Using a Geographic Information System to Analyze and Display Breeding Bird and Habitat Data Utilizing Image Base Maps for Decision Making Related to Land Management

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Abstract

The purpose of this study was to lay out a statistically valid sample grid and sample that grid to determine breeding bird occurrence, distribution, and habitat characteristics within Canaan Valley State Park, West Virginia. A graphical representation of the data was generated using a geographical information system (GIS) for identifying potential environmental impacts to these resources caused by factors such as land use specific to park events, new trail development, and habitat management.

A 250-meter grid was overlaid on a 7.5-minute USGS quadrangle using GIS. The centers of the grids were established as potential sampling points. The grid was oriented by selecting a random point on the map and rotating the grid a random number of degrees using the initial point as the axis. Sampling points were then selected systematically (every other point) using a random start. Points falling within highly developed or altered areas or open water were eliminated for sampling. Sampling points were not stratified by habitat, and those falling on divisions between two different habitat types were not rejected. A total of 162 individual points were selected for sampling within the boundaries of Canaan Valley State Park. All points were sampled once during June 2002 and again during June 2003.

UTM coordinates were generated for each sampling point. Sampling points were located in the field using a GPS receiver, topographic features, and plant community maps (aerial photographs). Sampling points were identified in the field using temporary markers during 2002.

Bird species and numbers present were recorded at each point using a fixed radius, independent double observer point count protocol. This protocol addresses the probability of detecting a bird when present.

Vegetation type and structure were recorded at each point within a 50-meter radius of each point. Dominant species were recorded for canopy, understory, and shrub layers. Cover density was estimated and scored as absent, sparse, moderate, or dense.

Analysis of the data allowed for the graphical representation of breeding bird occurrence, distribution, and habitat characteristics. Layered digital maps were created identifying such elements as vegetation density, vegetation type, and breeding bird richness and diversity.

Maps generated can be used by land resource managers to make decisions concerning potential environmental impacts on sensitive areas and breeding bird species. Impacts may result from special events, development within the park such as expansion of the golf course or ski slopes, and new trail development. Graphical representation allows the manager to view the actual area of possible environmental impact.

The geographic information system allows for the addition of future layers that contain information on other plant and animal communities within Canaan Valley State Park, West Virginia. This would broaden the knowledge base of the land manager, allowing more informed land management decisions.

1. Introduction

Geographic Information Systems (GIS) have been used for many years to support decisions related to resource management. Here we use a GIS to produce information that will enable the land manager to understand the resources he is responsible for and to make informed decisions concerning possible impacts to those resources.

The purpose of this paper was to use a geographical information system (GIS) to produce graphical representations of breeding bird and habitat data that would allow the land manager to make first-level decisions relative to potential impacts on these resources within Canaan Valley State Park, West Virginia. By transferring technical, paper-bound information into visual tools tailored to specific location characteristics, an initial platform can be established from which a more comprehensive GIS for resource management can grow.

Canaan Valley State Park is located in Tucker County in the highlands of West Virginia. It lies within Canaan Valley, a large oval-shaped valley 23 km long and 4–6 km wide. The valley floor is at an elevation of 975 m, with the surrounding mountain peaks rising to an elevation of 1,340 m. It comprises 2,430 hectares covered by a combination of hardwood and mixed hardwood coniferous forests, scrub swamp wetlands, wet meadows, hawthorn savannahs, and grasslands.

State park lands are relatively stable environments where development is usually limited to a small percentage of the total area. Development on Canaan Valley State Park includes approximately 200 hectares consisting of a championship golf course, a 34-trail downhill ski area, and a main lodge complex. Access roads are restricted to the south central and southwestern sections.

State parks lands represent a significant refuge for many species of plants and animals. A total of 181 bird species have been found on Canaan Valley throughout the year including permanent residents, migrants, and breeding and winter species. Eighty-six breeding species have been identified within the region (Northeimer 1996–2003; Buckelew and Hall 1994).

It is necessary for the land manager to understand the importance and extent of this resource, and to have access to information that will allow appropriate management decisions. Impacts on these resources could be caused by factors such as land use specific to park events, new trail development, and expansion of existing developed areas (ski area, golf course).

2. Data Collection

Any monitoring program for this purpose must be rigorous enough both from a design and implementation standpoint so that management decisions can be supported. The data set used for our GIS analysis consisted of breeding bird observations completed by the primary author and Marjorie Keatley during June 2002 and June 2003, utilizing the following sampling protocol.

A 250-meter grid was overlaid on a 7.5-minute USGS quadrangle using a GIS. The centers of the grids were established as potential sampling points. The grid was oriented by selecting a random point on the map and rotating the grid a random number of degrees using the initial point as the axis. Sampling points were then selected systematically (every other point) using a random start. Points falling within highly developed or altered areas or open water were eliminated for sampling. Sampling points were not stratified by habitat, and those falling near divisions between two different habitat types were not rejected. A total of 162 points were selected for sampling within the boundaries of Canaan Valley State Park. All points were sampled once during June 2002 and again during June 2003.

UTM coordinates were generated for each sampling point. Sampling points were located in the field using a GPS receiver, topographic features, and aerial photographs. Sampling points were identified in the field during Spring 2002 and temporary markers were placed.

Bird species and numbers present were recorded during a five-minute period at each point using a fixed radius, independent double observer point count protocol (Nichols et al. 2000). This protocol was used to address the question of detectability—the probability of detecting a bird that was present and singing.

The location of each bird detected was marked within two concentric circles on a field sheet. The circles represented a distance of 50 m and 100 m from the center of the sampling point. Each of the two observers independently recorded birds on a field sheet. Once the count was completed at each sampling point, the observers compared and justified observations. Individual birds recorded by both observers were noted, as well as birds recorded by a single observer (the individual observer was identified).

Vegetation type and structure were recorded at each point within a 50-meter radius of each sampling point. Dominant plant species were recorded for canopy, understory, and shrub layers. Cover density was estimated and scored as absent, low, moderate, or dense. Aspect, slope, and moisture regime were also recorded.

3. Data Analysis

Breeding bird and habitat field data were entered into Microsoft Excel spreadsheets and converted to database file format (DBF4) for incorporation into the GIS. ArcGIS® 9 Desktop software (with ArcGIS Spatial Analyst™ and Arc-

GIS 3D Analyst™ extensions) from ESRI, Inc. was used exclusively for GIS data analysis, graphical display, and map production.

Imagery used included National Land Cover Data (West Virginia, Version 05-27-99), and landcover maps of Canaan Valley (habitat and dominant cover species) developed by Ron Fortney, Salem-Teikyo University, Salem, West Virginia, in 1997 (Fortney 1997) as revised in 2001; DEM raster elevation data at 3 meter resolution compliant with National Elevation Dataset standards (UTM Zone 17 Projection, horizontal datum NAD 83, vertical datum NAVD88); and digital natural color orthophotography for the state of West Virginia created by the WV Statewide Addressing and Mapping Board (SAMB) 2003.

4. Results

The data were analyzed in many different ways and all possible graphical representations were considered. We were looking for maps and map layers that would have the greatest utility for the land manager when making first-level decisions.

Analysis of the data allowed for the graphical representation of breeding bird occurrence, distribution, and habitat characteristics. Digital map layers were created for breeding bird distribution and relative abundance by species, field count sheets were georeferenced to the corresponding landcover data for selected species, and species of management concern were highlighted. Other layers generated for the park included hillshade, aspect, contours, and slope.

5. Bird Detectability and Relative Abundance

It was important to ensure that the probability of detection was high enough for each species so that a bird present and singing during the recording period was in fact detected and recorded. The independent double observer data for both 2002 and 2003 were analyzed using DOBSERV software from Patuxent Wildlife Research Center (Hines 2000). The model selected assumed a difference in detectability both between species and between observers. Probabilities for detection of a bird when present and singing were equal to or greater than 95% for all species on all counts with the exception of Blue Jay (2003) and Red-winged Blackbird (2003). See Tab. 1.

6. Determining Sample Area and Landcover Composition

The sampled area (508 hectares) represented 21 percent of the total park area (2,430 hectares).To determine whether the area sampled was representative of the entire park, 100-meter buffers were created around each sampling point, representing the outer limit (fixed radius) of each point count area. These buffers were used to clip corresponding sections of the landcover map (Fortney 1997). See Fig. 1.

	2002		2003	
Species	X	P	X	P
Red-eyed Vireo	114	0.9982	104	0.9971
Black-throated Green Warbler	80	1.000	118	1.000
Common Yellowthroat	70	0.9825	72	0.9982
Swamp Sparrow	56	0.9837	66	0.9980
Red-winged Blackbird	58	0.9706	62	0.9439
Song Sparrow	66	0.9575	46	0.9968
Blue-headed Vireo	38	1.000	39	0.9848
Magnolia Warbler	39	0.9897	36	0.9545
Hermit Thrush	38	0.9968	37	1.000
Ovenbird	33	1.000	38	0.9899
Dark-eyed Junco	33	0.9720	36	0.9771
Indigo Bunting	23	1.000	33	1.000
Alder Flycatcher	31	0.9715	26	09800
House Wren	27	0.9913	23	09800
Black-capped Chickadee	29	0.9815	15	1.000
American Robin	27	0.9605	20	0.9804
Savannah Sparrow	18	1.000	20	1.000
Field Sparrow	24	1.000	12	1.000
Eastern Towhee	17	0.9714	18	1.000
Blue Jay	19	0.9500	16	0.8951
Black-throated Blue Warbler	12	1.000	17	1.000
Cedar Waxwing	11	0.9506	19	1.000
Scarlet Tanager	13	0.9931	15	1.000
Chestnut-sided Warbler	11	0.9900	13	1.000
Winter Wren	7	0.9786	13	1.000

Table 1: Detection Probabilities for Species With 10 or Greater Detections for Either Year. X = Total detections. P = detection probability.

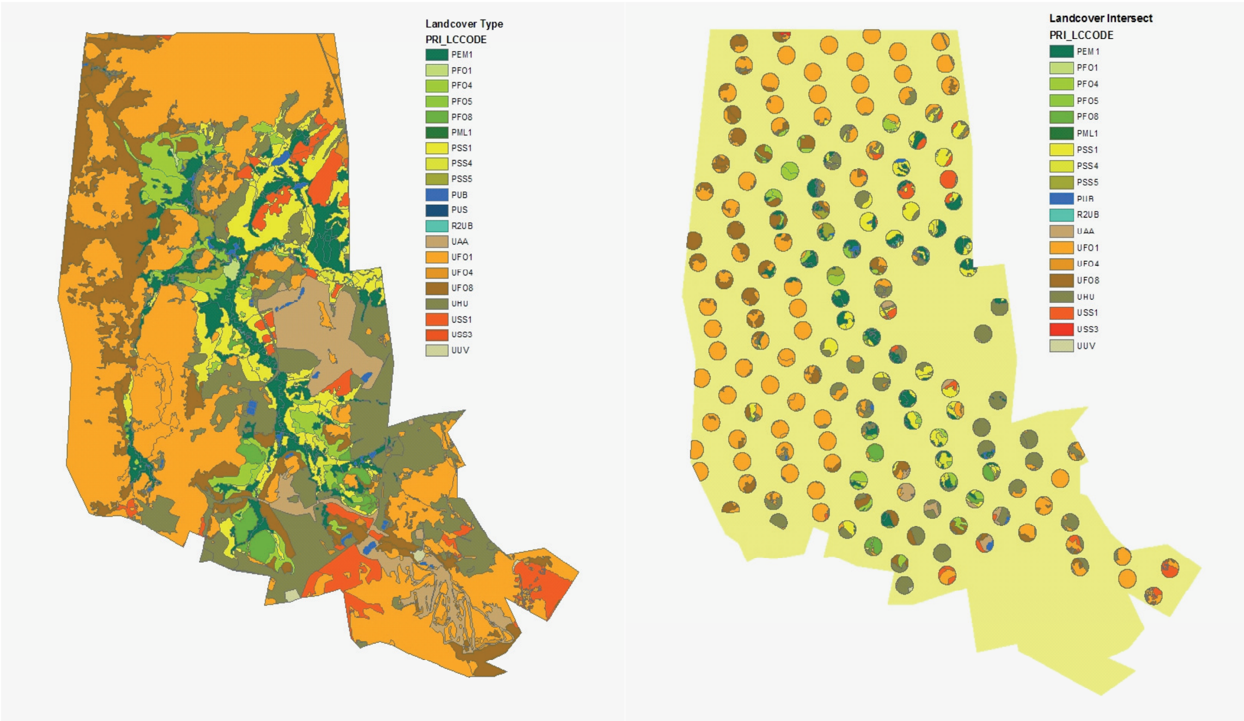


Figure 1: Detection Probabilities for Species With 10 or Greater Detections for Either Year. X = Total detections. P = detection probability.

Prior to this process, individual habitat parcels of the same type were dissolved into a single parcel. The resulting layer file was then converted to raster format and areas calculated from the attribute table. Area calculations allowed for the determination of the total area sampled within each habitat type.

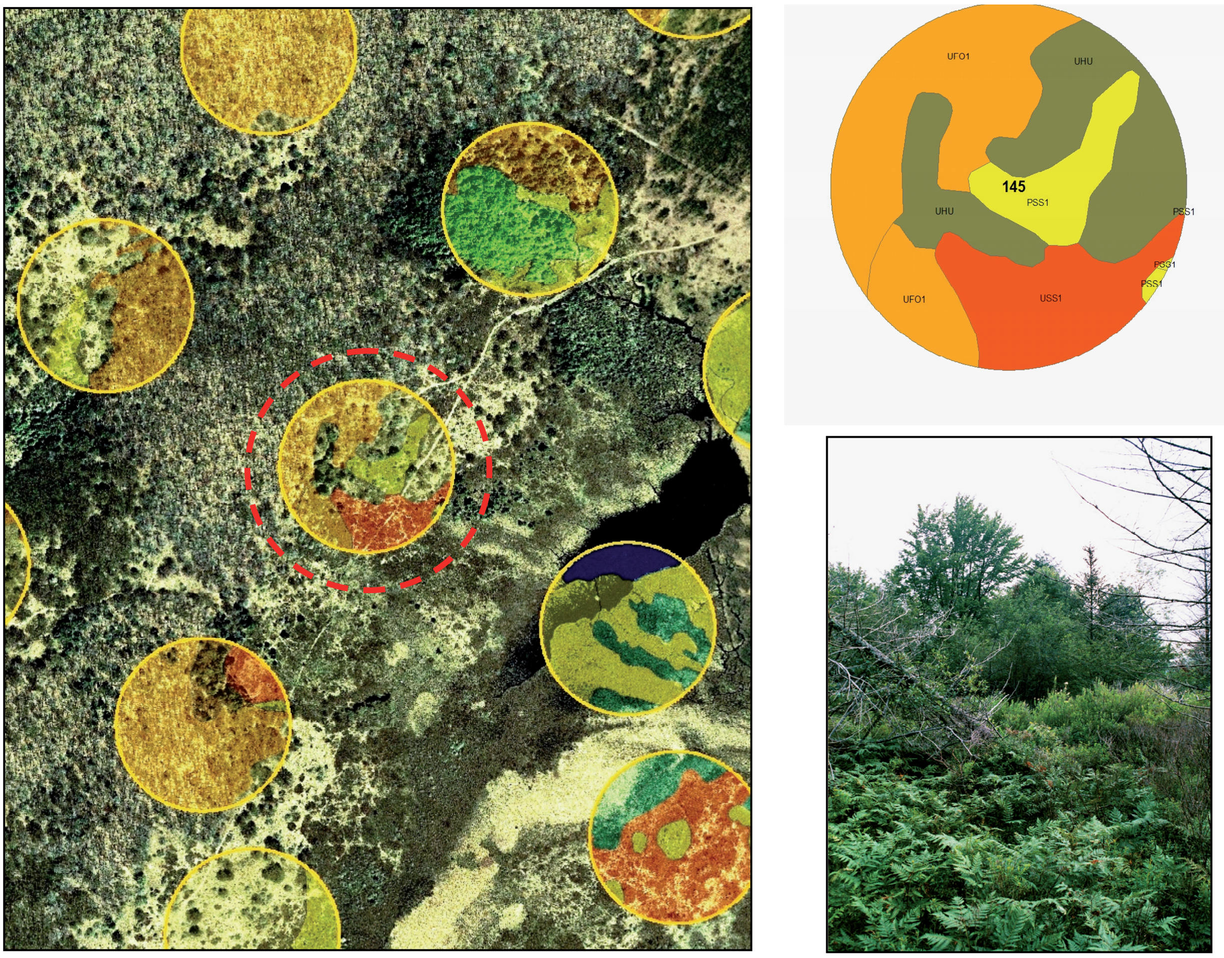
The proportion of each habitat sampled was compared with the total area represented within the park. The sampled area closely represents the proportional area of each habitat type within Canaan Valley State Park (Fortney 1997; Snyder, Young, and Stout 1996). See Tab. 2. The under-representation of Unvegetated Anthropogenic Cover (UAA) in the sampled area is due to the exclusion of point count station locations within the golf course and downhill ski area.

7. Sampling Point Characterization

Individual sampling points can be examined to determine habitat and site characteristics from imagery and field data and to illustrate their relationship to the surrounding landscape. Attribute tables reveal point coordinates, elevation, dominant plant species, bird species rich-

Cover Type (Cowardin and Golet, 1979)	% of Total Sample Area	% of Park Fortney	% Park-Snyder	% Valley-Snyder
PEM1 – Palustrine, Emergent, Persistent	8.717	7.200	6.563	4.354
PFO4 – Palustrine, Forested, Needle-leaved Evergreen	4.445	3.877	4.150	1.415
PFO5 – Palustrine, Forested, Dead	0.149	.079	0.092	0.025
PFO8 – Palustrine, Forested, Mixed	1.757	1.434	-	-
PSS1 – Palustrine, Shrub-Scrub, Broad-leaved Deciduous	8.586	7.573	8.755	13.421
PSS4– Palustrine, Shrub-Scrub, Needle-leaved	0.764	0.331	0.073	0.013
PSS5– Palustrine, Shrub-Scrub, Dead	0.812	0.438	0.471	0.071
UAA – Upland, Unvegetated, Anthropogenic Cover	1.885	6.339	0.287	0.067
UFO1 – Upland, Forested, Broad-leaved Deciduous	40.475	39.102	39.021	48.778
UFO4 – Upland, Forested, Needle-leaved Evergreen	0.224	0.700	0.498	0.984
UFO8 – Upland, Forested, Mixed	12.151	11.845	13.456	5.282
UHU – Upland, Herbaceous	15.860	15.334	23.817	16.094
USS1 – Upland, Shrub-Scrub, Broad-leaved Deciduous	3.543	4.589	2.042	6.046

Table 2: Comparison of the Area of Each Habitat Sampled to the Total Area of Each Habitat Within Canaan Valley State Park and Canaan Valley as a Whole.



POINTS	XCOORD	YCOORD	ELEV	S	A	HABTYPE	DOMSPECIES	NUMINDIV	SPECRICH	ALFL	AMRO	GRCA	CEWA	CSWA
145	633111	4323138	3250	2	154	SHRUB - WOODED - WET	Hypericum-Spirea-Crataegu	8.5	9	1.0	0.5	0.5	0.5	2

Figure 2: Sample point 145 characterization.

ness, and co-species present. Photographs of the physical characteristics at each station can be appended to maps and documents. See Fig. 2.

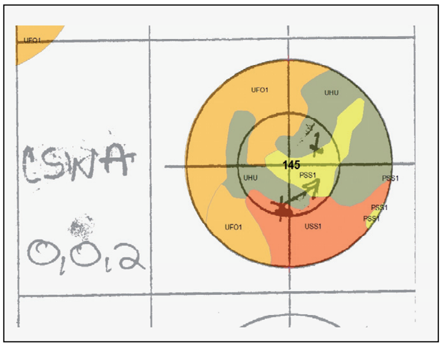
8. Georeferencing Count Circles to Land Cover

A benefit of using fixed radius point counts is that the field sheets can be georeferenced to base map imagery. Bird species detected were plotted within each fixed radius count circle by distance and direction from the center. The top of each circle on the field sheet was oriented to true north during the recording period. Distances were estimated. Observed movements of each individual bird were recorded with an arrow pointing in the direction of the movement and ending at the final location.

The individual field sheets were scanned and saved as bitmap files. A buffer of 100 m was created around each sample point, representing the outer boundary of the fixed radius. Each point buffer was used to clip the area of the landcover map that it intersected.

The scanned bitmap files from selected sampling stations were georeferenced to the clipped section of the landcover map for that station by aligning to true north. The recorded positions for individual bird species detected were then viewed within each count circle. Both dominant plant cover (Fortney 1997) and habitat classification (Cowardin et al. 1979) were selected from the landcover map for comparison. See Fig. 3 and 4.

Habitat associations can be examined for occurrences within all count circles for the selected species. This is particularly useful at sampling stations that contain more than one habitat type. This information can be used when the land manager selects a species to be investigated or managed and wants to examine the relationship between occurrence and habitat features.



Chestnut-sided Warbler

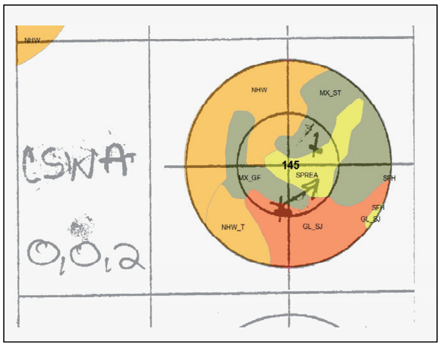


Figure 3: Chestnut-sided warbler detections at Point No. 145 georeferenced with habitat type.

Figure 4: Chestnut-sided Warbler detections at Point No. 145 georeferenced with dominant plant cover. NHW = Northern Hardwoods, NHW_T = Northern Hardwood Transition, GL_SJ = Glade St. John's-wort, SPREA = Pipestem, MX_ST = Mixed Shrub Thicket, MX_GF = Mixed Grasses and Forbs.

9. Bird Distribution and Abundance

Individual map layers were created for each species detected, showing relative abundance at each occupied point and the distribution of each species within the park. See Fig. 5. The land manager can overlay directly a defined area of potential impact. Questions that would follow include: What is the local, regional, and global status of the species? Does the area of impact overlap high occupancy areas?

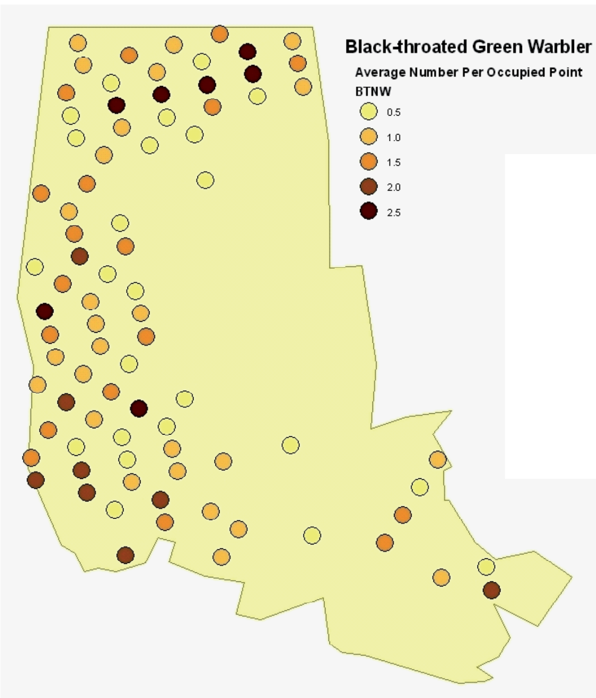


Figure 5: Distribution and relative abundance of the black-throated green warbler.

10. Species of Concern

Species of concern were identified and occupied habitat was characterized. For most the total number of detections was low. Because numbers are low, it takes more effort to locate these species. It is important to outline all available habitats on the park that might be suitable for each such species so that a more intensive survey could be conducted when a potential impact might occur.

One species, the sedge wren, was detected at two stations within the study area. Sedge wrens prefer wetland areas covered by emergent vegetation including grasses and sedges. Possible breeding habitat includes the extent of emergent wetland vegetation within Canaan Valley State Park. All detections occurred within this type of habitat.

A special characteristic of the sedge wren is that it has low breeding site fidelity - it rarely returns to the same nesting site year-to-year (Ehrlich, Dodkin, and Whey 1988). This requires the land manager to examine all potential breeding habitat, not just areas where detections occurred, when an area of impact overlaps. A map was created showing possible breeding areas, detections by vocalization only, and where both visual detections and vocalization occurred. See Fig. 6. These maps were saved as layer files and can be combined with base map imagery to show their location relative to landscape and cultural features.

11. Interpolation and Surface Analysis

Interpolated surfaces were generated for species richness and species diversity using Inverse Distance Weighting (IDW). See Fig. 7. IDW was selected on the basis of sample point density and distribution, and simplicity of use (Childs, Kabot, and Murad-al-shaikh 2001).

Interpolated maps for species richness were created using cumulative species richness for each point. Interpolated maps for species diversity were created using the Shannon Diversity Index calculated for each point using cumulative species richness, and the average of the sum of the number of individuals detected during 2002 and 2003. Equal effort was expended in the detection of birds at each station.

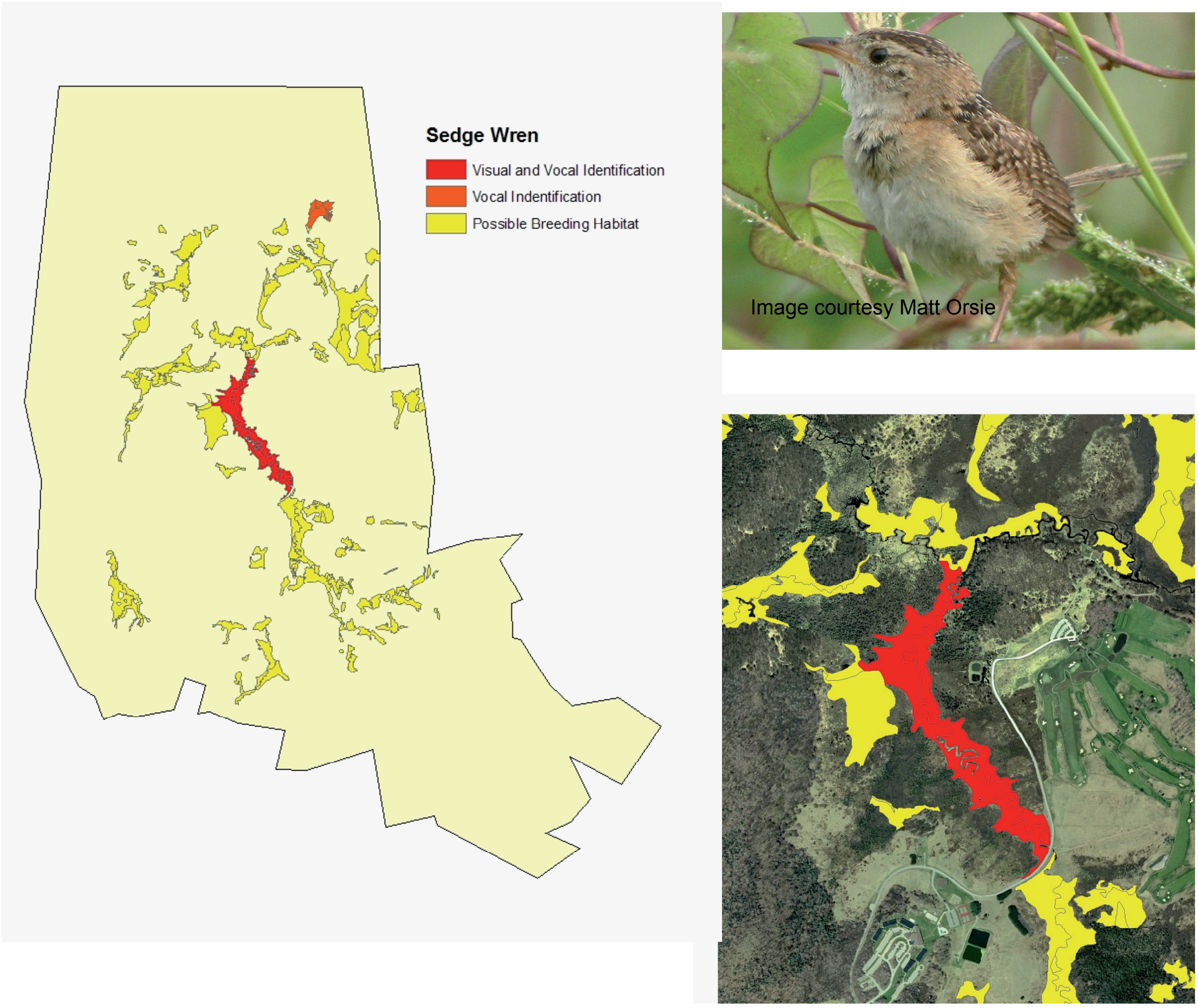


Figure 6: Sedge wren potential breeding habitat with areas of detection by type.

Although the interpolated maps probably do not represent actual species richness and diversity values between points, identifying "zones" of relatively high species richness and diversity may be useful to the land manager in identifying areas for more detailed study. Other forms of interpolation and the use of pre- and post-interpolation data processing may produce more accurate maps.

Habitat structure has been related to biodiversity, and bird species may select breeding sites based on the density and floristic composition of the canopy, understory, and shrub layers. Interpolated cover density maps for the canopy, understory, and shrub layer would be of use in determining habitat structural complexity and could be incorporated into suitability models to outline potential breeding habitat for selected bird species. However, since layer densities were estimated in the field, the resulting interpolated maps would have been of limited utility.

Measurements of habitat structure may be best addressed by emerging remote sensing technology. Improvements in spectral resolution, as well as spatial resolution, for aerial and satellite sensors is increasing the ability to resolve individual canopy species (Turner et al. 2003). Imaging radar can now provide information on forest structure, including height and density of canopy and understory layers (Bergen et al. 2002).

Digital Elevation Models (DEMs) were converted to raster format and used to derive surface maps such as hillshade, aspect, slope, and contours. These layers can assist the land manager in understanding landscape features in relation to species distribution and may be used in suitability models by selecting habitat preferences for species of interest.

12. Suitability Models

Suitability models could be constructed for individual bird species by incorporating general habitat requirements such as forest type, shrub cover density, and shrub type (Maquire, Batty, and Goodchild 2005). See Fig. 8.

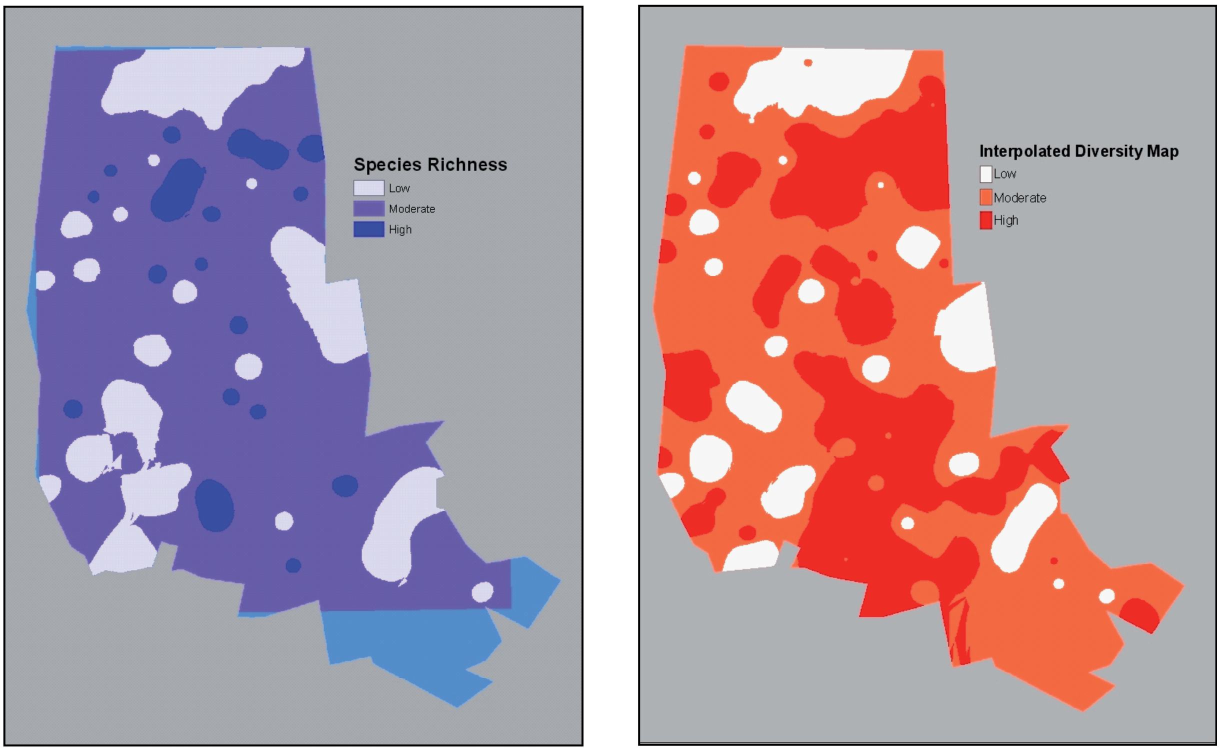


Figure 7: Interpolated maps for species richness and species diversity.

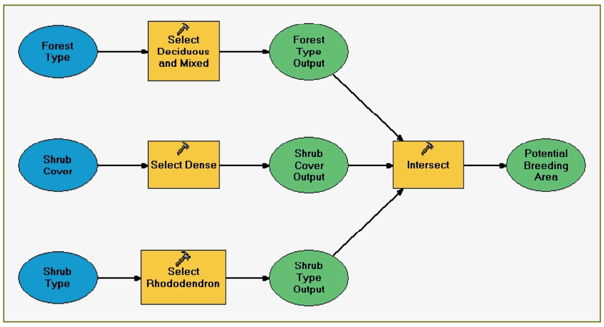


Figure 8: General suitability model for the black-throated blue warbler.

Models can become more sophisticated with the inclusion of more detailed imagery and additional field data.

13. Summary

The use of a GIS can enhance decision making relative to potential impacts on natural resources at the local park level. It can also help the land manager understand the process of generating data for decision making. Monitoring and data collection protocols used to generate baseline information can be adjusted to enhance analysis and display of additional data within the GIS.

Graphical display of data allows land managers to understand the resources and make first-level decisions related to potential impacts. The ability of the GIS system to answer questions related to land management can grow with each decision made through learning and feedback.

Map layers created in the GIS are dynamic and can be updated periodically and compared to past results. Data related to additional species of both animals and plants can be easily integrated into the GIS system. This integrated approach would broaden the knowledge base of the land manager, allowing more informed land management decisions.

The individual products of analysis (maps and map layers) have different levels of utility and must be used in the right context to avoid false conclusions. The land manager must understand these limitations.

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