shafted)	0.00 ± 0.00	0.00 ± 0.00
OROR	Orchard oriole	0.00 ± 0.00	0.00 ± 0.00
PIWO	Pileated woodpecker	0.00 ± 0.00	0.00 ± 0.00
RBGR	Rose-breasted grosbeak	0.00 ± 0.00	0.01 ± 0.01
RBWO	Red-bellied woodpecker	0.00 ± 0.00	0.00 ± 0.00
RNPH	Ring-necked pheasant	0.00 ± 0.00	0.00 ± 0.00
ROPI	Rock pigeon	0.00 ± 0.00	0.00 ± 0.00
RTHU	Ruby-throated hummingbird	0.00 ± 0.00	0.00 ± 0.00
RWBB	Red-winged blackbird	0.18 ± 0.02	0.11 ± 0.03
SAVS	Savannah sparrow	0.00 ± 0.00	0.00 ± 0.00
SEWR	Sedge wren	0.03 ± 0.02	0.08 ± 0.03
SORA	Sora	0.00 ± 0.00	0.00 ± 0.00
SOSP	Song sparrow	0.03 ± 0.01	0.02 ± 0.01
SSHA	Sharp-shinned hawk	0.00 ± 0.00	0.00 ± 0.00
SWSP	Swamp sparrow	0.05 ± 0.02	0.03 ± 0.01
TEWA	Tennessee warbler	0.00 ± 0.00	0.00 ± 0.00
TRSW	Tree swallow	0.06 ± 0.02	0.06 ± 0.02
WAVI	Warbling vireo	0.00 ± 0.00	0.00 ± 0.00
WBNU	White-breasted nuthatch	0.00 ± 0.00	0.00 ± 0.00
WIFL	Willow flycatcher	0.02 ± 0.01	0.00 ± 0.00
WODU	Wood duck	0.00 ± 0.00	0.01 ± 0.01
YBSA	Yellow-bellied sapsucker	0.00 ± 0.00	0.00 ± 0.00
YEWA	Yellow warbler	0.02 ± 0.01	0.01 ± 0.01

Table 9. Composition and mean abundance of birds ± SE during fall migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from August-October 2007.

COMPOSITION AND MEAN ABUNDANCE OF BIRDS ± SE - FALL MIGRATION 2007			
	Species	**Native wetlands**	**Invaded wetlands**
AMGO	American goldfinch	0.12 ± 0.04	0.12 ± 0.06
MAKE	American kestrel	0.00 ± 0.00	0.05 ± 0.05
AMRO	American robin	0.04 ± 0.04	0.02 ± 0.02
BCCH	Black-capped chickadee	0.12 ± 0.09	0.05 ± 0.05
BLJA	Blue jay	0.00 ± 0.00	0.01 ± 0.01
CEWA	Cedar waxwing	0.01 ± 0.01	0.06 ± 0.06
COGR	Common grackle	0.00 ± 0.00	0.01 ± 0.01
COYE	Dark-eyed junco	0.02 ± 0.01	0.00 ± 0.00
DICK	Dickcissel	0.02 ± 0.02	0.00 ± 0.00
DOWO	Downy woodpecker	0.01 ± 0.01	0.02 ± 0.02
EABL	Eastern bluebird	0.00 ± 0.00	0.02 ± 0.02
EAKI	Eastern kingbird	0.03 ± 0.03	0.01 ± 0.01
GRCA	Gray catbird	0.00 ± 0.00	0.04 ± 0.04
HOWR	House wren	0.00 ± 0.00	0.03 ± 0.02
LISP	Lincoln's sparrow	0.00 ± 0.00	0.03 ± 0.03
RBGR	Rose-breasted grosbeak	0.00 ± 0.00	0.04 ± 0.03
RCKI	Red-tailed hawk	0.03 ± 0.03	0.00 ± 0.00
RNPH	Ring-necked pheasant	0.00 ± 0.00	0.01 ± 0.01
RTHU	Ruby-throated hummingbird	0.04 ± 0.02	0.07 ± 0.07
RWBB	Red-winged blackbird	0.24 ± 0.21	0.00 ± 0.00
SAVS	Savannah sparrow	0.02 ± 0.02	0.00 ± 0.00
SEWR	Sedge wren	0.03 ± 0.03	0.07 ± 0.05
SORA	Sora	0.00 ± 0.00	0.05 ± 0.05
SOSP	Song sparrow	0.00 ± 0.00	0.05 ± 0.04
SSHA	Sharp-shinned hawk	0.00 ± 0.00	0.02 ± 0.02
SWSP	Swamp sparrow	0.11 ± 0.06	0.11 ± 0.07
TRSW	Tree swallow	0.00 ± 0.00	0.03 ± 0.03
WAVI	Warbling vireo	0.01 ± 0.01	0.01 ± 0.01
WIFL	Willow flycatcher	0.00 ± 0.00	0.01 ± 0.01
YRWA	Yellow-rumped warbler	0.15 ± 0.15	0.02 ± 0.02

Table 10. Composition of the small mammal community in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota during June-December 2006. Abundance is represented as the mean number of individuals for each species per wetland type (±1 SE). Density is represented as the mean number of individuals captured for each species per 100 traps (±1 SE).

	Relative Abundance		Relative Density	
Species	Native	Invaded	Native	Invaded
B. brevicauda *(Northern short-tailed shrew)*	19.3 ± 7.4	9.0 ± 6.1	4.82 ± 2.17	1.73 ± 0.82
S. arcticus (Arctic shrew)	17.0 ± 9.8	1.0 ± 1.0	3.75 ± 1.49	0.29 ± 0.14
M. pennsylvanicus (Meadow vole)	15.3 ± 2.8	21.3 ± 20.8	3.06 ± 0.83	4.11 ± 1.81
P. maniculatus (Deer mouse)	7.6 ± 3.7	5.3 ± 4.8	2.01 ± 0.45	2.02 ± 0.68
M. ermine (Ermine)	3.0 ± 1.5	0.3 ± 0.3	0.65 ± 0.24	0.14 ± 0.09
Z. hudsonius (Meadow jumping mouse)	2.3 ± 2.3	0.3 ± 0.3	0.87 ± 0.43	0.14 ± 0.09
S. tridecemlineatus (13-lined ground squirrel)	0.3 ± 0.3	1.0 ± 0.6	0.00 ± 0.00	0.00 ± 0.00
M. musculus (House mouse)	0.3 ± 0.3	0.3 ± 0.3	0.00 ± 0.00	0.00 ± 0.00

Table 11. Composition of the small mammal community in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota during May-September 2007. Abundance is represented as the mean number of individuals for each species per wetland type (±1 SE). Density is represented as the mean number of individuals captured for each species per 100 traps (±1 SE).

	Relative Abundance		Relative Density	
Species	Native	Invaded	Native	Invaded
S. arcticus (Arctic shrew)	9.7 ± 4.9	3.3 ± 2.0	2.25 ± 0.50	0.78 ± 0.35
P. maniculatus (Deer mouse)	8.3 ± 4.5	10.3 ± 4.2	1.81 ± 0.52	2.51 ± 0.81
B. brevicauda (Northern short-tailed shrew)	8.0 ± 4.7	7.3 ± 5.9	1.72 ± 1.15	1.73 ± 0.83
M. pennsylvanicus (Meadow vole)	5.7 ± 3.2	9.7 ± 2.4	1.47 ± 0.50	3.07 ± 0.71
M. ermine (Ermine)	2.7 ± 1.8	1.3 ± 1.3	0.69 ± 0.40	0.35 ± 0.35
S. cinereus (Masked shrew)	1.7 ± 0.9	2.3 ± 1.5	0.43 ± 0.19	0.61 ± 0.26
Z. hudsonius (Meadow jumping mouse)	0.7 ± 0.7	9.0 ± 7.0	0.17 ± 0.11	2.25 ± 0.98
M. frenata (Long-tailed weasel)	0.3 ± 0.3	0.0 ± 0.0	0.00 ± 0.00	0.00 ± 0.00
S. tridecemlineatus (13-linws ground squirrel)	0.3 ± 0.3	0.0 ± 0.0	0.00 ± 0.00	0.00 ± 0.00
T. striatus (Eastern chipmunk)	0.0 ± 0.0	0.3 ± 0.3	0.00 ± 0.00	0.00 ± 0.00

Table 12. Abundance of insects in eight wetlands in southern Minnesota during summer 2007.

Order	# of Families	# of Individuals
Hemiptera	30	1750
Diptera	32	1233
Collembola	1	1057
Hymenoptera	23	864
Coleoptera	20	639
Orthoptera	3	324
Thysanoptera	3	130
Lepidoptera	5	79
Odonata	3	7
Neuroptera	2	3
Plecoptera	1	1

APPENDIX B - FIGURES

Figure 1. Photos of 4 sites used to study the effects of invasion of reed canarygrass on wildlife. Plate A and B are from the Rasmussen and Swan Lake study areas, respectively, and are invaded by reed canarygrass. Plates B and C are from the Cannon River and Ottawa study areas, respectively, and are sites dominated by native vegetation.

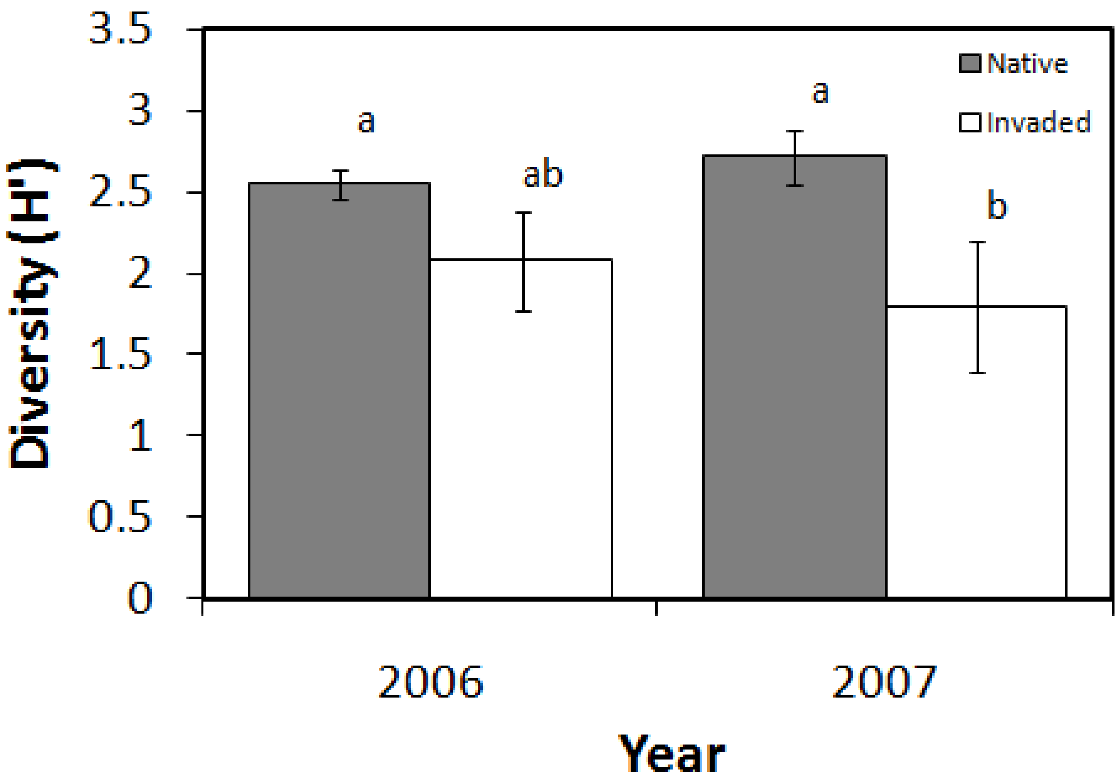

Figure 2. Mean Shannon-Wiener diversity (± SE) of plants in wetlands comprised of native vegetation and wetlands invaded by reed canary grass in southern Minnesota during the 2006 and 2007 growing seasons. Means with different letters represent significant differences (P < 0.05).

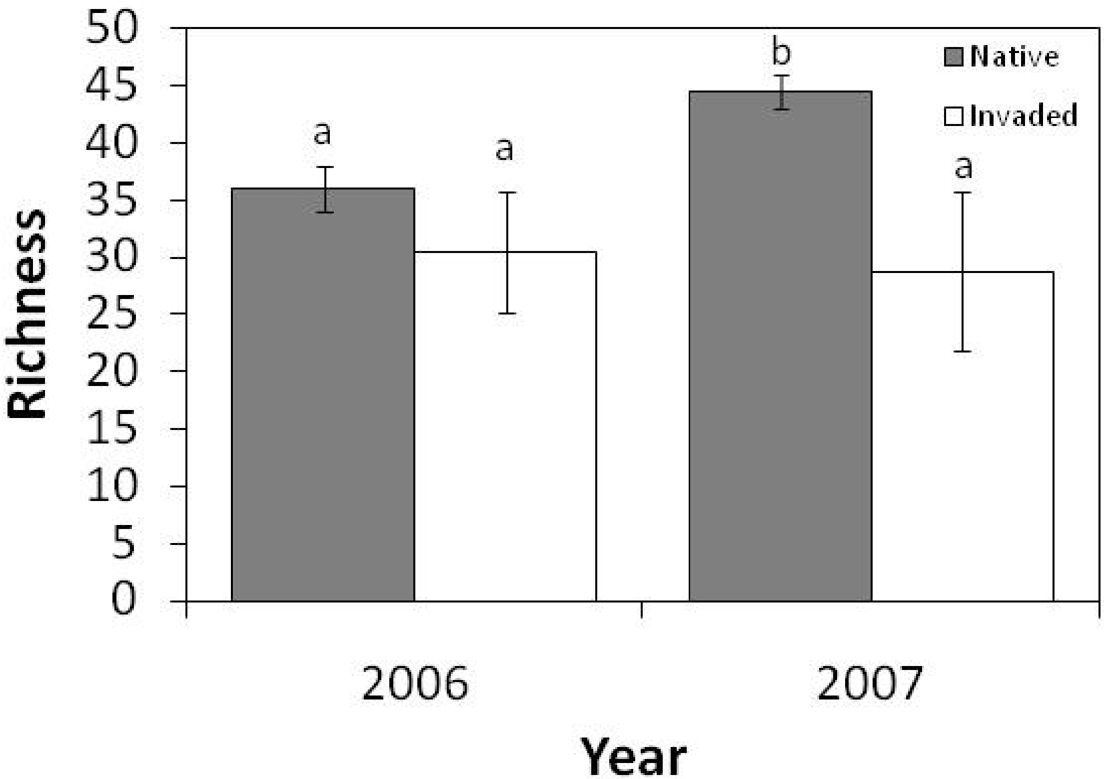

Figure 3. Mean species richness (± SE) of plants in wetlands comprised of native vegetation and wetlands invaded by reed canary grass in southern Minnesota during the 2006 and 2007 growing seasons. Means with different letters represent significant differences ($P < 0.05$).

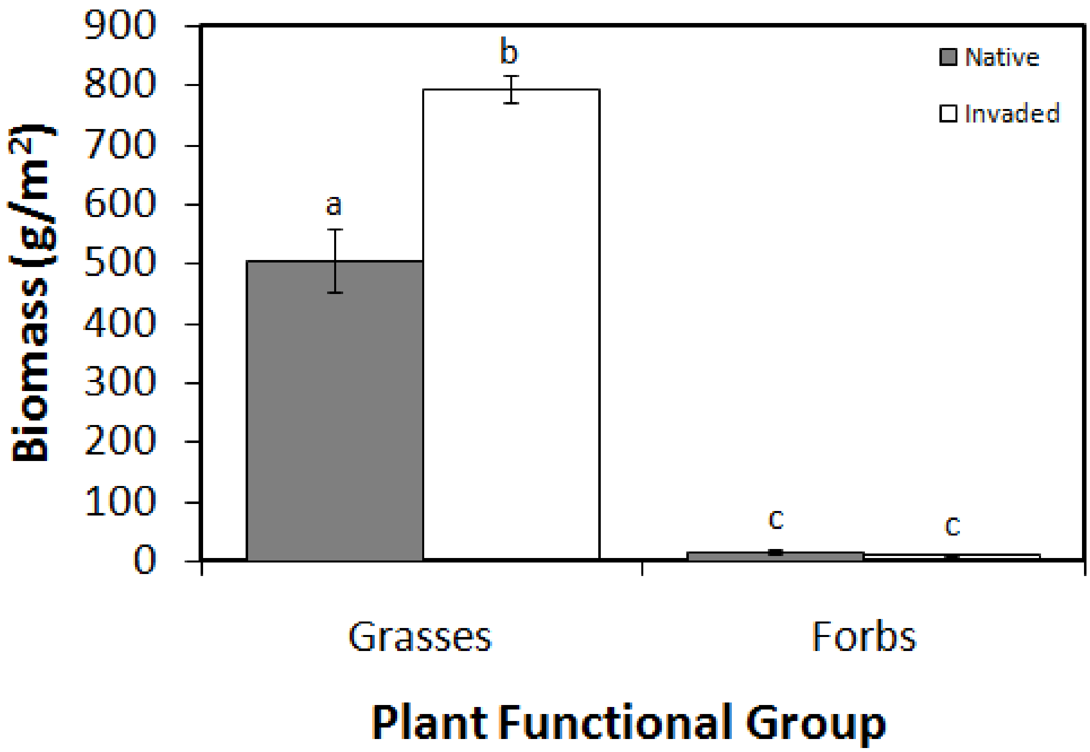

Figure 4.. Mean aboveground net primary production (± SE) of grasses and forbs in wetlands comprised of native vegetation and wetlands invaded by reed canary grass in southern Minnesota during September 2007. Means with different letters represent significant differences ($P < 0.05$).

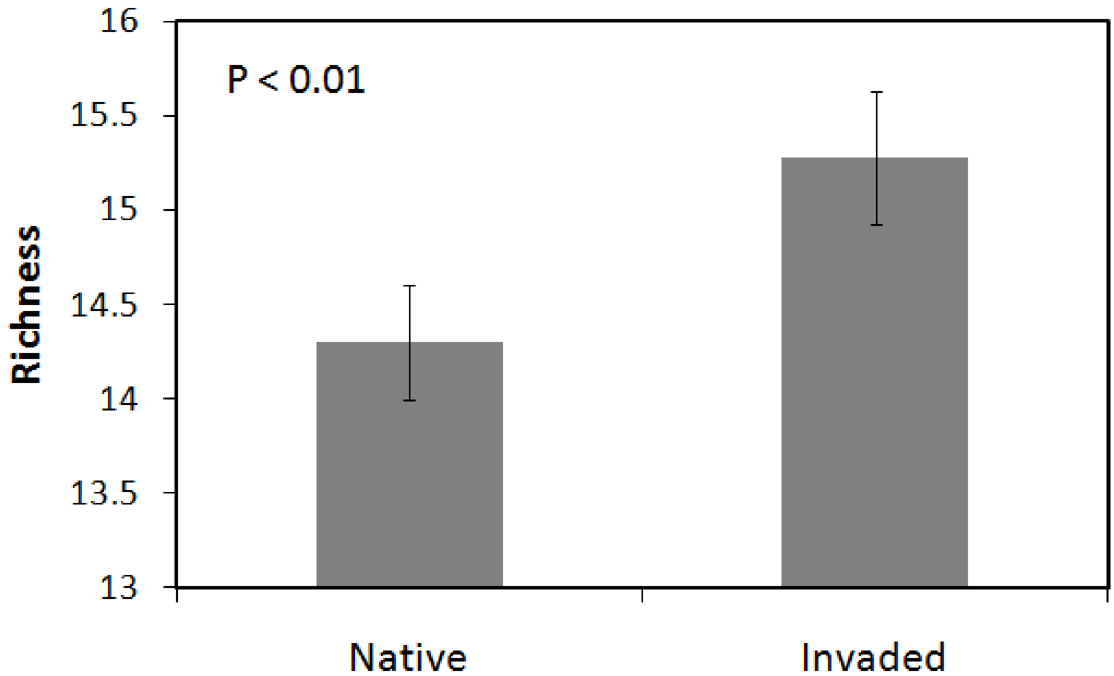

Figure 5. Mean species richness (± SE) of breeding birds in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-May-July 2006.

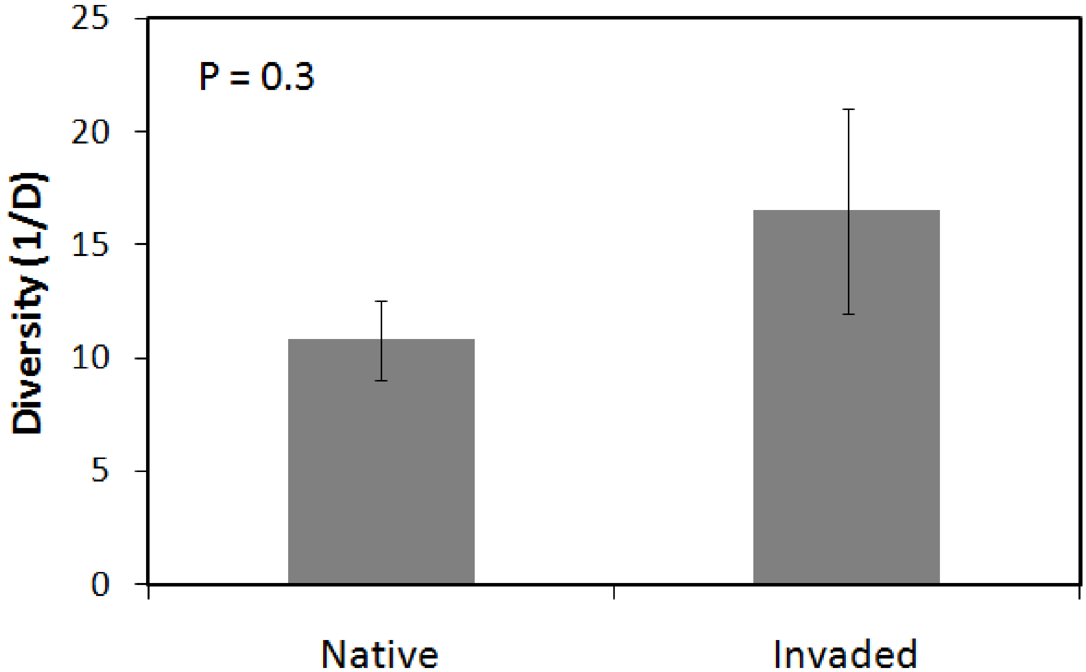

Figure 6. Mean Simpson's diversity (± SE) of breeding birds in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-May-July 2006.

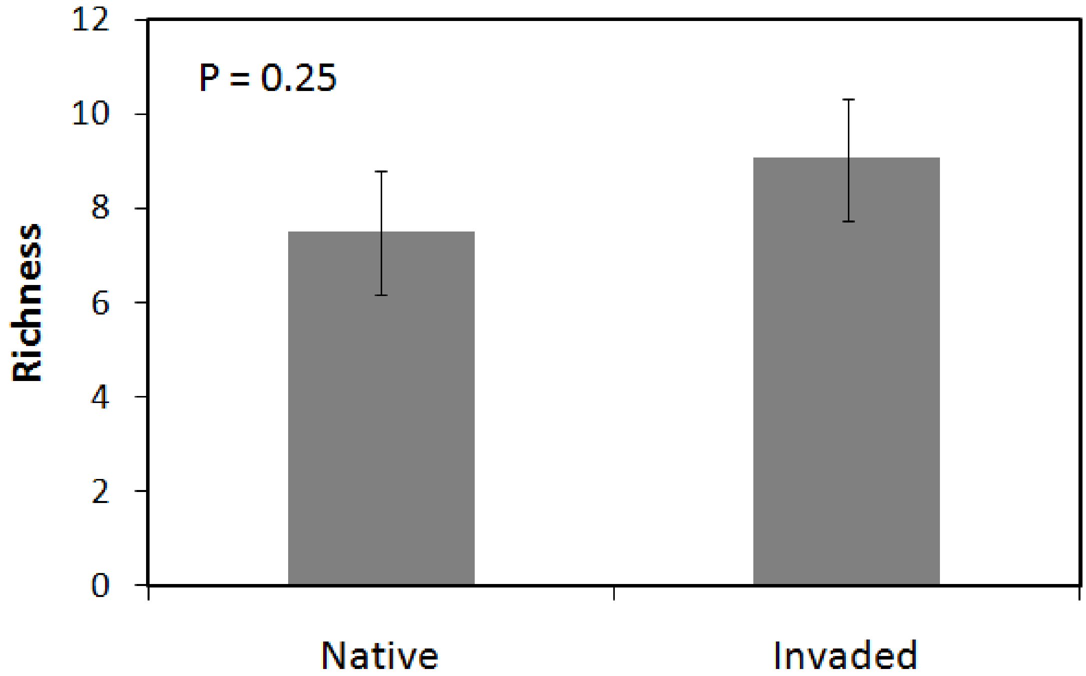

Figure 7. Mean species richness (± SE) of birds during fall migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from August-mid-November 2006.

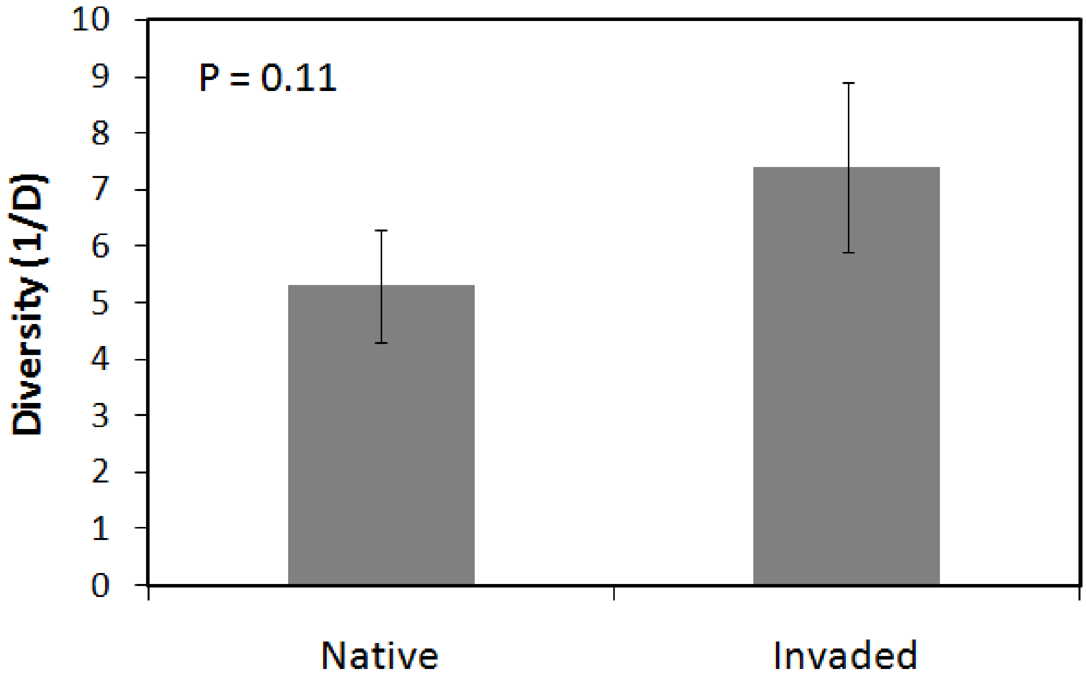

Figure 8. Mean Simpson's diversity (± SE) of birds during fall migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from August-mid-November 2006.

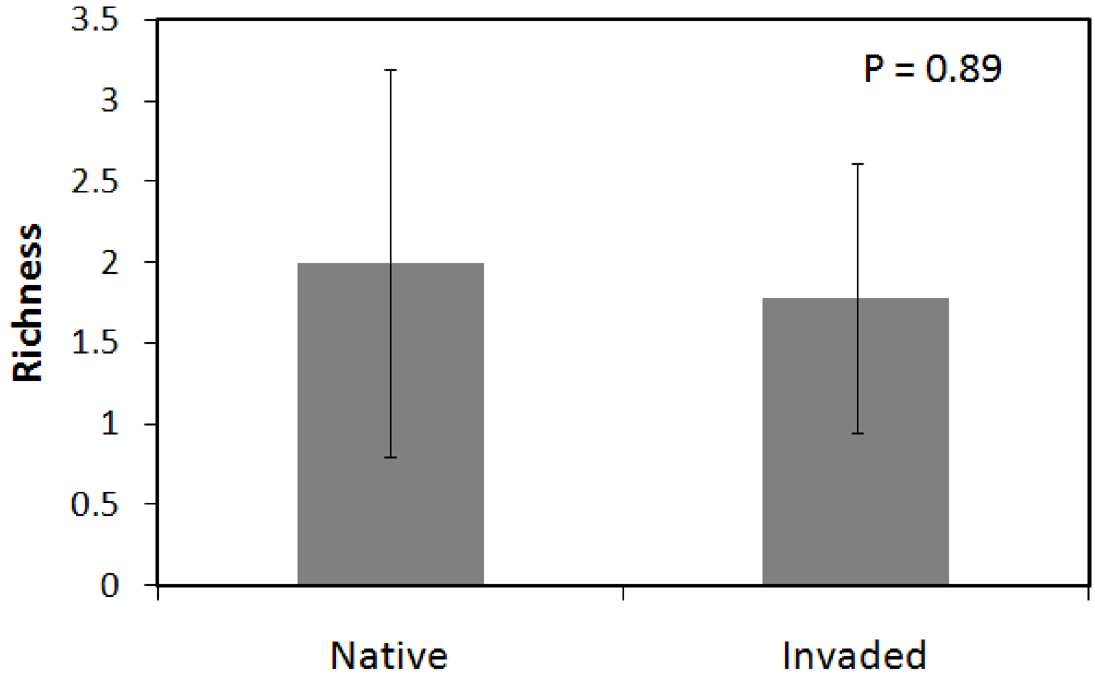

Figure 9. Mean species richness (± SE) of birds during winter in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-November 2006-February 2007.

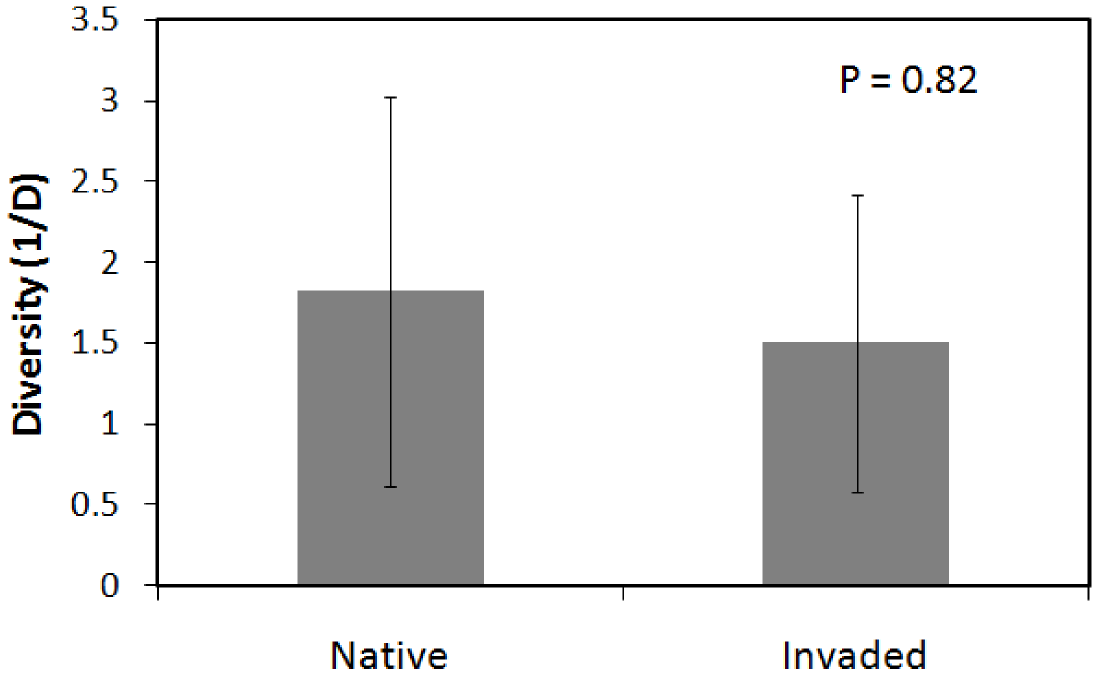

Figure 10. Mean Simpson's diversity (± SE) of birds during winter in diverse sedge wetlands (native) and wetland dominated by reed canarygrass (invaded) in southern Minnesota from mid-November 2006-February 2007.

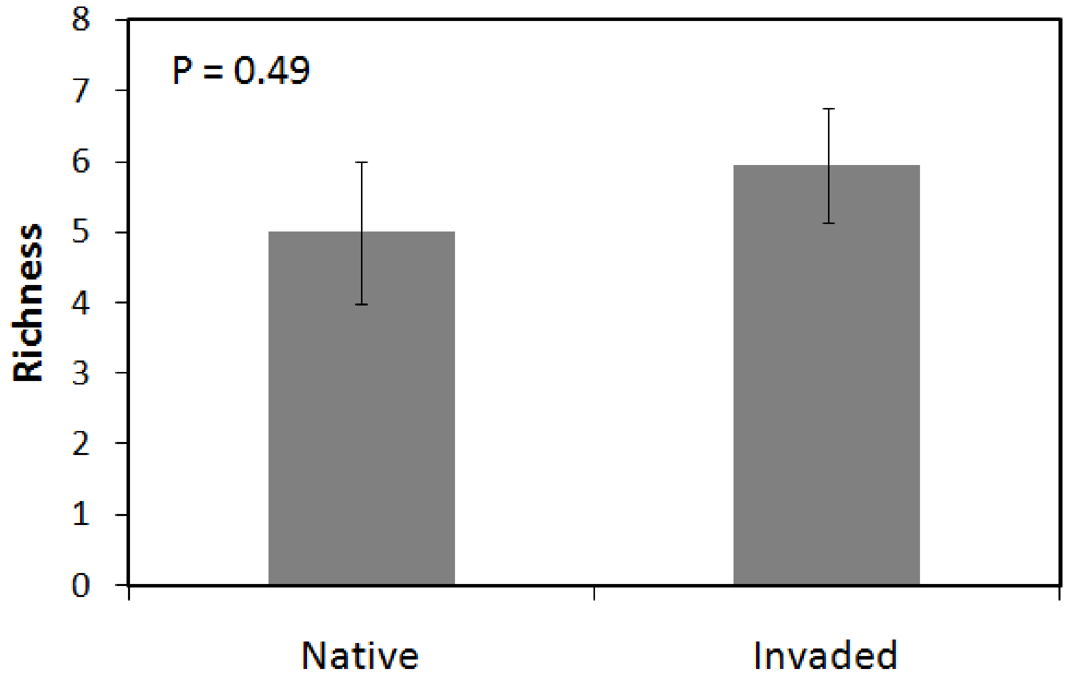

Figure 11. Mean species richness (± SE) of birds during spring migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from March-mid-May 2007.

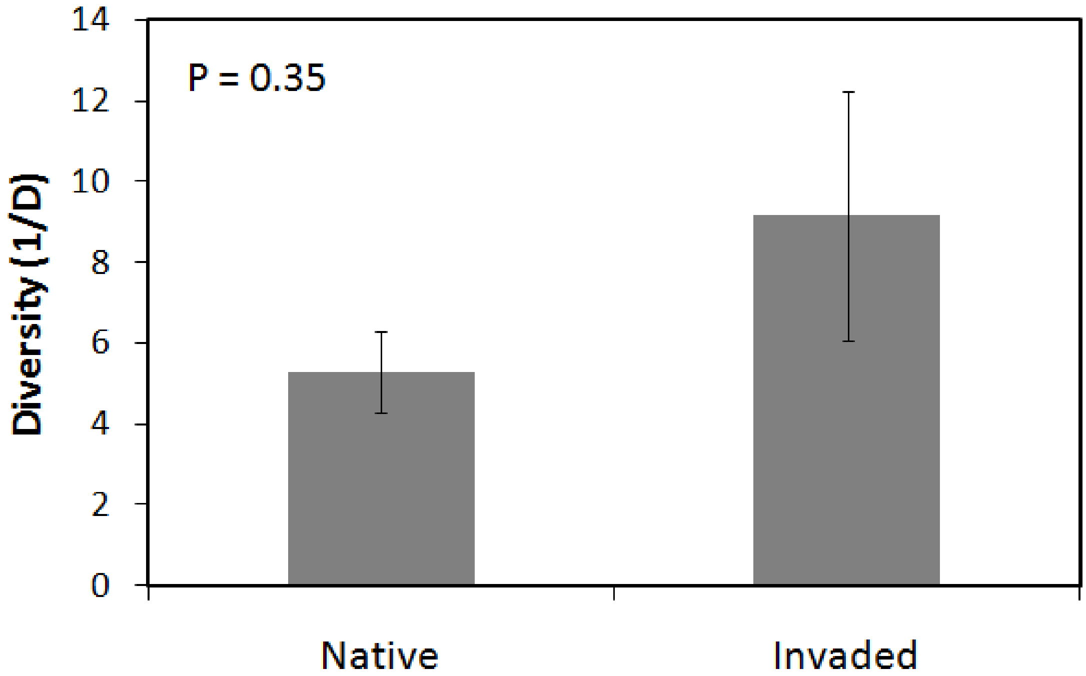

Figure 12. Mean Simpson's diversity (± SE) of birds during spring migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from March-mid-May 2007.

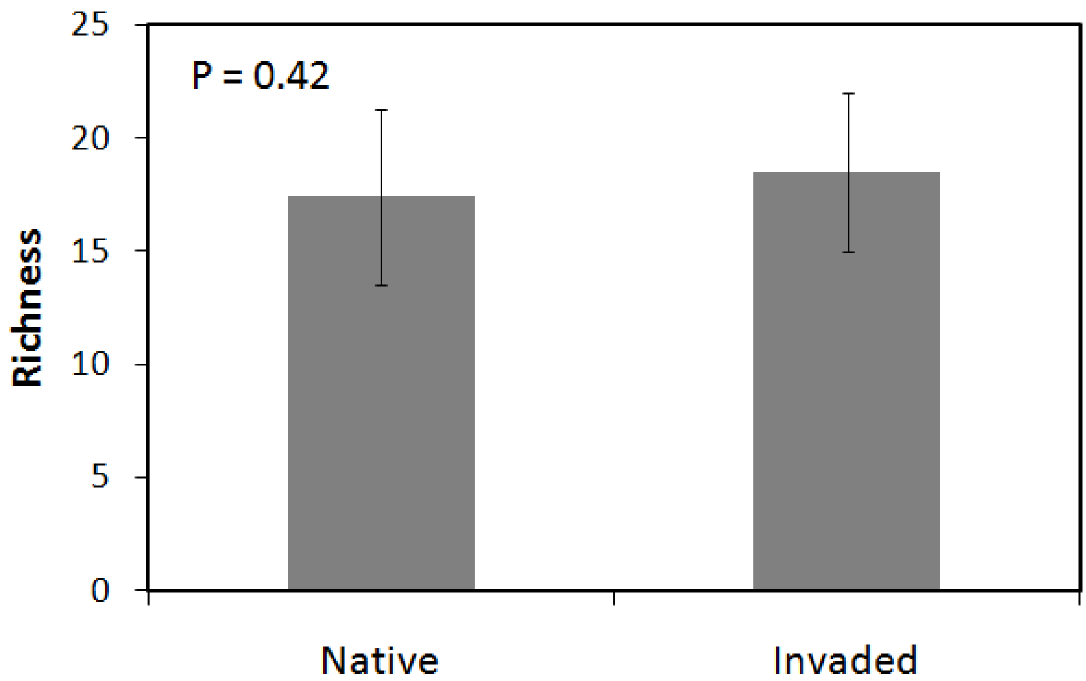

Figure 13. Mean species richness (± SE) of breeding birds in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-May-July 2007.

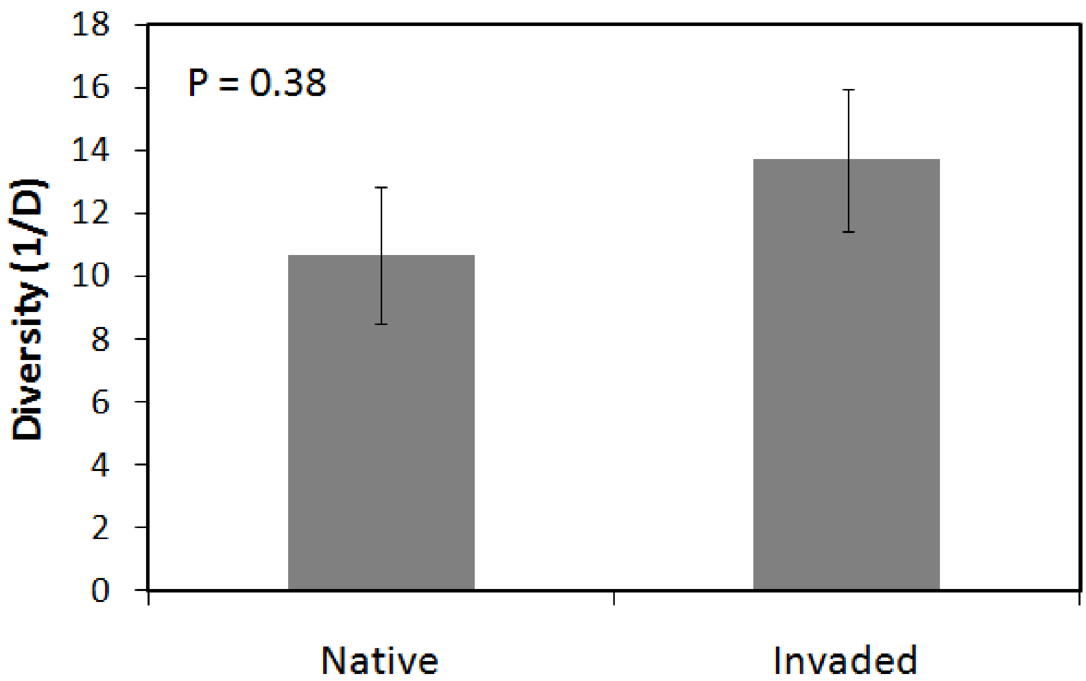

Figure 14. Mean Simpson's diversity (± SE) of breeding birds in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from mid-May-July 2007.

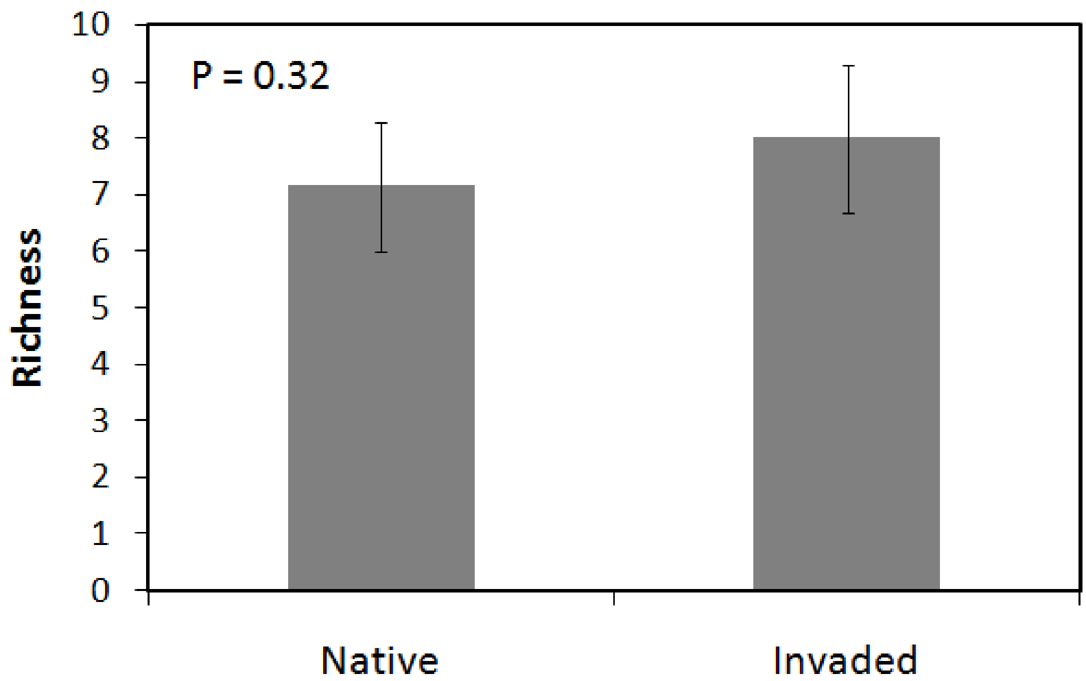

Figure 15. Mean species richness (± SE) of birds during fall migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from August-October 2007.

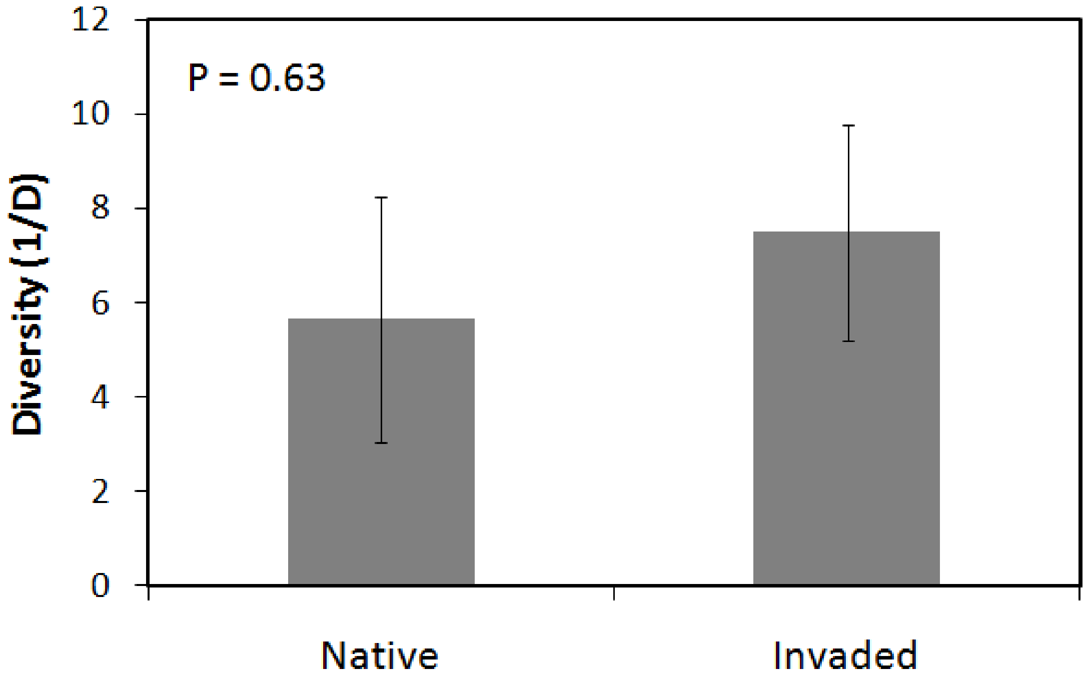

Figure 16. Mean Simpson's diversity (± SE) of birds during fall migration in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota from August-October 2007.

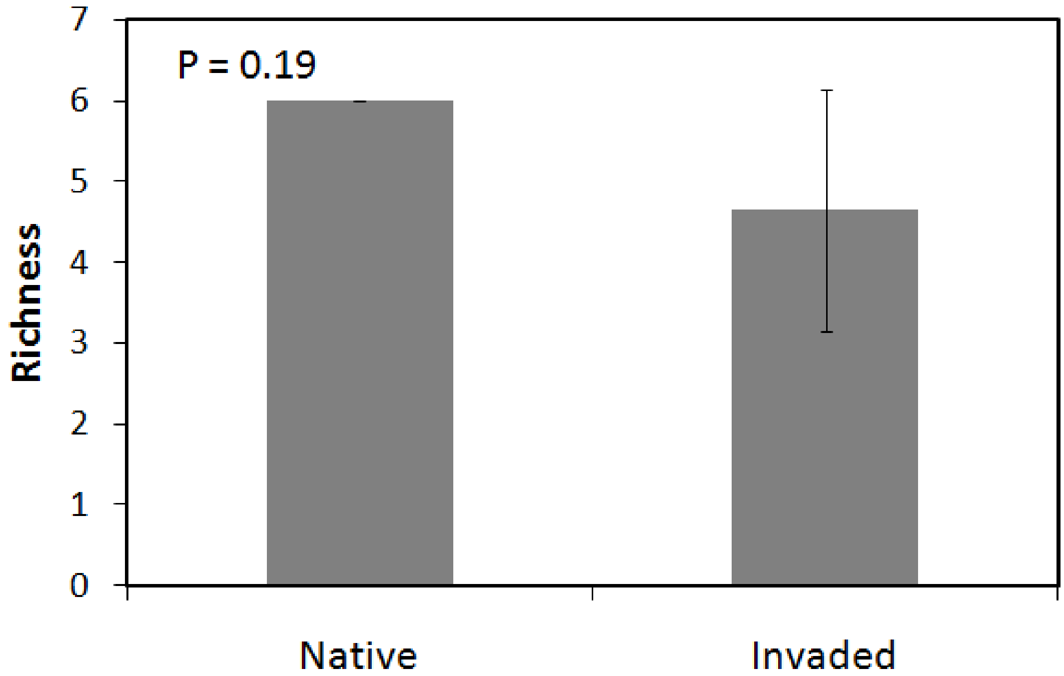

Figure 17. Mean species richness (± 1 SE) of small mammals in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota during June-December 2006.

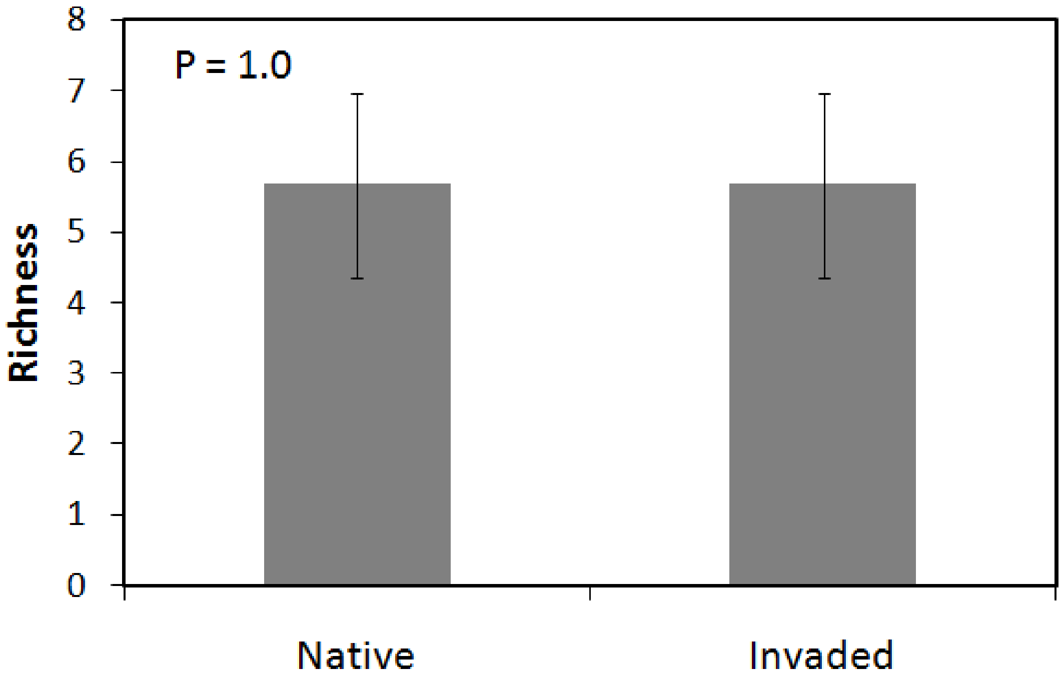

Figure 18. Mean species richness (± 1 SE) of small mammals in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota native and invaded wetlands during May-September 2007.

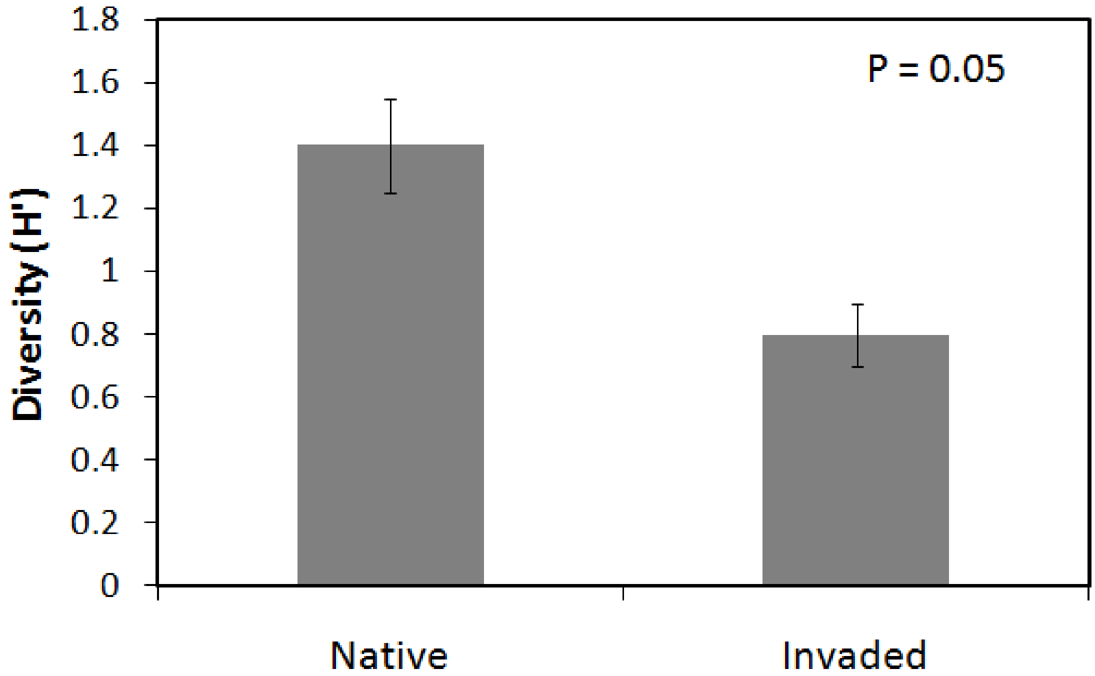

Figure 19. Mean Shannon-Weiner diversity (± 1 SE) of small mammals in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota during June-October and December 2006.

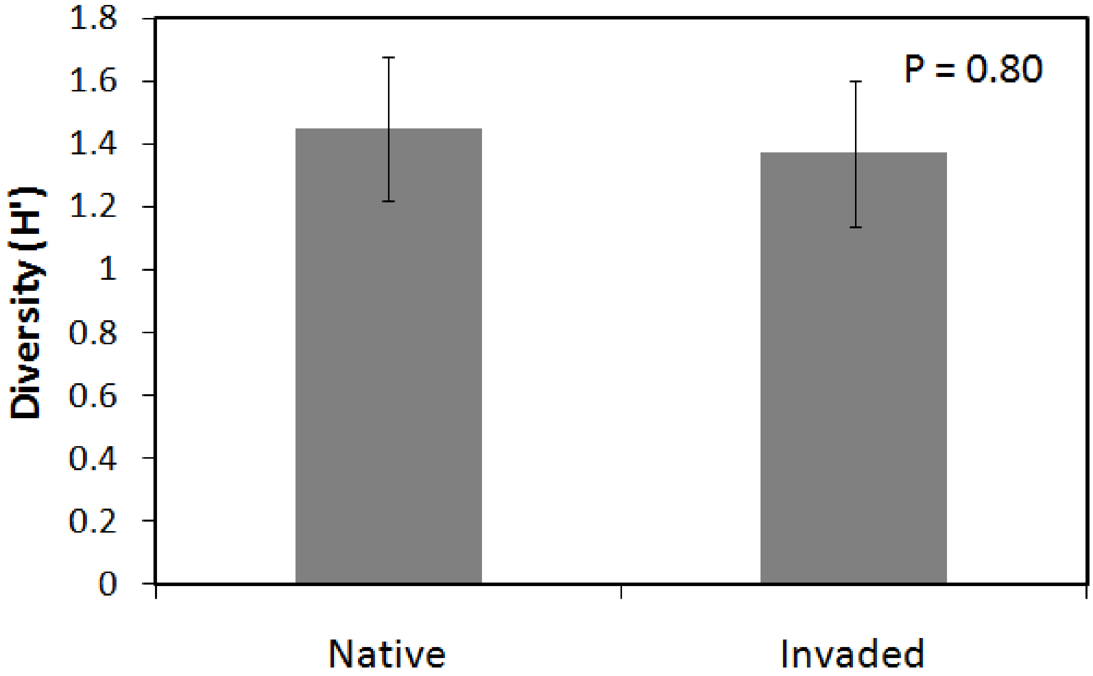

Figure 20. Mean Shannon-Wiener diversity (± 1 SE) of small mammals in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota during May-September 2007.

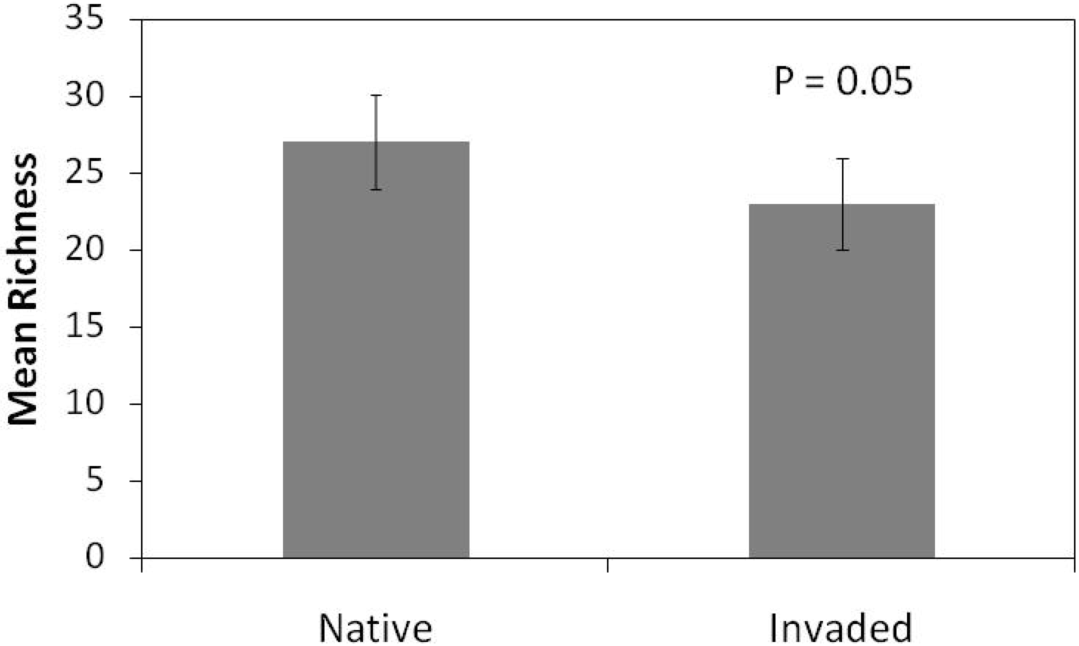

Figure 21. Mean richness (± 1 SE) of Families of invertebrates in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota native and invaded wetlands of southern Minnesota during summer 2007.

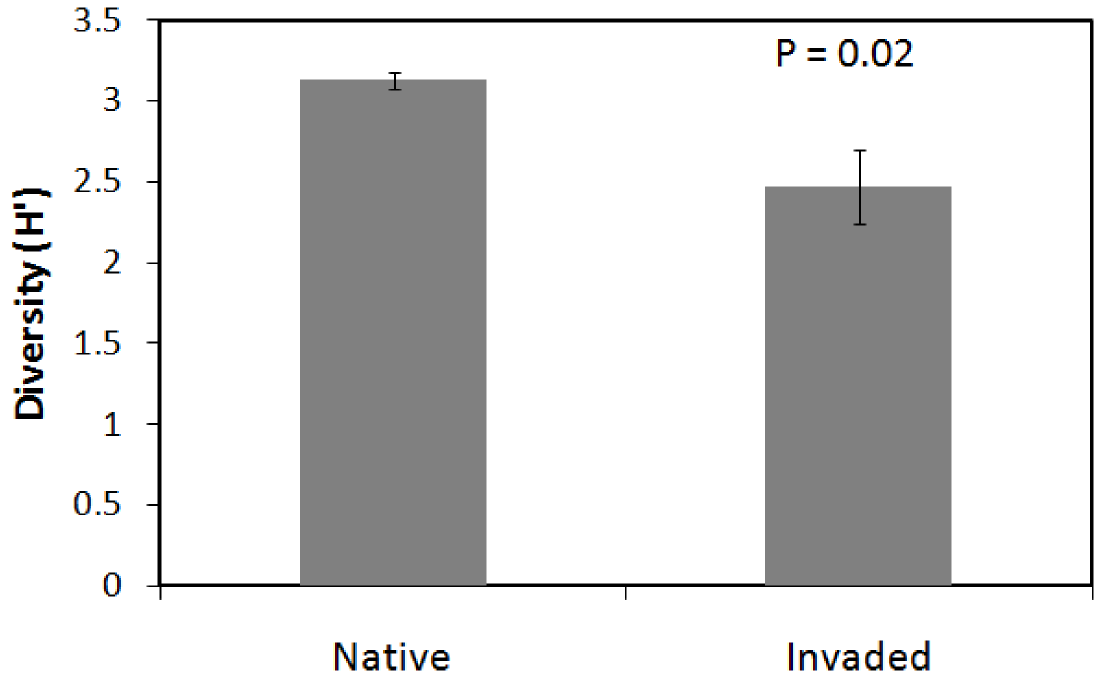

Figure 22. Mean Shannon-Weiner diversity (± 1 SE) of Families of invertebrates in diverse sedge wetlands (native) and wetlands dominated by reed canarygrass (invaded) in southern Minnesota during summer 2007.