Statewide Analysis and Surveys to Develop an Approach for Identifying Priority Conservation Areas in Michigan: 2008 Progress Report

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Cover photo: Dry-mesic northern forest at Pigeon River Pines in Michigan, photo by Joshua G. Cohen, MNFI

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INTRODUCTION

Land management decisions need to be based upon a foundation of sound and comprehensive ecological information. Many types of data currently exist that can be synthesized into an integrated analysis of Michigan's natural features that is comprehensive and scientifically sound and can inform land management decisions. Increased knowledge and analysis about the natural features on the landscape (e.g. ecological communities that perform important ecosystem services, endangered and threatened species, species of concern, rare ecological communities) will improve the State's ability to make wise decisions regarding conservation and management of these resources. The Michigan Department of Natural Resources (MDNR) has led several initiatives that have incorporated integrated and comprehensive analyses of the natural features of Michigan. These include forest certification, development of a wildlife conservation strategy (i.e., Wildlife Action Plan), the biodiversity/old growth initiative, and the biodiversity conservation planning process.

An important component of these initiatives is the identification of areas of high ecological value or significance for conservation and management. These can include high quality examples of natural features, functional representative native ecosystems, and areas with concentrations of rare, threatened or endangered species or natural communities. Ideally, identification of these high ecological value areas as priorities for conservation should be based on information collected from systematic and comprehensive field inventories of natural features and other areas of high ecological significance across the state. However, such inventories have not been completed to date due to funding and time constraints. In lieu of having complete information from field surveys, GIS-based models have been developed to help identify potential areas of high ecological value or significance. However, these models need to be tested, verified, and refined based on conditions in the field before they can be applied with confidence to help guide conservation and management decisions.

The goal of this project is to improve the MDNR's ability to identify terrestrial and aquatic areas of high ecological value. This would be achieved by developing an effective approach for evaluating and identifying these areas on the landscape remotely and systematically surveying these areas to assess their ecological condition and associated plants and animals. Specific objectives of this project include the following: 1) develop a GIS model that identifies areas of high ecological value statewide using currently available data; 2) evaluate air photo interpretation results compared to GIS model results; 3) develop and apply field metrics to assess ecological value; and 4) test GIS model and potentially other existing GIS and remote sensing models with field metrics/data.

This project is envisioned to be the first part of a 10 to 20 year effort that will lead to a scientifically sound and comprehensive statewide analysis, identification, and survey of high ecological value areas (as defined by this project, see below) as priorities for conservation. This project will address several statewide research needs identified in the Michigan's Wildlife Action Plan. These include developing and providing tools or approaches for landscape assessment and identification of high quality representative occurrences and providing information to address conservation needs that address statewide priority threats and issues, and needs to address ecosystem representation and network issues. The ultimate goal of this project is to provide information that will inform conservation and land use decisions by federal, state, and local government agencies and other entities.

This report provides a summary of project activities and progress made on the Statewide Analysis and Survey project during 2008. This project was initiated in 2006 and continued in 2007 and 2008. A subset of the data collected from 2006 through 2008 will be summarized and analyzed in 2009. A final report summarizing project accomplishments and findings from 2006 through 2009 will be prepared and completed in 2009. A project evaluation also will be conducted in 2009, and results of that evaluation will be provided in the 2009 final report.

METHODS

GIS Analysis/Component

This project has two major components. The first component is developing an effective and efficient approach for evaluating the landscape and identifying or predicting areas of high ecological value or significance remotely. To accomplish this, a GIS analysis of the state was conducted by MNFI to identify terrestrial areas of high ecological value, as defined by this project. A GIS model assessing the quality or condition of stream reaches that was developed by Wang et al. (2006) at the Institute for Fisheries Research was utilized to identify potential aquatic areas of high ecological value. The purpose of the GIS analysis or component ("GIS component") is to provide credible, scientifically sound guidance based upon currently available ecological information to identify areas with high ecological value and to provide the information in a short time frame for the entire state.

Terrestrial GIS Analysis/Component

Terrestrial areas of high ecological value that have been identified by the GIS analysis have been defined as high quality cover type patches. A patch analysis was conducted to identify high quality cover type patches. A cover type patch is a spatially defined area of the same land cover class or type delineated using GIS, based on the MDNR Integrated Forest Monitoring, Assessment and Prescription (IFMAP) land cover dataset (MDNR 2001). The IFMAP dataset is a raster dataset of 30-m resolution cells derived from remotely-sensed Landsat Thematic Mapper imagery. A total of 35 different land cover classifications are identified in IFMAP. The IFMAP land cover data were reclassified and aggregated into cover type patches of 16 general land cover types which comprised of the following: Upland Deciduous Forest, Upland Coniferous Forest, Upland Mixed Forest, Lowland Deciduous Forest, Lowland Coniferous Forest, Lowland Mixed Forest, Grassland, Shrub, Non-forested Wetland, Pines, Pasture/Parks, Agriculture, Sand/Soil, Bare Soil/Rock, Urban, and Water. The agriculture, bare soil/rock, urban, and water cover types were excluded from the GIS analysis. Because of file size limitations, the state was divided into 13 different regions for the analysis, 10 in the Lower Peninsula and 3 in the Upper Peninsula.

ARCGIS, FRAGSTATS, and SPSS were used to complete the GIS analysis or model to identify high quality cover type patches for this component of the project. Each cover type patch was scored from 1-4, with 4 indicating highest quality, for each of the following three variables or criteria: area, core area, and proximity to similar patches. We initially had included two additional variables in the GIS analysis, edge contrast and shape. However, subsequent testing showed that core area and edge adjacency were positively correlated with each other while area and shape were negatively correlated with each other. Core area and edge adjacency correlated because FRAGSTATS uses the adjacent cover types when calculating the patch core area. The negative correlation between area and shape was likely an artifact of the IFMAP dataset and the method FRAGSTATS uses to calculate shape. When testing a raster dataset, FRAGSTATS assigns a perfect shape score to a square. The greater the deviation from a square, the lower the shape score. In the IFMAP datasets, larger areas tend to be convoluted patches connected together by narrow strips. This gives large patches a relatively high edge to area ratio and a subsequent low FRAGSTATS shape score. Another problem scoring patches for shape was the inherent linear shape of some cover type patches. For example, lowland riparian forests in the southern Lower Peninsula and beach areas tend to naturally occur as linear patches, which resulted in lower scores for these cover type patches in the analysis. As a result, edge contrast and shape were removed from the analysis, and only area, core area, and proximity to similar patches were used in the final GIS analysis.

Area Scoring

Some land cover types occur over much larger areas than do certain other types in Michigan. Thus, cover types were classified into large patch or small patch communities for area scoring. Large patch communities were Grassland, Upland Deciduous Forest, Upland Coniferous Forest, Upland Mixed Forest, Lowland Deciduous Forest, Lowland Coniferous Forest, Lowland Mixed Forest, Shrub, Pines, and Pasture/Parks. Small patch communities were Non-forested Wetland and Sand/Soil. Small patch communities were given a score from 2 to 4 for area or size of the patch using the thresholds summarized in Table 1. Large patch communities were given a score from 1 to 4 for area or size of the patch based on the thresholds summarized in Table 2.

Table 1. Thresholds for patch scores for small patch communities for area scoring.

Patch score	Threshold
2	0 <= area < 2 hectares
3	2 hectares <= area < 20 hectares
4	20 hectares <= area

Table 2. Thresholds for patch scores for large patch communities for area scoring.

Patch score	Threshold
1	0 < area < 20 hectares
2	20 hectares <= area < 1000 hectares
3	1000 hectares <= area < 2000 hectares
4	area => 2000 hectares

Core Area Scoring

Patches were given a score from 0 to 4 for the percentage of the patch that is considered core area. Core area was determined using FRAGSTATS. FRAGSTATS utilizes user determined depth impacts of adjoining cover types to determine the amount of core area. Core area scores for each patch were determined using the thresholds summarized in Table 3.

Proximity Scoring

Patches were given a score from 0 to 4 for proximity to similar patches. FRAGSTATS assigns an open ended proximity value to each patch. Each patch was scored using SPSS to do a two-step cluster analysis of values assigned by FRAGSTATS to the patch. The cluster analysis was performed individually on each cover type. Those patches given a zero proximity value by FRAGSTATS were given a proximity score of zero.

Table 3. Thresholds for patch scores for core area scoring.

Patch score	Threshold
0	No core area
1	0 < core area <= .1
2	0.1 < core area <= 0.25
3	0.25 < core area <= 0.5
4	0.5 < core area

Area, core area, and proximity scores were then summed for each patch, resulting in a total score for each patch ranging from 3 to 12, with 12 indicating the highest quality. A score of 12 would indicate a large cover type patch with a high percentage of core area and in close proximity to other similar cover type patches. The Pines and Pasture/Parks cover type patches were scored for each criterion, but their summed criteria scores were halved, resulting in total patch scores ranging from 1.5 to 6. This was done because IFMAP does not differentiate between natural pine stands and pine plantations.

Aquatic GIS Analysis/Component

To develop an approach for identifying potential aquatic areas of high ecological value, a GIS model that predicts stream/river reach quality or condition that was developed by Wang et al. (in press) at the MDNR's Institute of Fisheries Research was used for this component of the study. A reach is generally a stretch of stream from confluence to confluence. This analysis or model assessed the quality or condition of stream/river reaches based on a number of variables including number of active mines, percentage of network watershed in agricultural and urban land use, number of point source facilities and toxic release sites, number of road crossings, road density, dam density, nitrogen loading, and watershed area treated with manure (Table 4).

Each stream/river reach in the model also is associated with a valley segment (i.e., VSEC) and a river type. Valley segments are aggregates of reaches based on a number of variables. Variables used in the classification of VSECs include the following: catchment size, catchment surficial geology, catchment slope, catchment land use, discharge, nutrient concentration, summer water temperature, valley character, valley width, valley wetlands, channel character, channel sinuosity, and key fish species. Valley segment boundaries were determined by applying the following priority criteria: 1) junctions of similar order tributaries, 2) corresponding breaks in land surface form, 3) changes in local groundwater source, 4) abrupt changes in major land uses, and 5) observed or expected changes in key fish species. River types are MNFI's draft river natural communities which are based on catchment size, water temperature, and gradient. Four size classes are defined using drainage areas of VSECs, following definitions outlined in Michigan's Wildlife Action Plan: 1) headwaters and small tributaries are less than 40 mi^2; 2) medium rivers are between 40-179 mi^2; 3) large rivers are between 180-620 mi^2; and 4) very large rivers are greater than 620 mi^2 (Eagle et al. 2005). Three classes of water temperatures are defined as follows: cold (<19˚C), cool (19-22˚C), and warm (>22˚C). Three classes of gradient are defined as follows: low (<0.001), moderate (0.001-0.006), and high (>0.006). Gradient classes were defined using the 25th and 75th percentiles of all stream reach gradients across Michigan. All of these values were pulled from the latest VSEC data (VSECxEDUxHUC8_noshoreline.shp).

Based on the variables assessed in the GIS model, each stream/river reach in the model has been assigned one of the following six rankings of expected impact: reference, no impact, detectable, moderate, heavy, and severe. These rankings can be compared and combined with field metrics to evaluate and determine if this GIS model can be used to accurately assess the quality or condition of stream/river reaches in Michigan. For example, a no impact ranking might indicate higher site quality or higher ecological value as defined by this project whereas a moderate, heavy or severe impact ranking might indicate lower site quality or lower ecological value as defined by this project.

Field Component

The second major component of this project involved developing and applying field metrics to assess the ecological value or condition of the cover type patches and stream/river reaches identified by the GIS models to test and verify the models. The field metrics or data will be used to test the GIS model developed by MNFI as part of this project. These metrics also could potentially be used to test other existing GIS and remote sensing models that identify areas of high ecological value or conservation priority. The purpose of the field component ("field component") of this project is to verify and improve the scientific foundation of the GIS models and provide information to enhance future analyses or models that identify areas of high ecological value and conservation priority.

Terrestrial Field Component

Terrestrial areas of high ecological value as identified by the field metrics for this project are

Table 4. Summary of variables utilized in GIS stream/river reach disturbance model developed by Wang et al. (in press) to predict potential quality or condition of stream/river reaches based on predicted impact rankings.

Variables for all streams
Active mining (#/10000 km^2)
Network watershed agricultural land use (%)
Network watershed urban land use (%)
MDEQ's permitted point source facilities (#/100 km^2)
MDEQ's permitted point source facilities having direct connection with stream (#/100 km^2)
USEPA's toxic release inventory sites (#/10000 km^2)
Population density (#/km^2)
Road crossing (#/km^2)
Road density (km/km^2)
Total nitrogen plus (phosphorus*10) loading (kg/l/yr)
Watershed area treated with manure from barn yards (m/km)
Additional variables for coldwater streams
Total nitrogen plus (phosphorus*10) yield (kg/l/year)
Additional variables for warmwater streams
Dam density (#/100 km^2)
USEPA's toxic release inventory sites discharging into surface water (#/10000 km^2)

referred to as high quality natural community field classes. Natural community field classes are groups of natural communities derived from MNFI natural community types that were evaluated for quality in the field based on various field metrics (Table 5). Field metrics were developed and applied to assess the ecological condition or quality of the natural community as well as the quality or condition of the plant and animal communities. Assessment of the animal community focused on breeding bird communities for this first phase of the project.

To adequately evaluate the efficacy of the GIS model, the goal of the terrestrial field component was to sample and collect field metrics from at least 30 cover type patches in each land cover type or class across a gradient of quality, as indicated by the patch score. Of the 30 total, the goal was to collect field metrics from approximately 10 cover type patches from the low end of the quality spectrum, 10 from the high end, and 10 in the middle (exact definitions of low, medium, and high are not important at this time) to capture a gradient of quality. Sampling in 2006 and 2007 was conducted in upland forest, lowland forest, grassland/shrubland, and non-forested wetland land cover type patches. The number of samples in each land cover type varied. To ensure sufficient sample size from at least one land cover type to draw some meaningful conclusions at the end of this year, sampling in 2008 focused only on one land cover type or class.

To identify sites for field sampling in 2008, the cover type patches that were surveyed in 2006 and 2007 were analyzed to address changes in the sampling scheme. Based on this analysis, it was determined that most of the cover type patches that were surveyed in 2006 and 2007 consisted of upland forest patches, primarily upland deciduous forest patches, that were ranked as high to moderate quality based on the GIS patch analysis scores. In 2006 and 2007, a total of 25 sample cells or plots were located in upland deciduous forest cover type patches that were ranked as high to moderate quality. Thus, survey efforts in 2008 focused on surveying upland deciduous forest cover type patches ranked as low to moderate quality in order to collect field metrics from a sufficient number of patches in this cover type across a gradient of quality.

As in previous years of the project, the terrestrial field component in 2008 was conducted primarily in the Newaygo County area (Figure 1). Some sampling occurred outside of Newaygo County

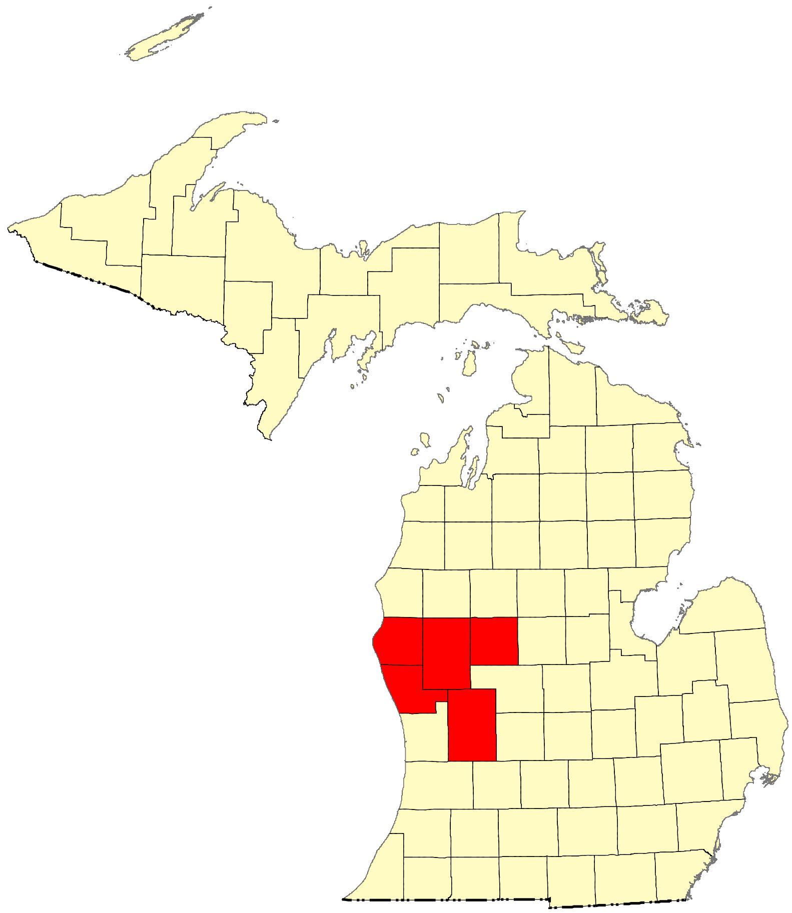

Figure 1. Map showing general location of study area in Michigan (counties highlighted in red).

in adjacent counties (i.e., Oceana, Muskegon, Kent, and Mecosta) and multiple ecological subsections in 2008 to obtain sufficient numbers of samples of upland deciduous forest cover type patches ranked as low to moderate quality (Figures 1 and 2). As in 2006 and 2007, field sampling in 2008 was conducted on state and federal public lands managed by the MDNR and the U. S. Forest Service.

Based on project meetings and discussions in 2008, several changes in the sampling scheme for the terrestrial field component of the project were identified and implemented in 2008. In 2006, field metrics were collected in randomly selected 10-ha (24.7 ac) sample cells or plots within upland forest cover type patches. A grid of 10-ha sample cells was intersected with the IFMAP land cover dataset. The sample cells were further stratified in that only sample cells that contained at least 85% of the targeted cover type (i.e., upland forest, lowland forest, grassland/ shrub, non-forested wetland) and were on public land (state or federal) were included in the pool of potential sample cells for field surveys. Sample cells were then randomly selected from this pool for field surveys. For the forested cover type patches, a random set of more than 30 sample cells was chosen from the set stratified by public ownership. This random set was then randomly ordered. If field visits determined that a cell was not usable for some reason (e.g., incorrect land cover classification, recent management action), that cell was removed from sampling and the next cell on the list was sampled. In 2007, a similar method for selecting sample cells was used except that the 10-ha sample cells were first located within photo-interpreted polygons (see section on Aerial Photo Interpretation Component) in specific cover type patches. The sampling scheme applied in 2006 and 2007 resulted in some sample cells containing portions of multiple cover type patches, with different patch analysis scores in some cases. The sampling scheme was changed in 2008 so that cover type patches were randomly selected for field sampling instead of sample cells, and sample cells were then randomly placed within cover type patches that were selected for sampling. This ensured that each sample cell was located within and consisted of only one cover type patch and not multiple patches.

Prior to field surveys, upland deciduous forest cover type patches that were ranked as low to moderate quality, based on the GIS patch analysis scores, were identified and randomly selected for field sampling. Sample cells were delineated in the cover type patches selected for field sampling. The sampling scheme in 2008 also was modified in that if a cover type patch was <10 ha in size, we conducted field measurements or metrics on the entire patch. If a cover type patch was >10 ha in size, we randomly selected or placed a 10-ha sample cell within that patch and conducted field metrics within the sample cell. If the patch was >10 ha but the shape of the patch did not provide sufficient area for a square or rectangular 10-ha sample cell, we randomly selected an irregularly shaped 10-ha sample cell for field measurements.

An aerial photo review of the randomly selected cover type patches and sample cells was conducted to identify and prioritize a minimum of 20 sample cells in upland deciduous forest patches with moderate to high quality scores (UDM) and low quality scores (UDL). All UDM sample cells consisted of square, 10-ha sample cells, whereas all UDL sample cells consisted of irregular polygons. A minimum of 10 qualifying UDM sample cells and 10 UDL sample cells were identified following aerial photo review and rejection of apparent non-qualifying plots (e.g. plots with no visible or reasonable access, or those lacking a sufficient extent of contiguous forest vegetation, etc.). It was noted that subsequent rejections could occur during initial field visits, and thus a list of at least 15 sites for each category were reviewed for initial approval and field reconnaissance.

Following the selection of sites, a folder or site package was prepared and printed for Botany, Ecology, and Zoology project staff. Each site folder or package contained two sets of labeled aerial photos for each of the plots (i.e., 1998 CIR and the 2005 color imagery) in addition to a representative topographic map layer. No plat maps were printed, as all plots fell within public land boundaries.

Ecological field surveys/sampling

Ecological field sampling was conducted from 16 June to 8 August 2008. Sample cells or plots in 10 UDM and 10 UDL cover type patches were surveyed in 2008. The ecological quality or condition of the natural community within the sample cell was assessed based on up to 11 field metrics/criteria, with each metric having a score from 1-4 (4 indicating excellent condition and 1 indicating poor condition). Field metrics were developed in 2006 were for each natural community field class (Appendix 1). These metrics were developed to score indicators of structural and functional biodiversity within a variety of landscapes (Noss 1990, 1999, McElhinny et al. 2005, Lindenmayer et al. 2000, 2006). These metrics can be divided into

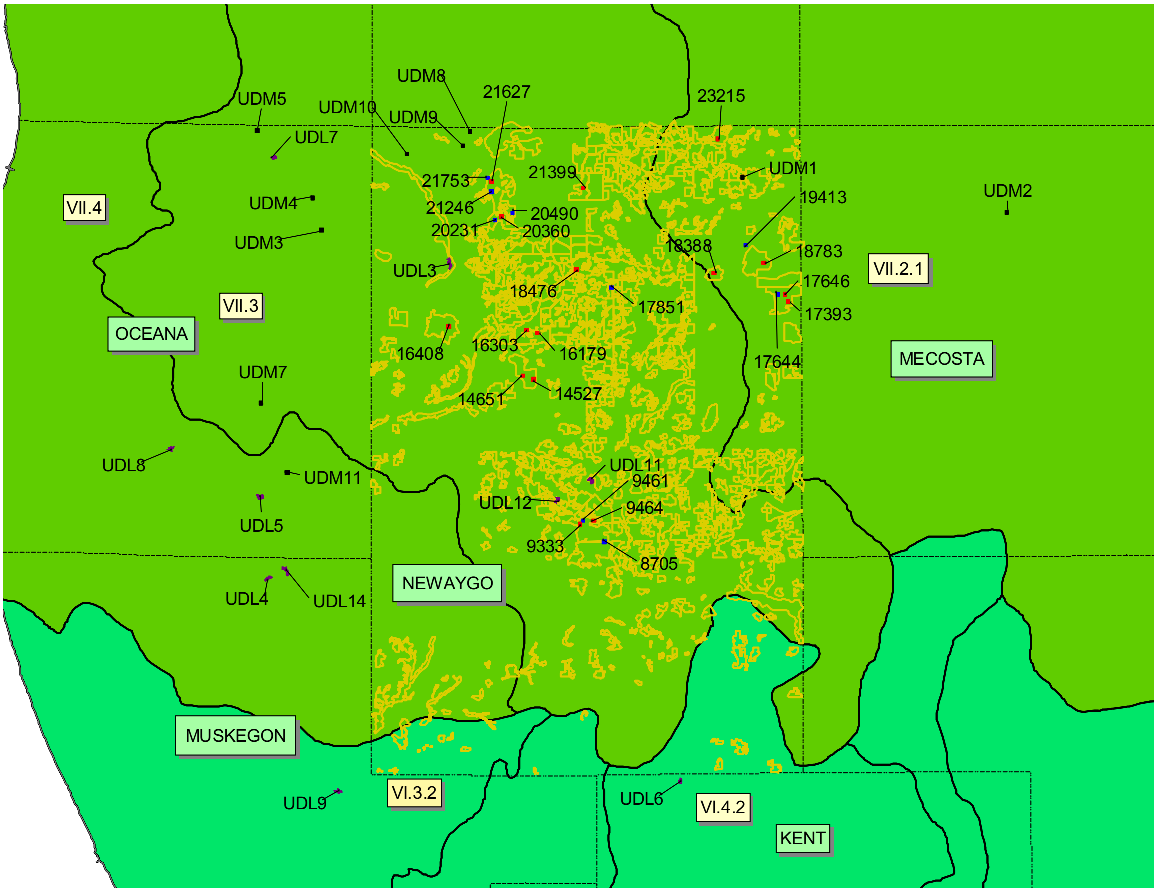

Figure 2. Map showing the names and locations of the sample cells or plots that were surveyed from 2006 to 2008 for the terrestrial field component of the project. Ecological, botanical, and zoological (breeding bird) surveys were conducted in these sample cells. Sample cells were primarily located in Newaygo County and subsection VII.3, but some sample cells also were located in surrounding counties and subsections.

three categories evaluating the landscape context, present condition, and threats facing of the natural community.

The upland forest land cover type/class in the GIS patch analysis model includes two natural community field classes, upland oak and oak-pine forest and upland mesic forest, which, in turn, relate to several MNFI natural community types (Table 5). Thus, the field metrics that were utilized for evaluating the condition of the natural community in the UDM and UDL sample cells consisted of the field metrics that have been developed for the upland mesic forest and upland oak and oak-pine natural community field classes (Table 6). The specific set of metrics that were used depended upon the natural community class that occurred in the field in the sample cell. The criteria that were used to evaluate and score the field metrics for these natural community field classes are summarized in Tables 7 and 8. The same ecological metrics were utilized in 2006 and 2007. Scores for these field metrics were derived by walking through and assessing the field metrics for the entire sample cell in the targeted cover type patch.

Botanical field surveys/floristic sampling

Early season floristic sampling ensued on June 16, and early surveys were conducted on 20 sample cells or plots (10 UDLs and 10 UDMs) through the first week of July. A handheld Ipaq computer was used for all field surveys to ensure thorough coverage of the sample cell and in many cases simply to locate boundaries. A comprehensive flora list was compiled during meander-searches of all sample cells. Specimens were collected and pressed for all species that could not be identified in the field and which were sufficiently fertile or in a condition suitable for keying and subsequent identification. The time upon entering and leaving each sample cell was recorded, and in addition, five representative photos were recorded for each sample cell. One sample cell was subsequently rejected as a sample site when examined in the field, and avoidance of this sample cell as a suitable sample site was immediately communicated to the Zoology and Ecology Section staff. When this sample cell was rejected, the next available sample cell on the list was queued up for sampling.

Late season floristic sampling took place from early to mid-September. Prior to sampling, all sample cell or plot data, with the exception of the collected specimens, were entered into the Michigan FQA program to prepare printed plant lists for each sample cell, such that an alphabetized list could be carried in the field for each sample cell. When encountered, new species were appended to the list, and any additional unknowns were collected for subsequent keying and verification. All 20 sample cells were revisited for the late summer inventory, with each sample cell producing a significant number of additional species.

All pressed specimens were dried and placed in collection folders. Once identification of these specimens is confirmed after consultation with specialists at The University of Michigan, these species will be added to the sample cell or plot data as appropriate, and all related FQA-measures (e.g. FQI) will be recalculated and summarized. Approximately 50-100 individual species collections were made for determination.

Plant information collected during the early and late season floristic sampling was used to assess the quality or condition of the plant community in the sample cells. The quality or condition of the plant community was determined primarily using the Floristic Quality Assessment (FQA) system or program (Herman et al. 2001). This program or approach assesses quality based on the following metrics: 1) plant species presence/composition, 2) species richness (i.e., total number of species present), 3) the Floristic Quality Index (FQI) (i.e., for each species and sample cell), 4) mean coefficient of conservatism, 5) mean coefficient of wetness, and 6) summary of physiognomic classes for both native and non-native plant species (Table 9).

Zoological field sampling

Birds have been considered good indicators of ecosystem integrity due to their relatively low birth rates and long life spans which make them sensitive to changes in the environment (Maurer 1993). In addition, the diversity of avifauna is strongly correlated with habitat type and quality making habitat specialization common (MacArthur and MacArthur 1961). This strong association with habitat and the prevalence of habitat loss and alteration in recent history has been frequently linked together to explain the population declines of many Nearctic migrant birds that winter in the tropics (Rappole and McDonald 1994). These characteristics make avifauna a useful focal group to examine the relationships among habitat characteristics, habitat quality, conservation, and species presence or absence.

Breeding bird surveys were conducted in May and June of 2008. These surveys were conducted in

Table 5. Crosswalk showing relationships between GIS model land cover types/classes, natural community field classes, and MNFI natural community classifications.

		GIS Model Land Cover Type/Class				
Natural Community Field Class	MNFI Natural Community	MNFI Mapping Code(s)	Upland Forest	Lowland Forest	Non-forested Wetland	Grassland/Shrub
Acidic peatlands	Bog	6121			x	
	Poor fen	6223			x	
	Poor conifer swamp	4234		x		
	Muskeg	6125		x		
Intermittent wetlands	Coastal plain marsh	62253			x	
	Intermittent wetland	62251			x	
Upland prairies and savanna	Dry sand prairie	31111				x
	Mesic sand prairie	31112				x
	Oak barrens	332				x
	Oak openings	336				x
	Oak-pine barrens	334				x
	Pine barrens	333				x
Upland oak and oak-pine forests	Dry southern forest	4123	x			
	Dry-mesic northern forest	4311	x			
	Dry-mesic southern forest	4122	x			
Upland mesic forests	Mesic northern forest	4112	x			
	Mesic southern forest	4111	x			
Lowland mixed and coniferous forests	Hardwood-conifer swamp	432		x		
	Rich tamarack swamp	4232, 4321		x		
	Rich conifer swamp	4231, 4242		x		
Lowland deciduous forests	Southern hardwood swamp	414		x		
	Northern hardwood swamp	414		x		
Floodplain forest	Floodplain forest	415		x		
Shrub-dominated wetlands	Inundated shrub swamp	6123			x	
	Northern shrub thicket	6122			x	
	Southern shrub-carr	6126			x	
Emergent and submergent marshes	Emergent marsh	6221			x	
	Inland salt marsh	6224			x	
	Submergent marsh	621			x	
Wet meadows, wet and wet-mesic prairies, and calcareous fen	Wet-mesic sand prairie	625			x	
	Northern fen	6262			x	
	Northern wet meadow	6223			x	
	Southern wet meadow	6223			x	
	Wet prairie	625			x	
	Wet-mesic prairie	625			x	

*** Aspen was typed as 413, then assigned to upland mesic or upland oak and oak-pine forest class.**

Table 6. Summary of field metrics utilized to assess the ecological quality or condition of the sample cells in upland oak and oak-pine forest and upland mesic forestnatural community field classes which are associated with upland forest cover type patches.

	Upland forest				
	Dry southern forest	Dry-mesic northern forest	Dry-mesic southern forest	Mesic northern forest	Mesic southern forest
Metrics	**Upland oak and oak-pine forests**			**Upland mesic forests**	
Landscape context**					
Buffer width	X	X	X	X	X
Broader land use	X	X	X	X	X
Site intactness					
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	X	X	X	X	X
Hydrology					
Presence of drains, ditches, channelization	X	X	X	X	X
Soil erosion	X	X	X	X	X
ORV damage					
Stream morphology					
Community structure and function					
Vegetative structure and composition	X	X	X	X	X
Evidence of logging	X	X	X	X	X
Evidence of plowing					
Evidence of fire	X	X	X		
Presence of invasive non-native vascular plant spp.	X	X	X	X	X
Presence of rotting logs and snags	X	X	X	X	X
Tree regeneration (oak, conifer, etc. as appropriate)	X	X	X		
Evidence of deer browse	X	X	X	X	X
Species-specific die-offs	X	X	X	X	X
Condition of sphagnum peat					
Cat-tail invasion (indicator of nutrient enrichment)					
Presence of red maple (*Acer rubrum*)	X	X	X		
Pit-and-mound topography				X	X
Dominance by native grasses and/or sedges					

Table 7. Summary of criteria for field metrics for evaluating the ecological quality or condition of sample cells in the upland mesic forest natural community field class.

Field Metric	Metric rating criteria			
	4 = Excellent	**3 = Good**	**2 = Fair**	**1 = Poor**
Landscape context **				
Buffer width	Occurrence is buffered by +/- natural land >100m on entire periphery.	Occurrence is well-buffered (50-100m) on >75% of periphery.	Occurrence is well-buffered on >50% of periphery or narrowly buffered (25 to 50m) on >75% of periphery.	Occurrence poorly buffered (<25m on entire periphery), or not buffered.
Broader land use	Natural (matrix) landcover dominates (>75% of landscape).	Landscape is partially natural (50-75%), remainder agricultural. Agricultural areas are isolated by natural cover.	Landscape predominantly agricultural, with some natural cover (33-50%). Natural lands are isolated by agricultural fields.	Landscape urban or suburban, or almost completely agricultural (<33% natural, natural lands being isolated, small pockets).
Site intactness				
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	Occurrence is unfragmented by roads or other development.	Occurrence is very locally impacted by development (est. <10% area impacted).	Occurrence moderately impacted by development (est. <25% of area impacted). Road(s) built through wetland.	Occurrence is significantly impacted by roads and/or other development (est. >25% of area impacted). Roads, trails, pipelines, etc. significantly alter wetland hydrology.
Soil compaction/ erosion	Soil essentially undisturbed, except along trails or nearby roads.	Soil locally disturbed, but that portion occupying <10% of area.	Soil moderately disturbed, but unplowed.	Soil plowed, or significantly compacted by logging equipment, or leaf litter removed.
Community structure and function				
Vegetative structure	Vegetative structure within expected range of variation. Canopy, understory and groundlayer vegetation typical for particular community type. Good patchiness, canopy gaps present.	One (but not more) of the following is true: canopy trees are of the same size class, understory is absent or atypical, groundlayer is depauperate or atypical, or site lacks canopy gaps and patchiness.	Two of the attributes described for Grade 2 sites are true. May display poor patchiness or low presence of canopy gaps.	Vegetative structure significantly altered at all three levels. Trees immature or of a single size class. Understory poorly developed. Groundlayer vegetation significantly reduced or absent.
Presence of rotting logs and snags	Highly decomposed rotting logs common on forest floor. Many logs moss-covered, moist. Snags common.	Highly decomposed rotting logs common on forest floor. Many logs moss-covered, moist. Snags rare.	Rotting logs in advanced stages of decomposition rare. Logs in less advanced stages of decomposition (little to no moss cover, etc.) occasional to common.	Forest floor lacks decomposing wood. Rotting logs absent or rare. Woody substrate is restricted to small fallen branches, if present.
Pit-and-mound topography	Forest floor is characterized by diverse pit-and-mound topography, with pits and mounds of various sizes.	Majority (>75%) of forest floor is characterized by diverse pit-and-mound topography, with pits and mounds of various sizes.	Pit-and-mound topography present, but not common, and likely of recent origin. Lack of pits and mounds indicate former savanna conditions or plowing.	Pit-and-mound topography absent. Site was likely pre-settlement savanna, or was plowed.

Table 7. Continued.

Field Metric	Metric rating criteria			
	4 = Excellent	3 = Good	2 = Fair	1 = Poor
Community structure and function (continued)				
Evidence of logging	No evidence of logging, or only very minor cutting without species elimination.	Selective cutting, but large, old trees of all typical species remain.	Widespread cutting >50 years before present. Canopy trees mature.	Widespread cutting <50 years before present. Canopy trees immature and/or of small diameter.
Herbivore impacts: deer and other large mammalian herbivores	Signs of deer presence (browsing, trails, scat) rare.	Occasional browsing—fewer than 10% of stems of preferred species (buds on woody plants or anything liliaceous) clipped, and preferred species still abundant. Deer trails and scat noticeable.	Moderate level of browsing—10 to 25% of stems of preferred species clipped. Deer trails and scat common.	Severe browsing. Browse lines visible on shrubs and trees (that topiary look on Juniperus); preferred species prominently browsed and/or rare or absent from site, and less preferred species also browsed. Deer trails and scat abundant.
Species-specific tree mortality (due to insects or disease rather than shade suppression, windthrow, etc.)	No evidence of conifer or hardwood die-off due to pests (hemlock woolly adelgid, emerald ash borer, beech bark disease, anthracnose, etc.). Past die-off of large American elm is expected and not scored.	Very little die-off noted. Less than 10% of individuals of any tree spp. affected by insect or fungal pests. These trees widely scattered or in isolated patches.	Tree die-off significant. Up to 25% of the canopy affected by pests or pathogens.	Extensive die-off of canopy trees noted. Greater than 25% of canopy trees are affected by pests or pathogens.
Presence of invasive non-native and/or native vascular plant spp.	Invasive species of significant impact absent. Other non-native spp. may be present, in low numbers.	Invasive spp. of significant impact present, but highly localized (limited to edges or small, widely spaced colonies).	Invasive spp. of significant impact present, occasional. May locally dominate community (<25%).	Invasive spp. of significant impact common or dominating >25% of occurrence.

* Includes mesic northern forest, mesic southern forest

** METRIC ASSESSED OUTSIDE THE BOUNDARIES OF THE 10 HA SAMPLE CELL.

Table 8. Summary of criteria for field metrics for evaluating the ecological quality or condition of sample cells in the upland oak and oak-pine forest natural community field class.

Field Metric	Metric rating criteria			
	4 = Excellent	**3 = Good**	**2 = Fair**	**1 = Poor**
Landscape context*				
Buffer width	Occurrence is buffered by +/- natural land >100m on entire periphery.	Occurrence is well-buffered (50-100m) on >75% of periphery.	Occurrence is well-buffered on >50% of periphery or narrowly buffered (25 to 50m) on >75% of periphery.	Occurrence poorly buffered (<25m on entire periphery), or not buffered.
Broader land use	Natural (matrix) landcover dominates (>75% of landscape).	Landscape is partially natural (50-75%), remainder agricultural. Agricultural areas are isolated by natural cover.	Landscape predominantly agricultural, with some natural cover (33-50%). Natural lands are isolated by agricultural fields.	Landscape urban or suburban, or almost completely agricultural (<33% natural, natural lands being isolated, small pockets).
Site intactness				
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	Occurrence is unfragmented by roads or other development.	Occurrence is very locally impacted by development (est. <10% area impacted).	Occurrence moderately impacted by development (est. <25% of area impacted). Road(s) built through wetland.	Occurrence is significantly impacted by roads and/or other development (est. >25% of area impacted). Roads, trails, pipelines, etc. significantly alter wetland hydrology.
Soil compaction/erosion	Soil essentially undisturbed, except along trails or nearby roads.	Soil locally disturbed, but that portion occupying <10% of area.	Soil moderately disturbed, but unplowed.	Soil plowed, or significantly compacted by logging equipment, or leaf litter removed.
Community structure and function				
Vegetative structure (especially presence of oak and pine regeneration as seedlings, saplings, and understory trees)	Canopy, understory and groundlayer vegetation typical for particular community type. Good heterogeneity. Oaks and/or pines show ample regeneration in all size classes.	One (but not more) of the following is true: canopy trees are of the same size class, understory is absent or atypical, groundlayer is depauperate or atypical, or site is homogeneous.	Two of the following are true: canopy trees are of the same size class, understory is absent or atypical, groundlayer is depauperate or atypical. Poor heterogeneity.	Vegetative structure significantly altered at all three levels. Trees immature or of a single size class. Understory poorly developed. Groundlayer vegetation significantly reduced or absent.
Presence of red maple (*Acer rubrum*)	Red maple uncommon or occasional, not a significant component (cover >25%) in any stratum. All size classes represented. Monodominant stands absent.	Red maple occasional. May be a significant component (cover >25%) of one stratum.	Red maple occasional to common, comprising >25% cover in two strata.	Red maple common to abundant, comprising >25% cover in the canopy, subcanopy, and shrub layers.

Table 8. Continued.

Field Metric	Metric rating criteria			
	4 = Excellent	**3 = Good**	**2 = Fair**	**1 = Poor**
Community structure and function (continued)				
Coarse woody debris	Coarse woody debris present and abundant in all expected size and decomposition classes. Snags and cavity trees common.	See excellent rating, but lacking snags and/or cavity trees.	Coarse woody debris absent over a significant portion of the forest (>25%). Size class and decomposition classes poorly represented. Snags and cavity trees, if present, are rare.	Coarse woody debris nearly absent. Only small branches and recent treefall present. Decomposition minimal. Snags and cavity trees absent.
Evidence of logging	No evidence of logging, or only very minor cutting without species elimination.	Selective cutting, but large, old trees of all typical species remain.	Widespread cutting >50 years before present. Canopy trees mature.	Widespread cutting <50 years before present. Canopy trees immature and/or of small diameter.
Herbivore impacts: deer and other large mammalian herbivores	Signs of deer presence (browsing, trails, scat) rare.	Occasional browsing—fewer than 10% of stems of preferred species (buds on woody plants or anything liliaceous) clipped, and preferred species still abundant. Deer trails and scat noticeable.	Moderate level of browsing—10 to 25% of stems of preferred species clipped. Deer trails and scat common.	Severe browsing. Browse lines visible on shrubs and trees (that topiary look on Juniperus); preferred species prominently browsed and/or rare or absent from site, and less preferred species also browsed. Deer trails and scat abundant.
Species-specific tree mortality (due to insect pests, fungus, or disease)	No evidence of tree die-off due to pests (gypsy moth, oak wilt, pine rust, etc.).	Very little die-off noted. Less than 10% of individuals of any tree spp. affected by insect or fungal pests. These trees widely scattered or in isolated patches.	Tree die-off significant. Up to 25% of the canopy affected by pests or pathogens.	Extensive die-off of canopy trees noted. Greater than 25% of canopy trees are affected by pests or pathogens.
Presence of invasive non-native and/or native vascular plant spp.	Invasive species of significant impact absent. Other non-native species may be present in low numbers.	Invasive spp. of significant impact present, but highly localized (limited to edges or small, widely spaced colonies).	Invasive spp. of significant impact present, occasional. May locally dominate community (<25%).	Invasive spp. of significant impact common or dominating >25% of occurrence.

* Includes dry southern forest, dry-mesic southern forest, dry-mesic northern forest

** METRIC ASSESSED OUTSIDE THE BOUNDARIES OF THE 10 HA SAMPLE CELL.

Table 9. Summary of botanical, zoological, and aquatic community field metrics used to assess the quality or condition of the sample cells in cover type patches across a gradient of quality based on the GIS patch analysis model.

Botanical Field Metrics
Species presence/composition
Species richness (total number of species)
Floristic Quality Index (FQI) - for each species and sample cell
Mean coefficient of conservatism
Mean coefficient of wetness
Summary of physiognomic classes for native and non-native species
Zoological Field Metrics
Bird species presence/composition
Number of birds
Density of birds
Species diversity
Partners in Flight conservation score - for each species and sample cell
Species guilds*
Aquatic Community Field Metrics
Mussel species presence/composition
Mussel species richness
Mussel species diversity (i.e., Shannon-Wiener score)
Mussel abundance
Presence/absence of exotic bivalves
Intensity of zebra mussel infestation on native mussels
Macroinvertebrate taxa composition - for each sample and sum for site
Macroinvertebrate taxa richness - for each sample and sum for site
Macroinvertebrate biotic indices (e.g., Hilsenhoff Biotic Index (HBI))
Mean tolerance value (MTV)
Relative abundance of benthic intolerant taxa

*Potential field metric

the same sample cells or plots in which botanical and ecological surveys were conducted in 2008. Breeding birds were surveyed in the sample cells using point counts. In 2006, nine 10-minute point count surveys were conducted in each sample cell. In 2007 and 2008, a different sampling protocol was used in that only one 20-minute point count was conducted in each sample cell. The point count was randomly placed within the sample cell. Point counts began 15 minutes before sunrise and continued until 1030 hours. No data were collected during periods of inclement weather such as rain, fog, or a wind speed greater 20 km per hour. After arriving at the point count site, observers allowed a one-minute acclimation period before conducting a 20-minute point count. Although many other studies have used a 5 – 10 minute point count, the 20-minute point count allowed us to observe more avian diversity with the most efficiency given the difficulties of traveling to each point count site (Huff et al. 2000). All birds observed (aurally and visually) were recorded within the 50-m fixed radius point count, however birds beyond this distance were recorded as well with detailed information recorded on their distance from the observer (variable circular plot method). Gender of the birds was recorded whenever possible. Birds flying over the site were noted as such and may not be used in further analysis. No playbacks or sounds were used to attract birds into the point count location.

The field metrics that were collected to assess the quality or condition of the breeding bird community include bird species composition, number of birds, density of birds, and species diversity (Table 9). Species guilds, indicator species, and/or conservation value of individual bird species also may be used to evaluate the bird community in the sample cells (Table 9). We also can compare the quality of the cover type patches based on the conservation value of the individual species and the bird communities using the Partner's in Flight (PIF) ranking system (Nuttle et al. 2003). This classification allows bird species to be ranked by their demography in many categories and the level of conservation concern (Carter et al. 2000). Each bird species has been assigned PIF scores including a population trend score, threats to breeding regional score, and regional combined score. Considering that a simple measure of the avian diversity index of a site does not consider the conservation ranking of each species, the use of PIF ranking system will add a component of conservation priority.

Aquatic Field Component

The aquatic areas of high ecological value or high site quality as identified by the field metrics will be referred to as high quality aquatic sites or stream/river natural community classes. The aquatic field component from 2006-2008 was conducted in the Rogue River and Flat River in Kent, Montcalm, Ionia, and Newaygo counties. Aquatic field sampling from 2006 to 2008 was conducted at 50 sites. To adequately test the GIS model developed by Wang et al. (in press) and the efficacy of the stream impact rankings identified in the model for accurately assessing the quality or condition of aquatic sites, the goal was to obtain field metrics from a sufficient number of stream/river reaches across a gradient of impact rankings. The aquatic field sites that were sampled from 2006 to 2008 were fairly evenly distributed across stream/river reaches of only three of the six expected impact rankings assigned by the GIS model, with 19 sites in stream reaches with the moderate impact ranking category, 15 in the detectable impact ranking, and 16 in the no impact ranking.

The field metrics to assess the quality of the aquatic site or stream/river natural community have focused on the macroinvertebrate and mussel communities found at the sample sites. Specific field metrics that were examined and used to assess the quality or condition of aquatic sites have included mussel species composition, mussel species richness and diversity (i.e., Shannon-Wiener score), mussel abundance, presence/absence of exotic bivalves, intensity of zebra mussel infestation on native mussels, macroinvertebrate taxa composition and diversity (i.e., Shannon-Wiener score), macroinvertebrate taxa richness, macroinvertebrate biotic indices (e.g., Hilsenhoff Biotic Index), macroinvertebrate mean tolerance value (MTV), and relative abundance of benthic intolerant taxa (Table 9).

Survey sites were primarily determined by access (i.e., accessible road and/or bridge crossing). Survey sites in first order stream/river reaches were omitted from the field portion of the study. A pool of potential survey sites was generated by identifying points 100 m upstream and 100 m downstream of all road-stream crossings. Survey sites were randomly selected from this pool of potential sites, and were located either 100-m upstream or downstream from select road/stream intersections in the targeted watershed. Some randomly selected sites were not surveyed because of access problems (i.e., when we were unable to contact the landowner for permission). At each sample site, we collected four Surber samples and one D-net sample for a total of five samples for invertebrates. D-net sweeps were made in microhabitats not covered by Surber samples, especially near the water's edge and emergent/ submergent vegetation. We also surveyed for mussels in a 128-m^2 area at each sample site. Freshwater mussel communities were sampled using glass bottom buckets and tactile searches. Substrate composition also was described by estimating the proportion of each particle size classes.

Aerial Photo Interpretation Component

In 2007, an aerial photo interpretation component was added to the project to improve our ability to accurately identify areas to a particular land cover or natural community type on the landscape and evaluate their quality remotely. The aerial photo interpretation component delineated photo-interpreted (PI) polygons which are spatially defined areas of a single land cover type or class, as defined by the terrestrial GIS analysis, based on aerial photo interpretation of 1998 air photos. Polygons were delineated based on cover type, condition, roads, and other barriers or gaps in the vegetation. These polygons were delineated independently of the cover type patches identified by the GIS model although significant overlap with the patches likely occurred. Polygons comprised an entire cover type patch if it was small and contiguous. As a result, each cover type patch identified in the GIS model that was photo-interpreted could include a single PI polygon or multiple PI polygons.

Each PI polygon was typed as one of two broadly-defined MNFI natural community types: upland deciduous or mixed forest (e.g., dry-mesic and mesic northern forest) and lowland mixed or coniferous forest (e.g., hardwood-conifer swamp and rich conifer swamp). Two additional natural community types, bog and intermittent wetland, also were used to classify PI polygons in 2007. These designations are based on a modified Anderson level 3 or level 4 land cover type which are used for land cover mapping at MNFI. The modified Anderson level classifications are generally similar to MNFI natural community classifications but not exactly the same. Each PI polygon was evaluated for ecological quality based on a number of criteria related to size/area, landscape context, and ecological condition using the air photos (Table 10). Specific aerial photo interpretation metrics or criteria were developed for different natural communities (Appendix 2). Based on this analysis, this component identified high quality photo-interpreted polygons. These results can be used to evaluate the GIS model results, and depending on the results, this component may be used to complement or enhance the GIS model. The field metrics also can be used to test and evaluate the accuracy of the PI polygons.

Conservation Gazetteer

This project also will develop a "conservation gazetteer" which will identify high ecological value areas as priorities for conservation in an ecoregional and statewide framework based on currently available data for the state. This product will provide information and analysis that will enable informed decisionmaking by federal, state, and local governments, non-governmental organizations, and other entities in management, land use and conservation planning decisions. The conservation gazetteer was initially proposed to be a printed document or book comprised of a series of maps depicting priority conservation areas by county. The data layers used in the analysis to identify the priority conservation areas also would be provided with associated background information or descriptions of the data layers including the data sources, limitations, and continuing needs. However, upon consultation with the MDNR this year, it was decided that the conservation gazetteer would consist of a web-based product instead of a printed document. The conservation gazetteer at this time will primarily provide the results of the GIS patch analysis and associated data layers that were developed as part of the GIS component of this project. Additional data layers that can be used to help identify and prioritize areas of high ecological value for conservation also may be provided as part of the conservation gazetteer. These may include important areas for rare species and high quality natural communities based on Michigan's Natural Heritage Database, areas that have been designated as important for birds, other wildlife, and biodiversity in general (e.g., important bird areas, old growth forests, GAP analysis, etc.), areas important for watershed function or watershed protection areas, proximity to public lands, and lands under threat (i.e., threat analysis).

Table 10. Summary of rank factors, key ecological attributes, metrics, and ranking criteria for assessing the ecological quality or condition of photo-interpreted polygons in general.

Rank factor	Key Ecological Attribute	Metric	Ranking criteria	
LANDSCAPE CONTEXT	Landscape Pattern [assessed @ 1:24,000 scale centered on polygon of interest]	Broader land use	**4 = Excellent**	Landscape characterized by >90% natural cover (i.e., classifiable to natural community type), with the sum total of built areas, active agriculture, old fields, and pine plantations comprising <10% of area.
			3 = Good	Landscape characterized by >60% natural cover, with strong connectivity among patches. Active agricultural fields, old fields, and/or pine plantations comprise 0-40% of landscape. Built areas cannot exceed 25%.
			2 = Fair	Landscape characterized by 30-60% natural cover, either as relatively few isolated blocks or as scattered patches with poor connectivity. The remainder of various types (see above). Built areas cannot exceed 50%.
			1 = Poor	Landscape urban or suburban, or dominated by active agriculture. <30% of landscape characterized by natural cover.
	Landscape Composition	Buffer width	**4 = Excellent**	Occurrence is buffered by +/- natural cover of >100 m width on entire periphery.
			3 = Good	Occurrence is buffered by +/- natural cover of >100 m width on >75% of periphery. Unbuffered portion not in active agriculture or built.
			2 = Fair	Occurrence is buffered by +/- natural cover of >100 m width on >50% of periphery or by >50 m width on >75% of periphery. Unbuffered portion can be in active agriculture or built. Includes sites buffered by pine plantation.
			1 = Poor	Occurrence buffered by +/- natural cover of <50 m width on entire periphery, or not buffered.
ABIOTIC CONDITION	Hydrology	Presence of drains, ditches, channelization, roads	**4 = Excellent**	Hydrology unimpacted by drains, ditches, roads, or channels. No anthropogenic hydrologic manipulation noted.
			3 = Good	Minor disruption of hydrologic regime. Drains, ditches, channels, or roads, if present, impact <10% of wetland. Or, for large wetland complexes, hydrology is impacted >100 m from periphery of area identified as being of potential natural quality. Includes areas associated with otherwise intact streams crossed by roads.
			2 = Fair	Moderate disruption of hydrologic regime. Drains, ditches, channels, or roads impact <25% of occurrence. Or, for large wetland complexes, hydrology is impacted <100 m from periphery of area identified as being of potential natural quality.
			1 = Poor	Hydrologic regime significantly altered. Drains, ditches, channels, or roads impact >25% of occurrence.
	Site Intactness	Within-patch fragmentation and disturbance, caused by logging, plowing, human development, etc.	**4 = Excellent**	<10% of patch impacted by fragmentation and/or human disturbance. Logging roads, two-tracks, and trails visible on aerial photographs are localized. Recent cutting, oil pad development, human-created soil disturbance, etc. local.
			3 = Good	<25% of patch impacted by fragmentation and/or human disturbance. Logging roads, two-tracks, and trails visible on aerial photographs local to occasional. Recent cutting, oil pad development, human-created soil disturbance, etc. local to occasional.
			2 = Fair	<40% of patch impacted by fragmentation and/or human disturbance. Logging roads, two-tracks, and trails visible on aerial photographs occasional to common. Recent cutting, oil pad development, human-created soil disturbance, etc. occasional to common.
			1 = Poor	Occurrence is significantly impacted by fragmentation and/or human disturbance (est. >40% of area impacted). Recent cutting, oil pad development, human-created soil disturbance, etc. common to widespread.

Table 10. Continued.

BIOTIC CONDITION	Community Structure and Function	Vegetative structure	**4 = Excellent**	Specific to natural community type
			3 = Good	Specific to natural community type
			2 = Fair	Specific to natural community type
			1 = Poor	Specific to natural community type
SIZE	Community size	Area in acres	**4 = Excellent**	Specific to natural community type, based on existing MNFI EO specifications.
			3 = Good	Specific to natural community type, based on existing MNFI EO specifications.
			2 = Fair	Specific to natural community type, based on existing MNFI EO specifications.
			1 = Poor	Specific to natural community type, based on existing MNFI EO specifications.

RESULTS AND DISCUSSION

GIS Analysis/Component

The GIS patch analysis modeling has been completed except for testing the model against the field metrics and aerial photo interpretation results. A total of 2,181,975 patches of land cover was delineated and included in the analysis. When scores for all 13 regions of the state were summed together, less than 5% of the patches were assigned a score of seven or higher. Only 5,751 patches of the total 2,181,975 patches included in the analysis scored ten or higher (i.e., 0.3%) (Figure 3). Figure 4 provides an example of the patch analysis results. Generally, both the number of high scoring patches and the size of high scoring patches increased with latitude (Figures 5 and 6). Also, the cover type patches, especially the patches having high quality scores, were generally very large. Sampling only one 10-ha sample cell or plot in very large cover type patches may need to be examined for the analysis. The data analysis will test whether the GIS patch scores correlate with the field metric scores.

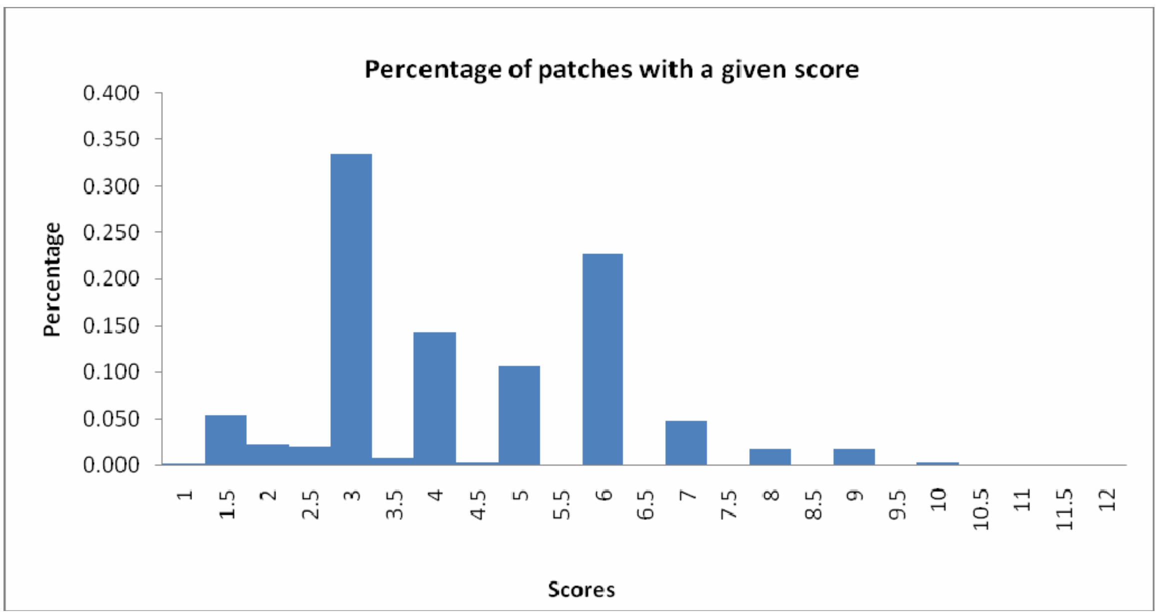

Figure 3. Distribution of quality scores for all cover type patches from GIS patch analysis.

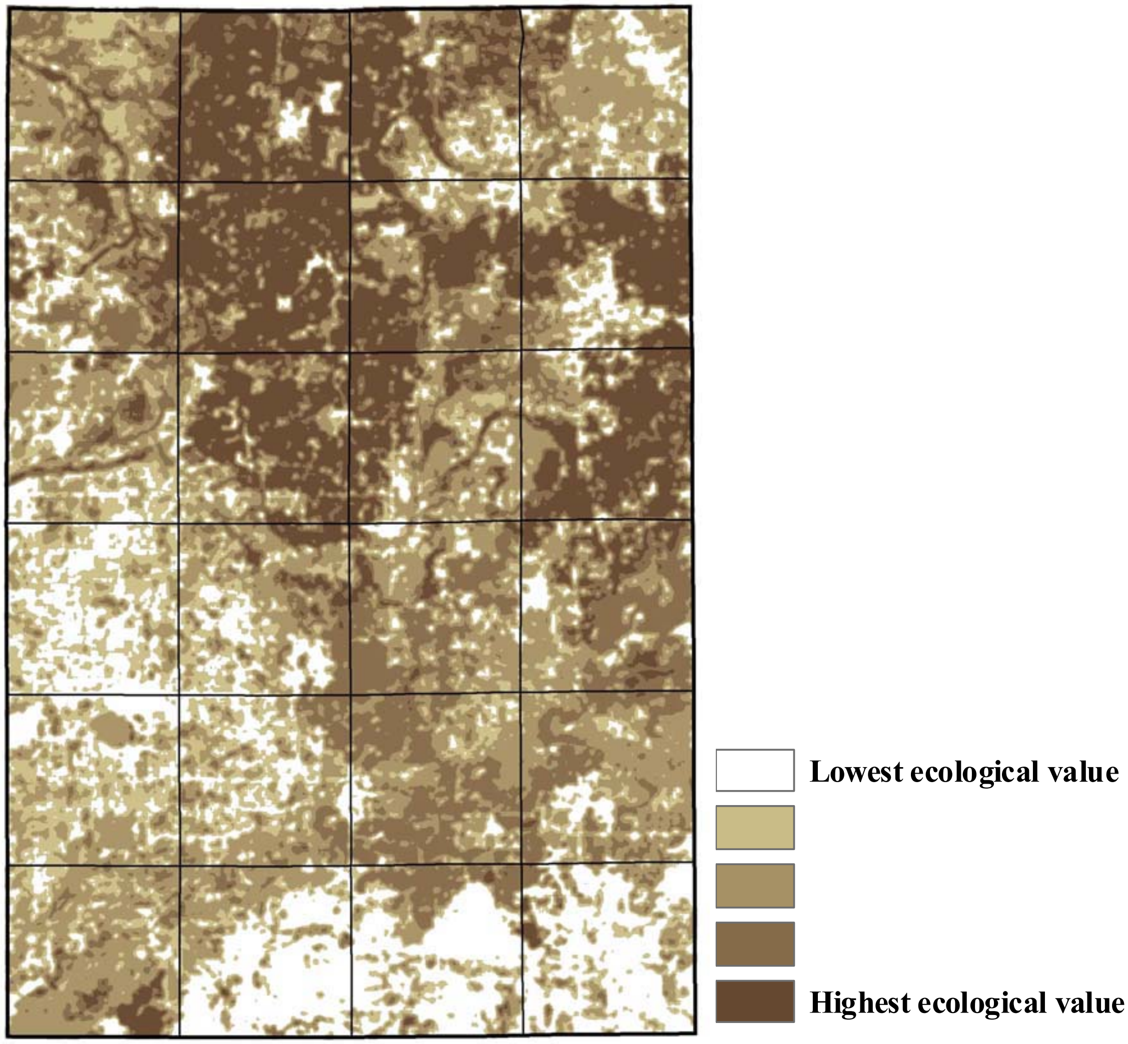

Figure 4. Example of GIS patch analysis results from Newaygo County.

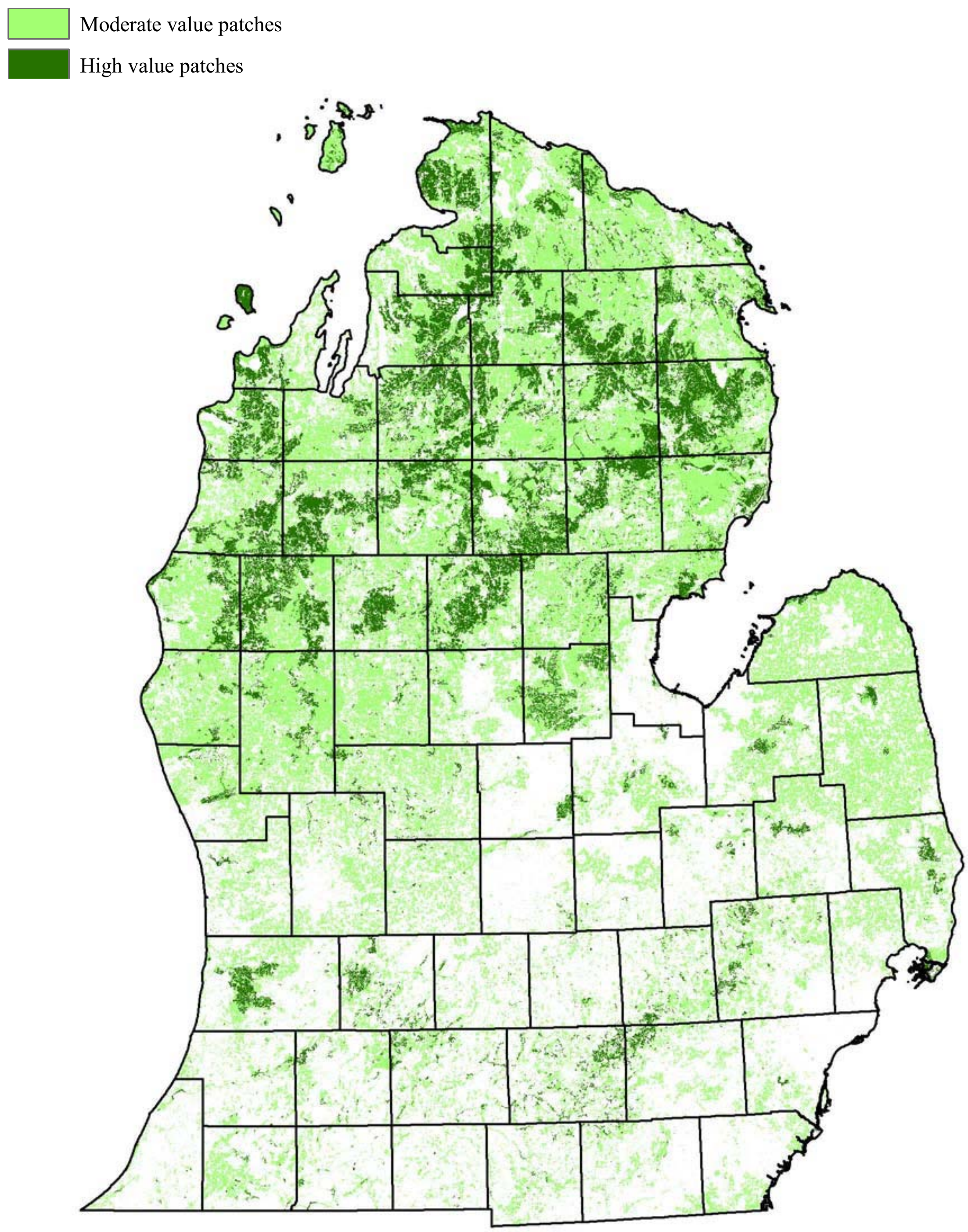

Figure 5. Map showing general distribution of high and moderately scoring cover type patches in the Lower Peninsula based on results from the GIS patch analysis.

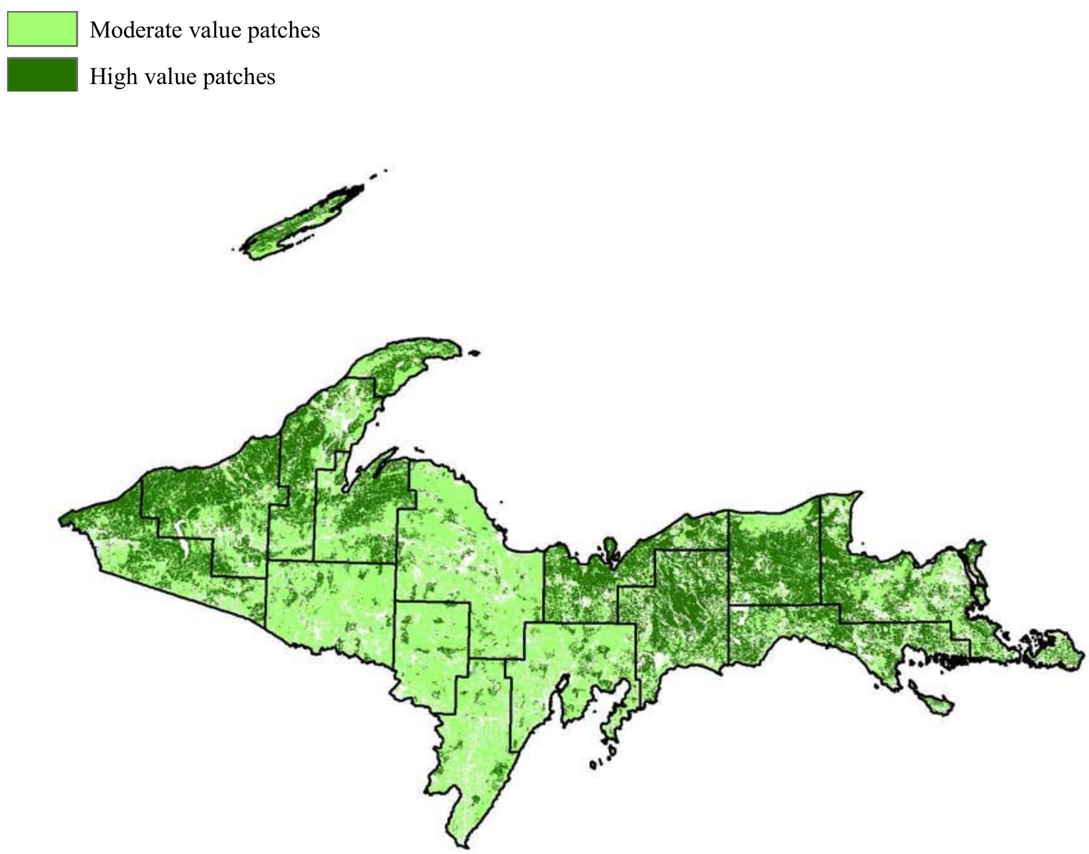

Figure 6. Map showing general distribution of high and moderately scoring cover type patches in the Upper Peninsula based on results from the GIS patch analysis.

Field Component

Terrestrial Field Component

In 2008, ecological, botanical, and zoological field metrics or sampling were conducted in 10 sample cells in upland deciduous forest cover type patches ranked as moderate to high quality (UDM) and 10 sample cells in upland deciduous forest cover type patches ranked as low to moderate quality (UDL) based on the GIS patch analysis scores. The same sample cells were surveyed by all three disciplines. Data from these sample cells will result in field metrics data from 2006 to 2008 from at least 30 upland deciduous forest cover type patches across a gradient of quality, with at least 10 sample cells/cover type patches in each of the three quality rankings (i.e., high, moderate, and low quality).

Also, the field sampling scheme was revised in 2008 so that cover type patches were randomly selected for field sampling instead of randomly selecting sample cells, and that each sample cell was located within a single cover type patch instead of multiple cover type patches potentially as in 2006 and 2007. For data collected in 2006 and 2007, if the sample cells fall within a single cover type patch, the data will be used in the current analysis. If the sample cell crosses multiple patch boundaries, the data will be censored and not included in the current analysis at this time. We should be able to keep field data from a number of upland forest sample cells from 2006 and 2007, but this needs to be verified. This will result in a GIS score and a field metric score or scores for each sample cell and cover type patch, rather than one sample cell/field metric score to multiple GIS patches/ patch scores.

Ecological field surveys/sampling

The majority of sample cells or plots that were surveyed in 2008 were characterized by dry-mesic northern forest, dominated by white oak (*Quercus alba*) and black oak (*Q. velutina*), often associated with white pine (*Pinus strobus*). Additional plots were characterized by aspen (*Populus grandidentata* and *P. tremuloides*), mesic northern forest, and oak-pine barrens. Several field metrics assessing landscape context, present condition, and threats were scored in the field based on meander surveys of the entire plot. GPS waypoints were taken to record locations of significant features, disturbances, changes in cover type, and soil samples. All but one plot fell within cover patches exhibiting significantly altered vegetative structure associated with timber removal and other habitat management. High deer browse and an abundance of red maple were identified as significant threats to the majority of sampled forest patches. Invasive species were uncommon and concentrated on roadsides, along well-used paths, and in clearings. Field scores were similar for habitat patches predicted as being of medium or low quality in the GIS-based patch analysis. Further data analysis will be conducted in winter/spring 2009. Part of the data analysis will be determining if any of the field metrics or variables correlate with one another and how to aggregate the field metric scores to develop a cumulative score for each sample cell.

Botanical field surveys/floristic sampling

Plant species presence/composition was recorded during meander/timed-meander surveys in all targeted sample cells or plots in 2008. No listed plant species were encountered during plot inventories. Several sites noted during aerial photo review as potential coastal plain marshes (in proximity to sample cells/plots) were subsequently visited in the field en route to sample cells/plots (and in one case, during a rainy day when it was not possible to use the handheld computer for plot sampling). Several high quality coastal plain marshes were thus identified, including several rare plant species, although there was not sufficient time to conduct thorough surveys or collect data adequate for formal processing. One state threatened species, *Eleocharis tricostata*, was identified and collected in coastal plain marsh habitat within a powerline right-of-way between UDM 8 and UDM 9 in northern Newaygo County, constituting a significant record (data were obtained for this site). A total of 103 plant specimens were collected during the field sampling. These specimens have been identified and verified. Data entry and analysis will be conducted in the winter/spring of 2009. As with the ecological data, part of the data analysis will be determining how to aggregate the field metric scores to generate a cumulative score for the plant community for each sample cell.

Zoological field sampling

Breeding bird point count surveys were conducted in May and June of 2008. These surveys were conducted in the same sample cells or plots in which botanical and ecological surveys were conducted in 2008. Several rare or noteworthy bird species that were detected during breeding bird surveys in 2008 include the state special concern Cerulean Warbler (*Dendroica cerulea*), state threatened Red-shouldered Hawk (*Buteo lineatus*), Golden-winged Warbler (*Vermivora chrysoptera*), and Bell's Vireo (*Vireo bellii*). The Cerulean Warbler, Red-shouldered Hawk, and Golden-winged Warbler also have been identified as species of greatest conservation need by Michigan's Wildlife Action Plan (Eagle et al. 2005). The breeding bird data will be entered and analyzed during the winter/spring of 2009. Part of the data analysis will need to determine how to deal with the different bird sampling methodology employed in 2007 and 2008 compared to that used in 2006. The exact field metrics that will be utilized in the analysis and how to aggregate or combine the field metric scores into a cumulative score for the bird community for each sample cell also will need to be determined.

Aquatic Field Component

Aquatic field sampling was conducted primarily in 2006 and 2007. Limited aquatic field sampling was conducted in 2008. The aquatic component of the project in 2008 focused primarily on processing the numerous macroinvertebrate samples that were collected during field sampling from 2006 to 2008. Five macroinvertebrate samples were collected in the field from each site, but only a subset of the samples will be processed, identified and included in the data analysis at this time due to time and funding constraints. Four samples from 16 sites (i.e., 64 samples) have been processed and identified. Two samples from an additional 14 sites (i.e., 28 samples) also have been processed and identified to date. This will result in 2-4 samples from 30 sites total, with 10 sites in each of the three predicted impact rankings, that will be processed, identified, and included in the data analysis at this time. Aquatic data processing/entry and analysis will be conducted in 2009. As with the terrestrial field metrics, part of the aquatic data analysis will be determining how to aggregate or combine field metrics into a cumulative score for each site to compare with the predicted stream impact rankings for each site from the GIS model. The field metric data will be used to see if they can be correlated to the predicted stream/river impact levels or rankings to test whether these impact rankings and the GIS model can be used to infer or assess the ecological quality or condition of stream/river reaches remotely.

Aerial Photo Interpretation Component

In 2007, all upland forests 10 ha or greater in 8 of the 24 townships in Newaygo County were photo interpreted. Only upland forest and lowland mixed forest polygons meeting C-rank size criteria in these eight townships were identified and photo interpreted. In addition, potential high quality occurrences of these and other natural communities were identified and delineated in the remaining 16 townships in Newaygo County to provide a more complete conservation layer of the county. A total of 833 sites were identified and delineated throughout the county. In 2008, no additional aerial photo interpretation or identification of additional photo-interpreted polygons was conducted other than an aerial photo review of the sample cells that were selected for sampling.

In 2007, all upland forest sample cells or plots were located in photo-interpreted polygons. In 2008, two of the 20 sampled cells or plots were located in photo-interpreted polygons. Results from the aerial photo interpretation and evaluation of polygon quality conducted in 2007 will be compiled and potentially analyzed during winter/spring of 2009. Each polygon has a score for each criterion, but we still need to determine the specific criteria that would be included in the analysis and develop an algorithm or formula for combining or aggregating the criteria into one score/ranking indicating the quality or condition of each photo-interpreted polygon. Also, additional photo interpretation would need to be conducted to delineate and evaluate the polygons in which 18 of the 20 cells sampled in 2008 were located if the PI polygons are going to be included in the data analysis. The photo-interpreted polygon scores can be compared with the GIS patch analysis scores and field metric scores to evaluate the efficacy and contribution of this approach to assessing the ecological quality of these areas remotely. The photo-interpreted polygons could potentially be used to enhance or complement the GIS models.

Conservation Gazetteer

Development of the web-based conservation gazetteer continued in 2008. The overall architecture of the gazetteer has been established. After substantial experimentation with displaying different data types, the format that will be used to present the data has been determined. This will entail converting the patch analysis models from the ESRI raster format to a vector format from which the models will be converted to a different raster format. We are currently investigating different ways for displaying the GIS models and resulting data layers in a user-friendly format. Development of the web-based conservation gazetteer will be completed in 2009. The web-based conservation gazetteer also will be updated and revised based on feedback from initial users.

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APPENDICES

Appendix I. Summary of field metrics to assess the ecological quality or condition of the range of natural community field classes associated with the GIS/IFMAP land cover types or classes and MNFI natural communities.

	Non-forested wetland		Lowland forest		Non-forested wetland	
	Bog	Poor fen	Poor conifer swamp	Muskeg	Coastal plain marsh	Intermittent wetland
Metrics	Acidic peatlands				Intermittent wetlands	
Landscape context**						
Buffer width	X	X	X	X	X	X
Broader land use	X	X	X	X	X	X
Site intactness						
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	X	X	X	X	X	X
Hydrology						
Presence of drains, ditches, channelization	X	X	X	X	X	X
Soil erosion						
ORV damage	X	X	X	X	X	X
Stream morphology						
Community structure and function						
Vegetative structure and composition	X	X	X	X	X	X
Evidence of logging						
Evidence of plowing						
Evidence of fire						
Presence of invasive non-native vascular plant spp.	X	X	X	X	X	X
Presence of rotting logs and snags						
Tree regeneration (oak, conifer, etc. as appropriate)						
Evidence of deer browse						
Species-specific die-offs						
Condition of sphagnum peat	X	X	X	X		
Cat-tail invasion (indicator of nutrient enrichment)	X	X	X	X	X	X
Presence of red maple (*Acer rubrum*)						
Pit-and-mound topography						
Dominance by native grasses and/or sedges						

Appendix I (continued). Summary of field metrics to assess the ecological quality or condition of the range of natural community field classes associated with the GIS/IFMAP land cover types or classes and MNFI natural communities.

	Grassland/shrub					
	Dry Sand Prairie	Mesic sand prairie	Oak barrens	Oak openings	Oak-pine barrens	Pine barrens
Metrics	**Upland prairies and savanna**					
Landscape context**						
Buffer width	**X**					
Broader land use	**X**	**X**	**X**	**X**	**X**	**X**
Site intactness						
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	**X**	**X**	**X**	**X**	**X**	**X**
Hydrology						
Presence of drains, ditches, channelization	**X**	**X**	**X**	**X**	**X**	**X**
Soil erosion	**X**	**X**	**X**	**X**	**X**	**X**
ORV damage						
Stream morphology						
Community structure and function						
Vegetative structure and composition	**X**	**X**	**X**	**X**	**X**	**X**
Evidence of logging						
Evidence of plowing	**X**	**X**	**X**	**X**	**X**	**X**
Evidence of fire	**X**	**X**	**X**	**X**	**X**	**X**
Presence of invasive non-native vascular plant spp.	**X**	**X**	**X**	**X**	**X**	**X**
Presence of rotting logs and snags						
Tree regeneration (oak, conifer, etc. as appropriate)						
Evidence of deer browse	**X**	**X**	**X**	**X**	**X**	**X**
Species-specific die-offs	**X**	**X**	**X**	**X**	**X**	**X**
Condition of sphagnum peat						
Cat-tail invasion (indicator of nutrient enrichment)						
Presence of red maple (*Acer rubrum*)						
Pit-and-mound topography						
Dominance by native grasses and/or sedges	**X**	**X**	**X**	**X**	**X**	**X**

Appendix I (continued). Summary of field metrics to assess the ecological quality or condition of the range of natural community field classes associated with the GIS/IFMAP land cover types or classes and MNFI natural communities.

	Upland forest				
	Dry southern forest	Dry-mesic northern forest	Dry-mesic southern forest	Mesic northern forest	Mesic southern forest
Metrics	**Upland oak and oak-pine forests**			**Upland mesic forests**	
Landscape context**					
Buffer width	X	X	X	X	X
Broader land use	X	X	X	X	X
Site intactness					
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	X	X	X	X	X
Hydrology					
Presence of drains, ditches, channelization	X	X	X	X	X
Soil erosion	X	X	X	X	X
ORV damage					
Stream morphology					
Community structure and function					
Vegetative structure and composition	X	X	X	X	X
Evidence of logging	X	X	X	X	X
Evidence of plowing					
Evidence of fire	X	X	X		
Presence of invasive non-native vascular plant spp.	X	X	X	X	X
Presence of rotting logs and snags	X	X	X	X	X
Tree regeneration (oak, conifer, etc. as appropriate)	X	X	X		
Evidence of deer browse	X	X	X	X	X
Species-specific die-offs	X	X	X	X	X
Condition of sphagnum peat					
Cat-tail invasion (indicator of nutrient enrichment)					
Presence of red maple (*Acer rubrum*)	X	X	X		
Pit-and-mound topography				X	X
Dominance by native grasses and/or sedges					

Appendix I (continued). Summary of field metrics to assess the ecological quality or condition of the range of natural community field classes associated with the GIS/IFMAP land cover types or classes and MNFI natural communities.

	Lowland forest					
	Hardwood-conifer swamp	Relict conifer swamp	Rich conifer swamp	Southern swamp	Northern swamp	Southern floodplain forest
Metrics	**Lowland mixed and coniferous forests**			**Lowland deciduous forests**		**Floodplain forest**
Landscape context**						
Buffer width	X	X	X	X	X	X
Broader land use	X	X	X	X	X	X
Site intactness						
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	X	X	X	X	X	X
Hydrology						
Presence of drains, ditches, channelization	X	X	X	X	X	
Soil erosion						
ORV damage						
Stream morphology						X
Community structure and function						
Vegetative structure and composition	X	X	X	X	X	X
Evidence of logging	X	X	X	X	X	
Evidence of plowing						
Evidence of fire						
Presence of invasive non-native vascular plant spp.	X	X	X	X	X	X
Presence of rotting logs and snags	X	X	X	X	X	X
Tree regeneration (oak, conifer, etc. as appropriate)	X	X	X	X	X	
Evidence of deer browse	X	X	X	X	X	X
Species-specific die-offs	X	X	X	X	X	X
Condition of sphagnum peat						
Cat-tail invasion (indicator of nutrient enrichment)						
Presence of red maple (*Acer rubrum*)	X	X	X			
Pit-and-mound topography						
Dominance by native grasses and/or sedges						

Appendix I (continued). Summary of field metrics to assess the ecological quality or condition of the range of natural community field classes associated with the GIS/IFMAP land cover types or classes and MNFI natural communities.

	Non-forested wetland												
	Inundated Shrub Swamp	Northern Shrub Thicket	Southern shrub-carr	Emergent marsh	Inland salt marsh	Submergent marsh	Lakeplain wet-mesic prairie	Northern fen	Northern wet meadow	Northern Wet-Mesic Prairie	Southern wet meadow	Wet prairie	Wet-mesic prairie
Metrics	**Shrub-dominated wetlands**			**Emergent and submergent marshes**			**Wet meadows, wet and wet-mesic prairies, and calcareous fen**						
Landscape context**													
Buffer width	X	X	X	X	X	X	X	X	X	X	X	X	X
Broader land use	X	X	X	X	X	X	X	X	X	X	X	X	X
Site intactness													
Presence of roads, RR tracks, or other (residential, industrial, commercial) development	X	X	X	X	X	X	X	X	X	X	X	X	X
Hydrology													
Presence of drains, ditches, channelization	X	X	X	X	X	X	X	X	X	X	X	X	X
Soil erosion													
ORV damage							X	X	X	X	X	X	X
Stream morphology													
Community structure and function													
Vegetative structure and composition	X	X	X	X	X	X	X	X	X	X	X	X	X
Evidence of logging													
Evidence of plowing							X	X	X	X	X	X	X
Evidence of fire													
Presence of invasive non-native vascular plant spp.	X	X	X	X	X	X	X	X	X	X	X	X	X
Presence of rotting logs and snags													
Tree regeneration (oak, conifer, etc. as appropriate)													
Evidence of deer browse													
Species-specific die-offs													
Condition of sphagnum peat													
Cat-tail invasion (indicator of nutrient enrichment)				X	X	X							
Presence of red maple (*Acer rubrum*)													
Pit-and-mound topography													
Dominance by native grasses and/or sedges													

Appendix II. Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

COMMUNITY TYPE	Rank factor	Key Ecological Attribute	Metric	Ranking criteria	
BOG	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Sphagnum mat intact. Zonation various depending on maturity.
				2 = Fair	Partially degraded bog mat (i.e., a portion of the system is intact, another portion is degraded).
				1 = Poor	Vegetation outside expected range of variation. OR Sphagnum mat degraded. OR flooded (including beaver flooding) former bog now lacking typical structure.
	SIZE	Community size	Area in acres	**4 = Excellent**	70+ acres
				3 = Good	40-69 acres
				2 = Fair	10-39 acres
				1 = Poor	<10 acres
POOR CONIFER SWAMP	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Sphagnum mat intact. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. OR Sphagnum mat degraded. OR flooded (including beaver flooding), now lacking typical structure.
	SIZE	Community size	Area in acres	**4 = Excellent**	120+ acres
				3 = Good	60-119 acres
				2 = Fair	30-59 acres
				1 = Poor	<30 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

RICH CONIFER SWAMP	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Old-growth sites appear to have relatively large crown diameters. May be scored if we use circa 1938 aerial photos.
				3 = Good	Conifers dominant (>66% cover). Should be mature, but place here if uncertain.
				2 = Fair	Conifers >50% cover, or cedars immature, if discernible on aerial photos.
				1 = Poor	Hardwoods dominant (>50% cover). Typically heavily disturbed stands that have converted to red maple dominance.
	SIZE	Community size	Area in acres	**4 = Excellent**	120+ acres
				3 = Good	60-119 acres
				2 = Fair	30-59 acres
				1 = Poor	<30 acres
RELICT CONIFER SWAMP	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Conifers (tamarack and others occasionally) >60% cover. Deciduous trees <33% cover. Zonation various.
				2 = Fair	Conifers 33-60% cover. Zonation various. Represents sites with some degree of conversion to hardwood (typically red maple) dominance.
				1 = Poor	Conifers <33% cover. Typically heavily disturbed stands that have converted to red maple dominance.
	SIZE	Community size	Area in acres	**4 = Excellent**	70+ acres
				3 = Good	45-69 acres
				2 = Fair	15-45 acres
				1 = Poor	<15 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

HARDWOOD-CONIFER SWAMP	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Old-growth sites appear to have relatively large crown diameters. May be scored if we use circa 1938 aerial photos.
				3 = Good	Conifers >33% cover, or distributed throughout site but comprising <33% cover. Should be mature, but place here if uncertain.
				2 = Fair	Conifers present, but localized or comprising <33% cover. OR, conifers have greater cover, but are immature (if discernible on aerial photos).
				1 = Poor	Conifers rare. Typically heavily disturbed stands that have converted to red maple dominance. Stands only mapped if conifer component identifiable.
	SIZE	Community size	Area in acres	**4 = Excellent**	100+ acres
				3 = Good	50-99 acres
				2 = Fair	25-49 acres
				1 = Poor	<25 acres
SOUTHERN SWAMP	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Old-growth sites appear to have relatively large crown diameters. May be scored if we use circa 1938 aerial photos.
				3 = Good	Stand dominated by wetland hardwoods. Exclude sites converted from conifer dominance. <30% aspen or shrub cover (see IFMAP lu_2000 GIS layer).
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Site contains >30% aspen or shrub cover (see IFMAP lu_2000 GIS layer). Exclude sites converted from conifer dominance.
	SIZE	Community size	Area in acres	**4 = Excellent**	80+ acres
				3 = Good	50-79 acres
				2 = Fair	25-49 acres
				1 = Poor	<25 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

SOUTHERN FLOODPLAIN FOREST	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Old-growth sites appear to have relatively large crown diameters. May be scored if we use circa 1938 aerial photos.
				3 = Good	Intact structure. Should be mature, but place here if uncertain.
				2 = Fair	N/A. Placeholder for immature stands. Place here if maturity discernible on aerial photographs.
				1 = Poor	Significantly degraded structure; site barely recognizable as floodplain forest. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	60+ acres
				3 = Good	30-59 acres
				2 = Fair	15-29 acres
				1 = Poor	<15 acres
NORTHERN SHRUB THICKET	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	60+ acres
				3 = Good	35-59 acres
				2 = Fair	15-34 acres
				1 = Poor	<15 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

Community	Attribute	Metric	Measure	Rating	Criteria
SOUTHERN SHRUB-CARR	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	60+ acres
				3 = Good	35-59 acres
				2 = Fair	15-34 acres
				1 = Poor	<15 acres
INNUNDATED SHRUB SWAMP	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	60+ acres
				3 = Good	35-59 acres
				2 = Fair	15-34 acres
				1 = Poor	<15 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

MESIC SOUTHERN FOREST	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Old-growth sites appear to have relatively large crown diameters. May be scored if we use circa 1938 aerial photos.
				3 = Good	Stand dominated by northern hardwoods (beech, sugar maple, etc.). Should be mature, but place here if uncertain. <30% aspen (see IFMAP lu_2000 GIS layer).
				2 = Fair	Immature stands, or stands with mixed hardwood and aspen dominance. Includes thinned hardwood forests.
				1 = Poor	>60% aspen-dominated. Or, young, successional stand, as determined on aerial photos.
	SIZE	Community size	Area in acres	**4 = Excellent**	80+ acres
				3 = Good	40-79 acres
				2 = Fair	15-39 acres
				1 = Poor	<15 acres
MESIC NORTHERN FOREST	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Old-growth sites appear to have relatively large crown diameters. May be scored if we use circa 1938 aerial photos.
				3 = Good	Stand dominated by northern hardwoods and/or hemlocks. Should be mature, but place here if uncertain. <30% aspen (see IFMAP lu_2000 GIS layer).
				2 = Fair	Immature stands, or stands with mixed hardwood and aspen dominance. Includes thinned hardwood forests.
				1 = Poor	>60% aspen-dominated. Or, young, successional stand, as determined on aerial photos.
	SIZE	Community size	Area in acres	**4 = Excellent**	100+ acres
				3 = Good	50-99 acres
				2 = Fair	25-49 acres
				1 = Poor	<25 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

DRY-MESIC NORTHERN FOREST	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Old-growth sites appear to have relatively large crown diameters. May be scored if we use circa 1938 aerial photos.
				3 = Good	Oak- or pine-dominated stand. Should be mature, but place here if uncertain. <30% aspen (see IFMAP lu_2000 GIS layer).
				2 = Fair	Immature stands, or stands with mixed oak and aspen dominance. Includes thinned oak forests, including those underplanted with white pine.
				1 = Poor	>60% aspen-dominated. Or, young, successional stand, as determined on aerial photos.
	SIZE	Community size	Area in acres	**4 = Excellent**	100+ acres
				3 = Good	50-99 acres
				2 = Fair	25-49 acres
				1 = Poor	<25 acres
OAK-PINE BARRENS	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey, unless native vs. non-native groundcover can be determined from aerial photos.
				3 = Good	Moderate tree and shrub encroachment, together comprising <50% cover at the site. Native vs. non-native groundcover likely indeterminable on aerial photos.
				2 = Fair	Tree and shrub encroachment severe, together comprising >50% cover at the site, which is still recognizable as barrens.
				1 = Poor	Represents former oak-pine barrens (based on circa 1800 vegetation map) that have converted to dry-mesic northern forest due to post-1800 fire suppression.
	SIZE	Community size	Area in acres	**4 = Excellent**	100+ acres
				3 = Good	55-99 acres
				2 = Fair	25-54 acres
				1 = Poor	<25 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

DRY SAND PRAIRIE	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey. Groundcover should be >90% native spp. (warm season grasses show as gray or brown on aerial photos).
				3 = Good	Moderate tree and shrub encroachment, together comprising <25% cover at the site. Mostly native cover, if determinable on aerial photos.
				2 = Fair	Tree and shrub encroachment significant, together comprising >25% cover at the site, which is still recognizable as prairie. Or, significant cover by non-native spp.
				1 = Poor	Converted oak-pine barrens, or severely degraded structure. Non-native spp. dominate ground layer (cool season grasses tend to show as pink on photos).
	SIZE	Community size	Area in acres	**4 = Excellent**	10+ acres
				3 = Good	6-9.9 acres
				2 = Fair	3-5.9 acres
				1 = Poor	<3 acres
SUBMERGENT MARSH	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	100+ acres
				3 = Good	60-99 acres
				2 = Fair	30-59 acres
				1 = Poor	<30 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

EMERGENT MARSH	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	100+ acres
				3 = Good	60-99 acres
				2 = Fair	30-59 acres
				1 = Poor	<30 acres
NORTHERN WET MEADOW	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Moderate shrub encroachment, comprising <25% cover at the site. Native vs. non-native groundcover likely indeterminable on aerial photos.
				2 = Fair	Shrub encroachment significant, comprising >25% cover at the site, which is still recognizable as wet meadow.
				1 = Poor	Shrub encroachment severe, comprising >50% cover at the site, which is still recognizable as wet meadow.
	SIZE	Community size	Area in acres	**4 = Excellent**	60+ acres
				3 = Good	40-59 acres
				2 = Fair	20-39 acres
				1 = Poor	<20 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

INTERMITTENT WETLAND	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	40+ acres
				3 = Good	20-39 acres
				2 = Fair	5-19 acres
				1 = Poor	<5 acres
COASTAL PLAIN MARSH	BIOTIC CONDITION	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Vegetation within expected range of variation. Zonation various depending on maturity.
				2 = Fair	N/A. Requires field survey.
				1 = Poor	Vegetation outside expected range of variation. Poor condition typically indicated by altered hydrology (see Abiotic Condition).
	SIZE	Community size	Area in acres	**4 = Excellent**	40+ acres
				3 = Good	20-39 acres
				2 = Fair	5-19 acres
				1 = Poor	<5 acres

Appendix II (continued). Summary of metrics and criteria used to evaluate the quality or condition of photo-interpreted polygons by natural community type.

LAKEPLAIN WET-MESIC PRAIRIE	**BIOTIC CONDITION**	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey, unless native vs. non-native groundcover can be determined from aerial photos.
				3 = Good	Moderate tree and shrub encroachment, together comprising <25% cover at the site. Native vs. non-native groundcover likely indeterminable on aerial photos.
				2 = Fair	Tree and shrub encroachment significant, together comprising >25% cover at the site, which is still recognizable as prairie.
				1 = Poor	Tree and shrub encroachment severe, together comprising >50% cover at the site, which is still recognizable as prairie.
	SIZE	Community size	Area in acres	**4 = Excellent**	5+ acres
				3 = Good	2-4.9 acres
				2 = Fair	1-1.9 acres
				1 = Poor	<1 acre
NORTHERN FEN	**BIOTIC CONDITION**	Community Structure and Function	Vegetative structure and composition	**4 = Excellent**	N/A. Requires field survey.
				3 = Good	Moderate shrub encroachment, comprising <25% cover at the site. Native vs. non-native groundcover likely indeterminable on aerial photos.
				2 = Fair	Shrub encroachment significant, comprising >25% cover at the site, which is still recognizable as fen.
				1 = Poor	Shrub encroachment severe, comprising >50% cover at the site, which is still recognizable as fen.
	SIZE	Community size	Area in acres	**4 = Excellent**	35+ acres
				3 = Good	20-34 acres
				2 = Fair	5-19 acres
				1 = Poor	<5 acres