Marshbird Habitat Analysis of Selected Pools of the Upper Mississippi River

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Abstract

Analyses were conducted to determine various habitat preferences for secretive marshbird species including the Virginia rail, sora, least and American bittern within the Upper Mississippi River National Wildlife and Fish Refuge and the Trempealeau National Wildlife Refuge . These birds are of special concern in the Refuge. The tape callback survey method was used to observe marshbird presence and numbers at 39 sites within the Refuge. The vegetative cover within study sites where relatively high numbers of wading birds were observed was then compared to the land coverage at sites that experienced below average waterbird observations. It was expected that sites that experienced high numbers of bird observations would exhibit land cover that was dominated by certain types of emergent vegetation, including *Sparganium*, *Scirpus*, and *Saggitaria*. The results of this analysis showed that marshbirds do indeed utilize various types of emergent vegetation for habitat. Presence of some other types of plant species do not seem to discourage marshbird habitat selection, and in some cases seems to enhance it. Some results indicate that there are specific emergent plant species, and other types of plants, whose presence are favorable for secretive marshbird habitat selection. Analyses were also conducted which shed some light on the variability and distribution of the vegetation types within the study areas, as well as on the effects of some human disturbances on waterbird habitat selection. Waterbirds do not seem to be terribly sensitive to nearby railroads, but might be somewhat sensitive to nearby urban and developed areas.

Introduction

A number of waterbird species are known to occur within the Upper Mississippi River National Wildlife and Fish Refuge. Four species in particular were detected by Kirsch (1994) during a two year marshbird study completed in Pools 4 and 6 of the Upper Mississippi River National Wildlife and Fish Refuge (UMRNW&FR), also to be referred to simply as the Refuge. These species are the American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), sora (*Porzana carolina*), and Virginia rail (*Rallus limicola*).

American bitterns are found in summer throughout most of the United States, Canada, and adjacent islands, except in the far north. A member of the Heron family, American bitterns typically grow to a size of 24-34 inches long, and possess a wingspan of about 50 inches (Terres, 1987). It is believed that American bitterns occur within the Refuge annually from late March/early April through late August or early September. They tend to be solitary nesters who are usually hidden in bogs, marshes, and wet meadows of either fresh or salt water. American bittern's favorite foods include frogs, suckers, and watersnakes that are abundant in these types of habitat conditions (Terres, 1987). The American bittern was among 30 non-game bird species in North America which had experienced declining populations in the previous 15 years (Hands, 1989).

Another bird that is in this category is the least bittern, the smallest member of the Heron family (Hands, 1989). Typically least bitterns grow to be 11-14 inches long, with a wingspan of 16-18 inches (Terres, 1987). This bird also occurs within the Refuge during the months spanning April to September, and it breeds from late May through early July. Least bitterns are solitary to loosely colonial nesters, who prefer dense emergent habitat types. Their nests usually consist of a platform of emergent vegetation and sticks. They typically feed on fish, insects, amphibians, and small mammals.

The sora typically grows to 8-10 inches long with a wingspan of 12-14 inches (Terres, 1987). Soras are solitary nesters who prefer dense growth of cattails and reeds in almost any small freshwater marsh along a river or pond (Terres, 1987). Attractive food sources to the sora are the small mollusks and aquatic insects that are found in marshes. Soras are most likely observed in the Refuge between April and September.

Virginia rails summer in freshwater marshes from southern Canada south throughout the United States. They grow to 8-10 inches long, and have a wingspan of 13-14.5 inches (Terres, 1987). The eating habits of the Virginia rail differ slightly from the birds described above, in that the Virginia rail likes to probe mud with its bill for earthworms and larval insects. It also eats slugs, snails, small fishes, and other things (Terres, 1987).

The main objective in this study was to determine what vegetative characteristics within the Upper Mississippi River floodplain are seemingly attractive to marshbirds in habitat selection. Another objective was to discover how various types of human disturbances affect marshbird habitat selection. It is known that the aforementioned birds are attracted to emergent types of vegetation that are found in marsh areas, but there is less understanding of what specific plant species these birds are attracted to, or whether marsh plant species content has any significant effect on the habitat selection of marshbirds. Also little is known about the effects of human disturbance on marshbird presence . For wildlife biologists at the Upper Mississippi River National Wildlife and Fish Refuge, these types of information are invaluable in enabling proper management for these birds, who are of special concern in the Refuge. For instance, with this information managers can determine if they need to protect and restore habitat of a particular plant species or series of them, or if simply preserving a broad category of emergent species is enough for the proper management of these birds. This information also can help managers to determine if searching for marshbirds various human disturbances is a worthwhile endeavor. Geographic Information Systems software, more specifically ArcView GIS Version 3.0a from Environmental Systems Research Institute (ESRI), was used to develop the appropriate data and perform the analyses that would provide this information.

A Geographic Information System is a database management system that allows spatial operations to be performed on data. Perhaps the greatest asset of utilizing GIS technology is that it provides the capability to develop visual representations of the types of events that are taking place in a geographic location. If managers are provided with graphic representations of information, they are able to come to better understandings of the data than if, for example, they have only standard database records to view. These types of data sets are essential for the development of a GIS project, but are not very effective for analysis in and of themselves. Another value of using GIS is that it allows for data to be easily subsetted for analytical purposes. Analysts are often confronted with databases that contain information that they need, but also have large amounts of data that are not needed for their purposes. GIS technology makes it relatively simple to extract data from large databases, therefore making analysis a less cumbersome process.

The use of GIS for the purposes of this project allowed for better understanding of the distribution of the 39 survey sites throughout the Upper Mississippi River National Wildlife and Fish Refuge and Trempealeau National Wildlife Refuge, vegetative characteristics within and surrounding the site, and how proximity of various human disturbances affects marshbird presence.

Methods

Data Collection

To determine the study areas for this project, 40 sites were randomly selected by wildlife biologists at the Refuge where marshbird data had been recorded during the summers of 1994 through 1998. Only 39 of these sites were used in the project, however, because it was discovered that inaccurate data had been recorded for one of the study areas. The remaining sites fell within a number of different pools of the upper Mississippi River lock and dam system, including pools 4, 5, 5a, 6, 7, 8, 9, 12 and 13. For each year, data were recorded for each site that included the number of Virginia Rails, soras, American and least bitterns present, and the number of times the site was visited for marshbird observation purposes. The Fish and Wildlife Service also provided Universal Transverse Mercator (UTM) coordinates for the location of each survey site. These coordinates were collected using Global Positioning Systems (GPS) technology.

The survey method that the Fish and Wildlife Service field technicians used to gather the bird data was the tape-playback survey method. During data collection, cassette recordings of the appropriate marshbird calls were used to elicit responses from bitterns and rails. The volume of the broadcast calls was approximately 90 db measured one meter from the source. The orientation of the audio call was recorded as an azimuth by the field technicians. Data were collected from late May until late June of each year between 1994 and 1998.

Because the main objective of the study was to perform analyses regarding habitat selection by secretive marshbirds, it was essential to obtain

GIS land use coverages of all of the pools of the upper Mississippi River that contained study sites. Such coverages are available for free download from the web site of the Upper Midwest Environmental Sciences Center, located in Onalaska, Wisconsin (www.emtc.nbs.gov). Land use coverages of all appropriate pools were downloaded. These coverages represent 1989 land use data, and contain both generalized land use data within their associated attribute tables, as well as detailed land use data that describe coverage polygons to a plant species level. The latter data were primarily used for this study.

Railroad coverages were also downloaded from the web site of the Upper Midwest Environmental Sciences Center, to investigate whether or not the proximity of them had any apparent effects on marshbird presence. Similar analyses were desired regarding the effects of roads on marshbird presence, but because most sites were simply observed by technicians from roads adjacent to the wetlands, conducting them was not a worthy endeavor. Proximity of the study sites to urban and developed areas was also analyzed using the land use coverages mentioned above.

All coverages received from the Upper Midwest Environmental Sciences Center are projected in Zone 15 of the Universal Transverse Mercator coordinate system, and in the North American Datum, 1927.

Tape-Playback Method Logic

Secretive marshbirds tend to vocalize infrequently, and their habitats are localized and largely inaccessible to most observers. Consequently, a method of surveying was needed that allowed technicians to gather data without actually penetrating into the bird's habitat. As stated many sites were simply observed from adjacent roads. In a similar study conducted in Maine, researchers found that the broadcast of tape-recorded calls at 60 wetlands improved marshbird species detectability 320 percent over passive observation (Gibbs and Melvin, 1993). During this study least bitterns, soras, and Virginia rails were detected primarily within 50 meters of observers, while American bitterns were detected up to an estimated 500 meters from observers. Gibbs and Melvin (1993) also determined that 3 visits per season to an individual study site were adequate to determine the presence or absence of all species with 90 percent certainty. This does not mean that all marshbirds present will respond to the taped calls, but simply that their presence can be identified in an area by at least one waterbird response. Because of the nature of the technique, it is vital that the technicians collecting the data are very familiar with the calls of each of the targeted birds. Data recorded for each individual type of bird were grouped together for the purposes of the analyses, because there was not adequate data to analyze habitat characteristics for each individual waterbird species.

Data Issues and Concerns

Concerns arose because of the substantial time differences between the data represented in the land use GIS coverages used for this study and the collection of the bird data. More recent GIS land use coverages were simply not available for use in this project. As stated, 1989 land use coverages were used, while bird data were collected seasonally between 1994 and 1998. This introduces possible error into the data, and therefore the analysis. It is possible that there have been substantial changes in some land patterns on the upper Mississippi River floodplain in the past 10 years, and that the data for some areas do not necessarily represent the types of vegetation that covered the appropriate areas during the actual collection of the bird data. This must be kept in mind when reading this paper, and when using the analyses within it for any purpose.

Creation of Coverages

The next step involved in the project was to simply plot the study site locations on the appropriate land use GIS coverages collected from the Upper Midwest Environmental Sciences Center. For this purpose all study sites that fell within the same pool were grouped in a Microsoft Excel database which included all data associated with the study sites; such as the UTM (easting and northing) coordinates, the orientation of the study site, and the bird data associated with the site. For example, all study sites that fell within Pool 6 of the Refuge were put into the same Excel database. Once these tables were created for each of the necessary pools, it was a relatively simple process to bring the data into ArcView GIS 3.0a software. This was done by utilizing ArcView's "Add Event Theme" command, which brings in a database (.dbf) file and plots the geographical features in it according the coordinates that are found in the original Excel database. In this case, points were plotted by specifying the databases "Easting" and "Northing" fields, which contained the UTM coordinates for each site within each pool. Later, each individual site was put into its own theme by first selecting the point, and then using ArcView's "Convert to Shapefile" function. This allowed work to be conducted for each site independently of the others within the same pool.

Once the study site point locations were plotted on the correct land use maps and their locations verified with wildlife biologists at the Refuge, the next step was to determine how the study areas would be represented on the land use coverages. It was determined by Refuge biologists that study sites for this project should be represented with a conical shaped area. These cones represent the hypothetical extents that the recorded bird calls reached across the landscape using the tape playback data collection method of eliciting vocal responses from secretive marshbirds.

Determining a method of creating conical representations of the study areas was a very problematic process. Not only was it required that the cone representing each site be of the same dimensions and area, but the shape also had to be rotatable in order to represent the varying orientations of the recorded bird calls in the field. Several methods were tested to accomplish this. Unfortunately, none of them were successful. Thankfully, Saint Mary's University of Minnesota graduate student Timothy Fox was able to create an extension using ArcView's Avenue programming language that solved this problem. This extension allowed simple specification of study area dimensions and azimuths.

Wildlife biologist Eric Nelson of the Fish and Wildlife Service in Winona, MN was consulted to determine what the actual size and dimensions of the conical shape representing the study areas should be. This was a rather arbitrary decision, because the audibility of the recorded calls across the landscape could have varied from day to day due to weather conditions and so forth. Also, it would have been very difficult to test how far the sound projected, as it would have required technicians to penetrate dense marsh areas. Because of the subjectivity of this decision, Eric Nelson was forced to prioritize what he thought were important traits for the study areas. First, he wanted the sites analyzed to be approximately 5 acres in area. Secondly, the angle of the cone at the study site point location (the point where the tape recorder was placed during data collection) was to be set at 135 degrees. After some trial and error, using Tim Fox's Avenue extension conical study areas that met these requirements were developed. The exact area of the cones developed were 4.591 acres. They extend from the study site point location outward about 400 meters. These dimensions roughly match Gibbs and Melvin's estimates of the distances that marshbirds can be observed from using the tape callback data observation method (Gibbs and Melvin, 1992.) Wildlife biologist Nelson approved these study area parameters upon demonstration of them to him. Figure 1 is a graphic representation of the conical study area dimensions, and of the relationship between the cones and the study site point locations.

Once cones such as this were developed for each study area, it was possible to begin performing operations on the land use coverages that were

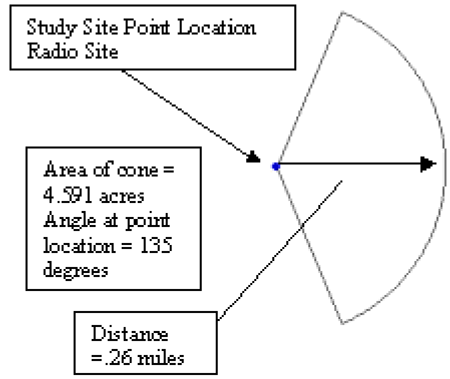

Figure 1. Conical study area dimensions and relationship to survey point locations

necessary to this study. Because most of the intended analysis was only concerned with land use classification trends within the conical study areas, the areas of the land use coverages that fell within the cones were subsetted from the areas that were not in the study areas. This was done using ArcView's X-Tools extension and it's "Clip with Polygons" function. One by one, the process of "clipping" the land use coverages (or shapefiles, as they are commonly referred to in ArcView) was done to bring them to the extent of each study area. This left 39 cone shaped land use shapefiles, one for each study site.

Wildlife managers and biologists at the Upper Mississippi River National Wildlife and Fish Refuge were also interested in obtaining information about the types of land coverage that exist outside of the study areas. This information allows them to not only come to an understanding of what land trends are found within the study areas, but also what is surrounding them. It is important to come to these broad understandings to properly manage for a particular species habitat.

For this reason, it was determined that each survey point location would have a buffer of 0.5 miles placed around it. This was also done using ArcView's X-Tools extension, with its "Buffer Selected Features" function. Once the 0.5 mile buffer was created for each site, the "Clip with Polygons" function of X-Tools was again used to subset the large land use coverages that encompassed entire pools of the Upper Mississippi River down to the extent of the point buffers. This process was very similar to the one used for subsetting the land use coverages to the extent of the conical study areas. Figure 2 displays a typical study site after these processes have been completed, showing the relationship between the conical areas and the 0.5 mile buffered areas, as well as land use polygons that fall within their extents.

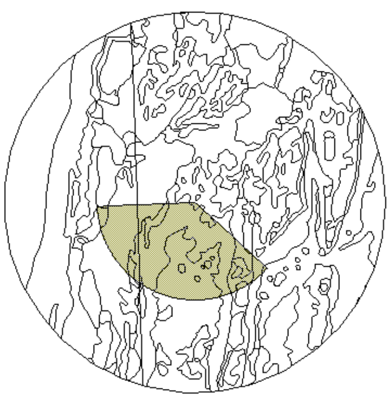

Figure 2. Study site cone and 0.5 mile buffered area (from the speaker location) with land coverage clipped to their extents.

It should be noted that the conical study areas for each survey site were the primary subject of analysis for this study. Large amounts of useful data were developed for biologists at the Upper Mississippi River National Wildlife and Fish Refuge regarding the 0.5 mile buffer areas around each site, but the analyses presented in this paper are focused on the content of the conical shaped study areas.

Data Manipulation and Organization

After all of the conical study areas and 0.5 mile buffered areas were created and had land use coverages clipped to their extents, databases existed for each site that contained only land use data within each cone and buffer. This is an example of how GIS software can be utilized to make large datasets more manageable.

At this point, each land use polygon within the conical and buffered areas was represented individually, with their own sets of attributes describing the spatial information contained within them. The data of significance for the purposes of this project were found in the "Veg_code_d" field of the land coverage feature attribute tables. In each table this field held data that described land use polygons to a species level. To come to a better understanding of the land use data within the conical study areas and the 0.5 mile buffered areas, tables were created in ArcView that grouped together all polygons that shared the same values in the "Veg_code_d" field. For example, all polygons with a value of *Scirpus* were grouped together for a given study site. To do this, ArcView's field "Summarize" function was used. Using this function, tables were generated for each site's conical shaped study area and 0.5 mile buffered area in which polygons were grouped by plant species content. The total acreage for each land cover type within the study sites and buffered areas was calculated and added to these tables, as was the percent of these areas that each land classification occupied. Also placed into each of these tables was a "Count" field, which simply represents the number of polygons within a cone or buffered area that are of a given land classification. These tables provided data summaries that were very helpful in the analyses conducted for this study. Figure 3 displays a sample of one of these site summarization tables.

12sl3acres.dbf

Veg_code_d	Count	Sum_Acres	Percent
Forest-mesic (moist soil sp.)	4	0.9090	19.800
Leersia	2	0.1270	2.800
Lemnaceae/submergents	2	0.6370	13.900
Mixed forbs and/or grasses	3	0.0750	1.600
Nelumbo/submergents/Lemnai	1	0.0470	1.000
Phalaris	2	0.1730	3.800
Rdside-levee/grass/forbs/shru	1	0.0220	0.500
Sagittaria	2	0.2580	5.600
Scirpus/Leersia	2	0.1900	4.100
Water	2	0.2880	6.300
Outside of Pool	1	1.8640	40.600

Figure 3. Example of table generated using ArcView GIS to “summarize” an individual conical study area. Such tables were generated for every study site and buffered area.

After each of these summarization tables were created, it was determined that it would be helpful for managers at the Refuge to obtain the cone and buffered land use data in a format where their associated statisitics could be viewed together for each site. This would make it easy for them to visually compare the land coverage statistics within the study areas to the coverage in the buffered areas. These tables were created by exporting both the database files (.dbf) representing the land classifications within the conical study areas and the buffered areas from ArcView GIS, and then combining them in Microsoft Excel file format (.xls). Marshbird data (including number of specific birds, total number of birds, and so forth) for the associated sites were added to these spreadsheets, as were the distances of each survey point locations to the nearest roads and railroads. The results of this process were 39 Excel databases, each of them containing all of the appropriate data for a particular study site except for proximity to urban and developed areas, the analysis for which were conducted after these tables were generated. Not only were these databases critical to the analyses, but they will also serve as quick references for wildlife biologists and managers who need information about a specific marshbird study site in the future.

Results and Discussion

Vegetation Analysis

Having created tables that contained all pertinent information about each site, it was then possible to move into the analysis portion of the project. For this statistics were calculated which led to a better understanding of the large quantity of information that had been generated.

To obtain a general overview of what vegetation types occurred most often within the study sites, data were sorted through for each study site and the vegetation classes that fell within them were tallied. From this tally list it was possible to determine which types of vegetation occurred most often within the 39 study sites (Table 1).

Table 1. The five most commonly occurring plant classifications within the 39 study areas.

Veg_code_d	**Number of Sites**	**Percent of Sites**
Acer	26	66.7
Sagittaria	24	61.5
Lemnaecae/ Submergents	22	56.4
Mixed Forbs And/or Grasses	20	51.3
Scrirpus	29	48.7

Finding this information allowed for a better understanding of the vegetative composition of the study areas, and also determination of which species should have close attention paid to them in later analyses.

The next task that needed to be done was to determine a method to separate study sites based on whether or not their secretive marshbird observations were high or low relative to the other sites. This information was needed to establish a methodology by which the sites exhibiting relatively high numbers of bird observations could be compared to the ones where relatively few birds were observed by field technicians. Because each site was visited a different number of times over the five year survey period, it was not feasible to simply use bird counts as the divisive factor, as sites which had been visited more often would have had an advantage. Instead, a decision was made to calculate the number of birds that were observed per visit for each site. After this, the average number of birds per visit for all 39 study sites was calculated.

It was discovered that the study sites averaged 0.79 Virginia rail, sora, least or American bittern observations per visit. For comparative purposes, the study sites were then simply divided into two groups; sites where greater than 0.79 birds were observed per visit and those where less than 0.79 birds were observed per visit. Only 12 sites were above the average, while 27 fell below. Because the number of above average sites as compared to below average sites was quite skewed (12 versus 27), it may have been beneficial to use the median of the birds per visit statistics as the divisive factor in order to have more balanced numbers of the two types of sites.

Having divided the sites in such a way, it was then possible to investigate what vegetative characteristics the sites with above average bird observations per visit might exhibit that below average sites might not.

Next a tally analysis similar to the previous one was conducted to determine which plant species occurred most in study sites which exhibited less than average bird observations per visit versus land coverage in sites with above average bird counts. This method was valuable in that it allowed for comparative analysis of the vegetative characteristics for sites with above and below average birds observed per visit. The most often occurring plants observed in sites where below and above average bird observations were made are shown in Figures 4 and 5, respectively.

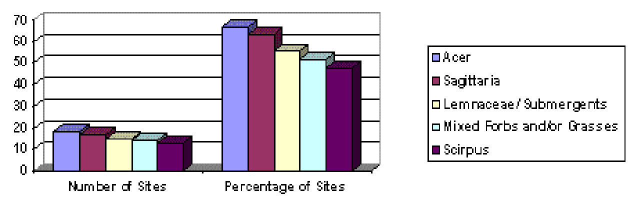

Figure 4. The most commonly occurring plant species classifications for study areas with below average marshbirds observed per visit

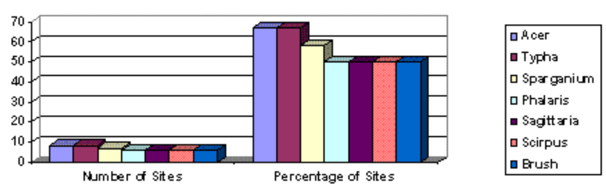

Figure 5. The most commonly occurring plant species classifications for study areas with above average marshbirds observed per visit.

Developing the information contained in Figures 4 and 5 made it possible to perform comparative analyses on the data to determine what vegetative characteristics differed or remained the same between study sites where an above average number of marshbirds were observed as opposed to those of sites that experienced relatively low bird data. These analyses revealed what some types of plant species are that seem to be favorable and ones that do not seem to have an effect on marshbird habitat selection.

It was somewhat surprising that the species classification *Acer* was the most often occurring type in both areas that were above and below average marshbird observations. *Acer* falls within the broad vegetation classification of "Woody Terrestrial," and not within the "Emergents" category that was expected to dominate the study sites. However, because *Acer* is so prevalent in both types of sites it does not seem to have any drastic negative or positive effects on the presence of secretive marshbirds in an area.

The emergent species *Typha* is prevalent in sites with above average numbers of bird observations, and not so abundant in the other sites. As seen in Figure 5, *Typha* occurred in 66.7 percent of sites where above average numbers of marshbirds were observed, while it only was present in 18.5 percent of sites which displayed lower than average bird counts.

Sparganium is also an emergent plant species that seems to be favorable for secretive marshbird habitat selection. *Sparganium* occurred in 58.3 percent of sites with an above average number of bird observations, versus 25.9 percent of sites with lower numbers of bird observations.

While it was expected that this study might give an indication of what emergent plant species tend to attract secretive marshbirds, some of the following results were not expected. These results show that in many of the sites which exhibited higher than average birds observed per visit, other types of vegetation classifications (including "Grasses/Forbs" and "Woody Terrestrial" plants) were prevalent.

One plant species that falls into this category is *Phalaris*. This plant falls within the generalized land use classification "Grasses/Forbs." *Phalaris* is found in 50 percent of sites with above average birds observed per visit and in 37 percent of below average sites. Given that only 39 sites were used in the study, this might not be very strong evidence that *Phalaris* attracts secretive marshbirds. However, it is important to note that *Phalaris* made up 63.8 percent of the study site that exhibited the greatest number of birds observed per visit, Halfway Creek 4 in Pool 7. This may indicate that it is a favorable plant species for marshbird habitat. Because of the small sample size of sites, however, this information could be misleading.

Brush also was present in a much greater percentage of favorable bird sites than in sites with below average bird observations. It occurred in 50 percent of "good" bird sites and in only 22.2 percent of "bad" bird study areas. Like *Acer, Brush* is also a "Woody Terrestrial" plant classification.

"Comparing Two Proportions" tests were performed on *Typha, Sparganium, Phalaris,* and *Brush* to determine if the differences in their presence in above versus below average marshbird sites were statistically significant. The results of these tests are summarized in Table 2.

From the results exhibited in Table 2, it can be determined that *Typha* is the only one of the four species that was statistically proven to occur more frequently in sites with above average birds per visit than in sites with below average waterbird observations ($P < .05$). This is because it is the only species that exhibits a Z-value greater than the critical Z-value.

Table 2. Results of "Comparing Two Proportions" statistical tests at 95% confidence (one-tailed test).

	Z-value	Critical Z -Value
Typha	2.6	
Sparganium	1.609	
Phalaris	.412	
Brush	1.503	1.65

On the other hand, the proportions of *Sparganium*, *Phalaris*, and *Brush* in above average sites compared to below average study areas did not prove to be statistically different ($P > .05$). It can be seen, though, that both *Brush* and *Sparganium* are nearly statistically significant, as their Z-values are rather close to the critical value. This might indicate that these vegetation types should be further researched with regard to their impacts in secretive marshbird presence.

The remaining plant species that were present in high percentages at both types of sites (many bird observations and few bird observations) were very comparable and for the most part emergent type species. These include *Sagittaria* and *Scirpus*. Because these species occurred often in both above and below average bird observation sites, it is impossible to come to any conclusions or hypotheses about the affects of these species on secretive marshbird habitat selection.

Using the methodology for this project, it seems that these birds are attracted to areas that have both emergent and non-emergent types of vegetation cover, though only *Typha* proved to exhibit a statistically significant difference in the frequency of its occurrence in above average marshbird sites versus below average sites. It is important to remember here the possible error that was introduced when 1989 land use data were used to reference bird collection data from 1994 to 1998. It is also important to note that the "Comparing Two Proportions" test renders more accurate results when utilizing greater sample sizes. Given the relatively small sample size utilized for this project, it must be said that these numbers are not necessarily representative of what they would be had more study areas been used.

Variability/Distribution Analysis

The above analyses seem to indicate that marshbirds are attracted to areas which contain a diverse plant species makeup. To further analyze the land cover distribution within the study sites it was important to generate more detailed information to study the average polygonal distribution within the sites. In this analysis, study areas where bird counts were above average were once again compared to sites that experienced relatively few marshbird observations.

To come to more of an understanding of the spatial distribution of the study areas, numbers were also developed that referred to the variability and distribution of the vegetation types within the study sites. The goal in determining these numbers was to discover if marshbirds prefer areas with many different land patches in habitat selection, or if they would rather have areas with relatively homogeneous land cover. In Table 3 "Avg. Patches" is the average number of land use patches/polygons that fall within the sites. This was calculated for both sites that had above average and below average waterbird observations. Also calculated for both types of sites were the average number of plant species classifications (Avg. Species) that fell within the study sites. Results are shown in Table 3.

Table 3. Numbers developed for variability analysis of study sites.

	Avg. Patches	Avg. Species
Above Avg. Birds Per Visit	20.33	10
Below Avg. Birds Per Visit	22.7	10.44

As seen in Table 3, sites with above average birds observed per visit averaged slightly fewer polygons and number of species present per study site than sites with below average bird observations. Statistical t-tests were utilized to determine if these numbers are significantly different (Table 4).

Table 4. The t-test results for variability analysis. Test conducted at 95% confidence level (two-tailed test).

	t-Value	Critical t-Value
Avg. Patches	.978	
Avg. Species	.631	2.687

The results displayed in Table 4 show that there is no significant difference in the two means exhibited for both "Avg. Patches" and "Avg. Species" for above and below average bird sites ($P > .05$). Using this methodology, it is determined that polygonal and species variability do not seem to have much of an effect on whether or not marshbirds will be present in a certain study area.

"Comparing Two Medians" statistical tests were also conducted to determine if results would have differed had the variability analyses used medians, and not means as the divisive factor between above and below average bird sites. The results of these tests were that with regard to average patches and average numbers of species in a site, the medians exhibited by the above average bird observations sites were not statistically significant ($P > .05$) from below average sites.

Proximity Analysis

Measurements were taken using ArcView GIS to determine the distance from each study site point location to its nearest urban/developed area and railroad. These measurements helped to discover whether or not these human created structures and disturbances have a significant impact on the habitat selection patterns of Virginia rails, soras, and least and American bitterns. Once again, comparisons were made with regard to these data by calculating the average distances to these disturbances for study sites where greater than average numbers of birds were observed, and comparing these distances to those that relate to sites with below average marshbird observations per visit (Table 5).

As seen in Table 5, sites with above average waterbird observations are on average slightly farther away from roads than sites with below average bird observations.

Proximity of railroads did not seem to have any negative effects on marshbird habitat selection practices. In fact, on average sites with above average birds observed per visit were closer to railroads than those with below average bird observations.

On the other hand, in this study the proximity of urban and developed areas did seem to have an affect on the

Table 5. Average distance from study site point locations to nearest potential human disturbances. Distances are in miles.

	Avg. Distance To Railroad	Avg. Distance To Developed Areas
Sites with Above Avg. Birds/Visit	.48	.59
Sites with Below Avg. Birds/Visit	.57	.41

number of marshbirds observed at a particular study site. As seen in Table 5, study sites where bird observations were greater than the average were on average .18 miles further from urban areas than sites with below average bird observations. The trend in these data is that corridor type human disturbances such as railroads don't seem to have a negative effect on marshbird habitat selection, while urban and developed areas might. Once again, statistical t-tests were utilized to test if the numbers generated are statistically significant (Table 6).

These results show that distance to developed areas are closer to being statistically signicant in affecting marshbird habitat selection than are distance to railroads, as the distance to developed areas t-value is approaching the critical t-value. However, neither of these tests proved to be statistically significant (P > .05). Therefore, in this analysis, it cannot be stated that either proximity to railroads or proximity to developed areas has a statistically significant impact on marshbird presence. As stated earlier, proximity analysis to roads was not possible due to the methods used in data collection.

Table 6. The t-test results for proximity analysis at 95% confidence level (one-tailed test).

	t-Value	Critical t-Value
Distance To Rails	.626	
Distance To Developed Areas	1.368	1.687

Once again, "Comparing Two Medians" statistical tests were done to discover how results would have differed had medians been tested rather than means in the proximity analysis. With regards to proximity to railroads and developed areas, the median distances from above average and below average waterbird sites did not prove to be statistically significant (P > .05).

Summary of Analyses

As previously stated, the one of the key objectives of this project was to determine what habitat preferences are for secretive marshbirds (more specifically Virginia rails, soras, least and American bittern) in the Upper Mississippi River National Wildlife and Fish Refuge. Given the limited data that were available and the potential error associated with the data due to important time differences in data sets, it was impossible to narrow down the results of this study into a specific "key" habitat. It is possible, however, to apply the results of this study to make some generalizations regarding secretive marshbird habitat selection. For example, these marshbirds seem to thrive in areas with rather heterogeneous land cover characteristics. It was expected at the beginning of this study that the results would reveal that marshbirds are attracted to areas that are for the most part covered by emergent vegetation. This was true to an extent, as emergent species such as *Scirpus, Typha, Sparganium,* and *Sagittaria* were all found in many sites that exhibited greater than average numbers of bird observations. *Typha,* in fact, was the only species that proved statistically to occur more often in sites with above average bird observations per visit. It was surpising, however, that the presence of other types of vegetation were found often in sites with above average numbers of marshbirds. Indeed, *Phalaris* and other non-emergent plant species were some of the most commonly occurring species within study areas with high bird counts, though none of them statistically proved to be significant.

Proximity of railroads and urban/developed areas did not prove statistically significant with regard to marshbird presence. The proximity of roads analysis was skewed because of the nature of the data collection method, and therefore was left out of the study. It is interesting that on average sites with many bird observations were located closer to railroads than sites with below average bird counts. Railroads, therefore, do not seem to be a deterrent for marshbirds when they are choosing nesting sites. This is perhaps because railroads do not take up much area (being a corridor) and they are not a constant disturbance, as train frequency is not always very high. Though they did not statistically prove to have an impact on marshbird habitat select, developed areas might have some effects based on their t-values being relatively close to the critical t-value. From the analyses included in this paper, one could come to a general conclusion that marshbirds are not affected in habitat selection by corridor type human disturbances, but might be driven further away from large areas of developed land, which are characteristic of urbanized areas. Once again, this seems to be a trend, but was not proven statistically. Tests should be conducted in the future in order to come to more detailed conclusions regarding these issues.

Originally analyses similar to the work done for each study site was also going to be conducted for the half mile buffered areas around each study site. A great deal of information was generated regarding these areas, but were left out of the analysis at this time.

Value of GIS in Habitat Analysis

GIS technology, and ArcView software in particular, proved to be an invaluable tool for performing the analyses contained within this work. It was very effective for subsetting, manipulating, and organizing data. Graphic depictions of areas are essential to understanding the types of events that are occurring in those areas. With GIS it was possible to perform analyses of marshbird habitat sites. In addition to this paper, various maps and reports have been developed for the people at the Upper Mississippi River National Wildlife and Fish Refuge, as well as the Trempealeau National Wildlife Refuge. GIS was very useful in the creation of all of these products.

Potential for Use

This study will benefit biologists and managers at the two refuges in that it gives them a more detailed understanding of the types of land cover that marshbirds prefer in habitat selection. Because of data limitations and possible error that were introduced by using relatively old land use coverages, this analysis is not without error, but is useful nonetheless. Not only is the information generated in this work valuable, but this project can effectively serve as a pilot from which future studies can borrow from and improve upon.

In any analysis of marshbird habitat selection to follow, one suggestion would be that a greater number of survey sites be used that what was the case in this project. With only 39 sites to study, it was very difficult to know whether results pertaining to certain vegetative and proximity characteristics were truly representative of what is going on in the field.

Conclusion

In this study, sites preferred by secretive marshbirds were made up of a variety of plant species, both emergent and non-emergent types. Variability, with regard to the numbers of patches and plant species present in each site, did not seem to have any effect on marshbird presence.

Proximity of railroads to study sites seemingly had no effect on marshbird presence. Developed areas did not statistically prove to have such an effect, but seem to be a factor that should be taken into consideration in future marshbird habitat studies.

Potential error must be taken into account when using the contents of this analysis for any purpose. Hopefully this work will be valued for its general usefulness in understanding some of the issues that might affect secretive marshbird habitat selection. Due to data limitations and the small sample size, however, readers should be hesitant to use this as a sole basis for understanding marshbird habitat issues.

This project is an example of one application of geographic information systems technology. GIS's ability to manipulate and analyze data can be applied to any problem that references geospatial data. GIS is recommended not only in future studies of marshbird habitat, but for spatial analysis of any type.

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