Ecological Assessment of the USDI Fish and Wildlife Service's Kirtland's Warbler Wildlife Management Area

Final Report

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Cover photo: Jim Patton

Executive Summary

The Kirtland's Warbler Wildlife Management Area (KWWMA) is an assemblage of 124 stands totaling 6,582 ac (2,264 ha), all located within eight counties of the northern Lower Peninsula of Michigan. Many of these stands are adjacent to existing jack pine forest ecosystems owned and managed by the Michigan Department of Natural Resources (MDNR). The characteristics of these tracts, however, are varied. Almost half of the area of the KWWMA is currently dominated by jack pine that is 5-23 years old, which is the preferred habitat of breeding Kirtland's Warbler. Our analysis suggests that many of these stands are not optimally stocked to provide high-quality Kirtland's Warbler habitat. However, songbird surveys on a subset of KWWMA stands in 2006 show that these stands do provide some habitat that is conducive for breeding Kirtland's Warblers. Furthermore, the diversity of habitats, both in terms of stand age and species composition and structure, suggest that a variety of songbird species, many of which are of conservation concern, are utilizing these habitats. This suggests that the KWWMA may contribute significantly to avifaunal productivity and diversity in northern Lower Michigan.

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Part I. Introduction

As part of a multi-agency strategy to provide breeding habitat for the Endangered Kirtland's Warbler (*Dendroica kirtlandii*), in 1980 the USDI Fish and Wildlife Service (USFWS) began purchasing lands for the Kirtland's Warbler Wildlife Management Area (KWWMA). In 1994, active management of these lands began under the direction of the manager of Seney National Wildlife Refuge and through a Memorandum of Understanding with the Michigan Department of Natural Resources. The original goal of the KWWMA was to acquire 7,500 ac (3,035 ha) of land on which habitat would be managed for the benefit of Kirtland's Warbler. At present, the KWWMA is an assemblage of 124 tracts (hereafter referred to as stands) totaling 6,582 ac (2,264 ha), all located within eight counties of the northern Lower Peninsula of Michigan (Fig. 1). The management objective for the majority of these lands is to produce large habitats (> 40 ha) comprised of densely-stocked (>2500 stems/ha) stands of young jack pine (*Pinus banksiana* Lamb.)

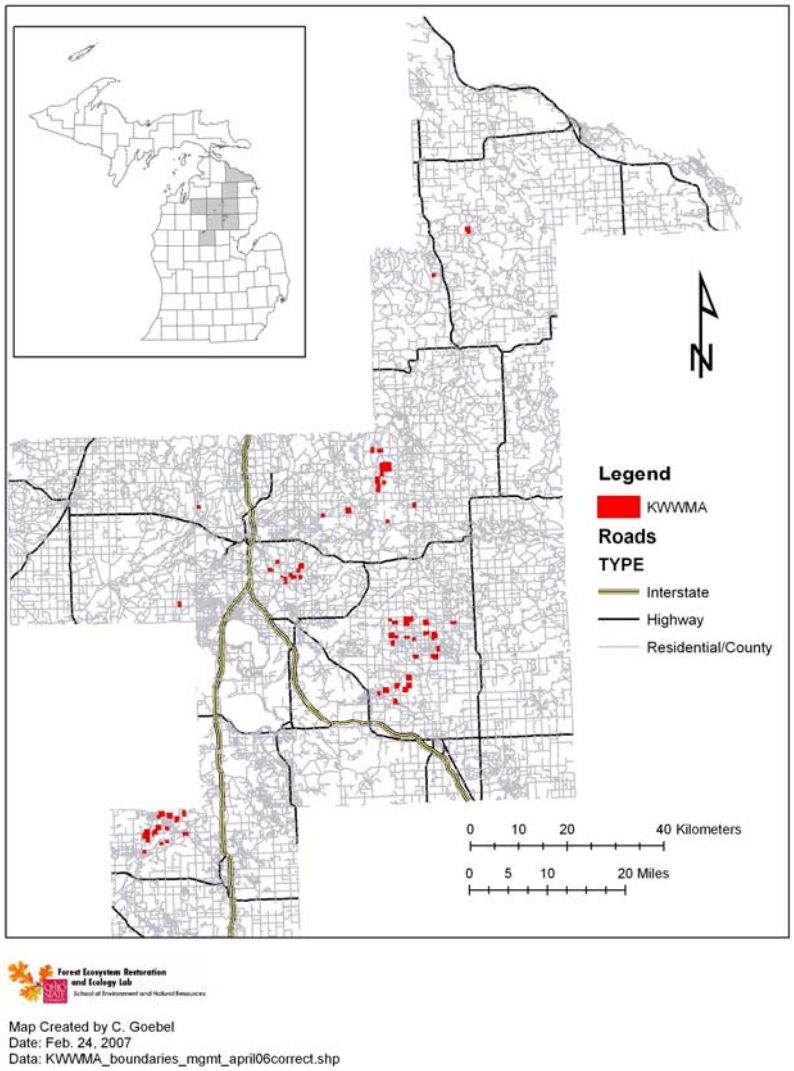

Fig. 1. Location of the 124 stands that comprise the Kirtland's Warbler Wildlife Management Area (KWWMA) in northern Lower Michigan.

growing on sandy, nutrient-poor soils that are 5 to 23 years old and 4.6 to 16.4 feet (1.4 to 5.0 m) in height (Probst and Weinrich 1993; Probst et al. 2003). Despite these general attributes, the distribution of suitable jack pine habitat for Kirtland's Warbler is often patchy reflecting the natural development of jack pine forest ecosystems following fire.

The Kirtland's Warbler Recovery Team, a consortium of federal and state organizations tasked with the recovery of the Kirtland's Warbler, has recommended that intensive stand-level management focus on emulating the effects of fire in jack pine forest ecosystems in order to provide the early successional habitat required by the Kirtland's Warbler (Kirtland's Warbler Recovery Plan 1985). Based upon concerted multi-agency efforts, silvicultural methods that emulate the natural patterns of jack pine forest ecosystem development have been devised and applied by foresters and resource managers across the landscape and have yielded considerable success (Fig. 2). For instance, the total estimated population of singing male Kirtland's Warblers is now over 1,500 individuals, more than a seven-fold increase from a low of around 200 singing males in the early 1970s (Probst et al. 2003). While the majority of these birds are found on land managed by the Michigan Department of Natural Resources and the United States Forest Service, the KWWMA plays an important role in the management and conservation of this species.

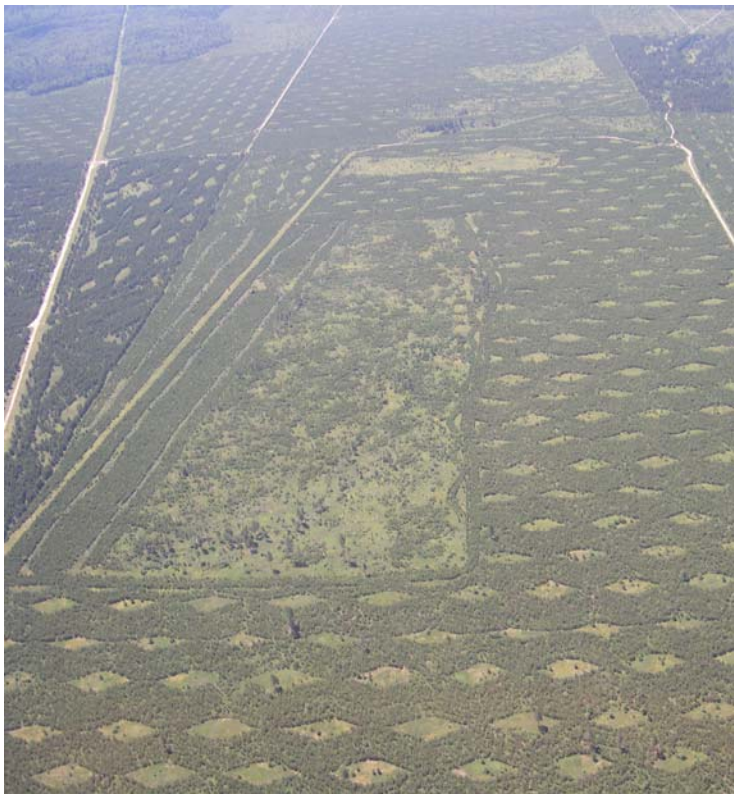

Fig. 2. Weave-patterned mosaic of jack pine forest ecosystems managed for Kirtland's Warbler in Oscoda County, Michigan. Note the "patchiness" of habitat following prescribed fire on the left and the more regular pattern following hand-planting of jack pine. Photo: G. Corace.

One important aspect of the KWWMA is that purchased lands be adjacent to Michigan Department of Natural Resources (MDNR) parcels similarly managed for Kirtland's Warbler. Such management creates larger patches of contiguous habitat and provides habitat for more birds per unit area for a longer period of time. The result of this process is that the KWWMA is comprised of small parcels that are distributed across a large area. Unfortunately, specific information on the current successional status of the stands that comprise the KWWMA is not available, nor is there specific information on the use of these different habitats by other taxa, including USFWS regional priority species. These stands, however, may provide opportunities for multi-species conservation, especially on lands with more mesic or hydric soils,

and may provide opportunities for applied research that investigates silvicultural options for the production of Kirtland's Warbler habitat and examines the patterns and processes associated with producing such habitat in a broader landscape context.

Starting in 2004, we began a multi-scale ecological assessment of the KWWMA in order to assess the efficacy of management actions aimed at meeting Kirtland's Warbler habitat objectives and to provide baseline information for the soon-to-be developed Kirtland's Warbler Wildlife Management Area Comprehensive Conservation Plan. This assessment included:

1) Developing an updated geographic information system (GIS) database of KWWMA stands that were cross-referenced against the original property deeds;
2) Describing the range of variation in KWWMA stands in terms of physiography, soils, and pre-European settlement forest types at the landscape-scale;
3) Describing the current composition and structure of KWWMA stands at the stand-scale; and;
4) Examining breeding bird assemblages associated with a subset of KWWMA stands that are distributed across three different age classes that represent the successional stages of jack pine forest ecosystems.

Part 2. Landscape Assessment and GIS Database Development

Introduction

In 2004, we began our assessment of the KWWMA by developing a GIS for both landscape-level and tract-level analyses. The objectives of this process was to 1) verify and update the existing GIS database of KWWMA stands, and 2) characterize the KWWMA stands in terms of their physiography, soils, and pre-European settlement vegetation.

Methods

The first step of our assessment required that we update the existing database of KWWMA tracts. To do this we cross-referenced the GIS database against the original property deeds located at the Seney National Wildlife Refuge. When discrepancies were found, the GIS database was edited to reflect the correct information. This assessment was conducted in the winter and spring of 2004, with later updates made as necessary.

In the summer and fall of 2004, we used ArcGIS™ 8.2 (ESRI®, Redlands, CA) to conduct a series of landscape analyses. Updated KWWMA tract boundaries[1] were obtained from the Seney National Wildlife Refuge (G. Corace, Refuge Forester). Additional spatial data were acquired from the Michigan Geographic Data Library (http://www.mcgi.state.mi.us/mgdl/) for the eight counties of the KWWMA: Clare, Crawford, Kalkaska, Montmorency, Ogemaw, Oscoda, Presque Isle, and Roscommon. Files downloaded from the data library included: 1) Michigan

[1] KWWMA_boundaries_mgmt_april06correct.shp and associated files obtained by G. Corace, Seney National Wildlife Refuge by email on May 15, 2006. Landscape characteristics were re-analyzed in the fall of 2006 to reflect the modifications made to the original KWWMA tract boundaries shapefile from 2004.

State Roads; 2) Michigan STATSGO soils; 3) Hydrography data for each county (e.g. intermittent and perennial streams, wetlands, and lakes); 4) Landtype Associations of Michigan (Albert et al. 1995); and 5) Land Cover circa 1800 for each county.

We also obtained orthoimagery for the KWWMA including color-infrared images from 1998 and 1-m resolution color imagery from the USDA National Agriculture Imagery Program (NAIP) (http://165.221.201.14/NAIP.html). All data are included on digital media accompanying this report and are located on the Forest Ecosystem Restoration and Ecology Lab Data Server (http://164.107.87.30/).

All files were in the Michigan GeoRef projection when downloaded. Statewide files (e.g. Michigan State Roads) were clipped with the KWWMA tract boundaries. Similar files for all eight counties (e.g. intermittent streams) were merged into one file and then clipped with the KWWMA tract boundaries.

Regional data was also acquired for the KWWMA landscape. Landtype Associations, or ecoregions, were downloaded from the Michigan Geographic Data Library. A digital elevation model (DEM) and the national land cover dataset (NLCD) for 1992 was downloaded from the United States Geological Survey National Map Seamless Data Distribution System (http://seamless.usgs.gov/).

Tract-level files were named by including "KW" in the file title (e.g. KW_lakes). County-level files were named by including "KW_Counties" in the file title (e.g. lakes_KW_Counties). Regional files were titled without reference to the KWWMA. Finally, in an effort to provide some structure to the identification of stands, we designated each stand with an alphanumeric code that begins with the first two letters of the county where the stand is located (e.g., CL – Clare County; OG – Ogemaw County, etc.)

Metadata was created for all files using ArcCatalog™ 8.2 (ESRI®, Redlands, CA). For files that had metadata information available from their source (e.g. Michigan Geographic Data Library), the metadata was copied and a hyperlink was added for its URL location. Files that were created or lacked original metadata were described as completely as possible. Finally, stand-level information was summarized for each file (e.g. KW_lakes) for all 124 KWWMA stands.

Results

The KWWMA totals 6,582 ac (2,664 ha) in 124 stands. While the average (± 1 SD) stand size is 53.1 ± 92.5 ac (22.6 ± 37.4 ha), the largest stand is 780.5 ac (315.9 ha) in Oscoda County and the two smallest stands are just 0.15 ac (0.06 ha) and located in Ogemaw County (Fig. 3). The stands are distributed across eight counties of northern Lower Michigan with 47 stands in Ogemaw County, 26 stands in Clare County, 24 stands in Crawford County, 23 stands in Oscoda County, and one stand each in Kalkaska, Montmorency, Presque Isle, and Roscommon Counties (Fig. 1).

Stand-level landscape characteristics were summarized in terms of their area, percent area, and frequency of the landscape characteristics across the KWWMA stands (Table 1). Surprisingly,

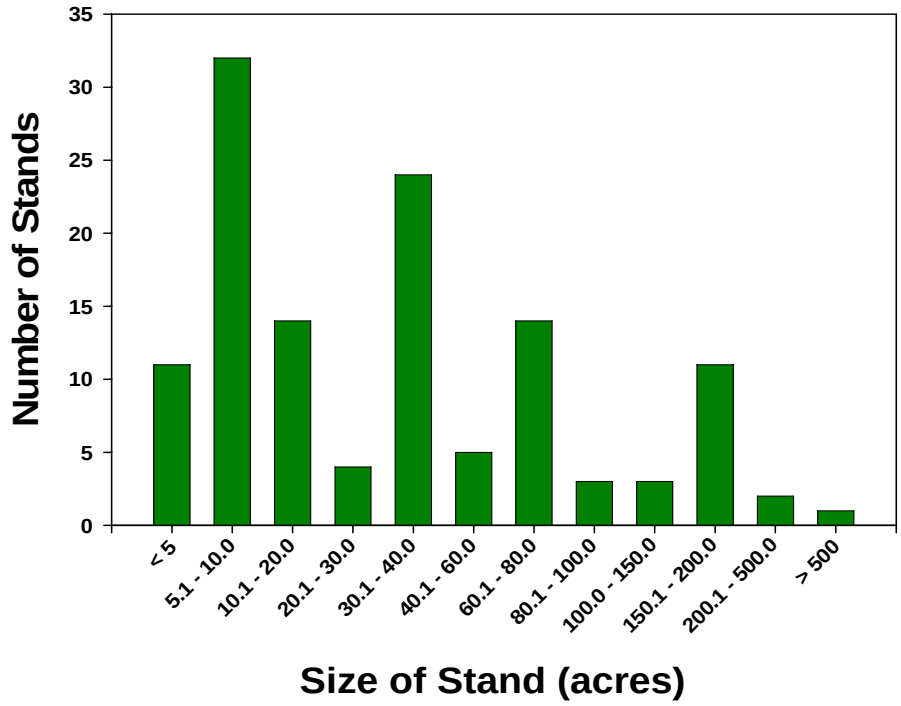

Fig. 3. Distribution of KWWMA stands by stand size.

about 2% of the KWWMA or 137.1 ac (55.5 ha) is characterized by wetland ecosystems and 0.6% is classified as lakes (Table 1). Although these areas will not provide Kirtland Warbler habitat, they increase landscape diversity and provide habitat for other species of concern within the dominant matrix of jack pine forest ecosystems of the study area.

Descriptions of Pre-European settlement vegetation cover, generated from the land cover circa 1800 file, indicate that around 64% of the KWWMA stands were in Jack Pine- Red Pine forest cover type with another 18% in the Pine Barrens cover type (Fig. 2). Other pre-European settlement cover types represented in the KWWMA include aspen-birch forests, cedar swamps, marshes, grasslands, mixed-conifer and hardwood swamps, oak-pine barrens, and white pine-red pine forests (Table 1).

In terms of physiography, the majority of the stands (94%) are in the Highplains Landtype Association with 6% in the Presque Isle Landtype Association. Three soil associations dominate the tracts namely Grayling – Graycalm - Au Gres (35%), Grayling – Rubicon - Au Gres (21%), and Rubicon – Grayling - Croswell (34%). As one would anticipate, all of the soil series in the three soil associations are sands.

Appendix A includes additional information and data associated with the landscape assessment and GIS development. Specifically, Appendix A includes:

- Official Soil Series Descriptions (Au Gres, Croswell, Graycalm, Grayling, Kalkaska, Markey, Menominee, Montcalm, Rubicon)
- National Land Cover Class Definitions

Table 1. Landscape characteristics of the KWWMA based upon a GIS analysis. See text for data sources.

Lotic Water Bodies	Length (ft)	Length (mile)
Perennial Stream	8762.50	1.66

Lentic Water Bodies	Acres	Hectares	% of KWWMA
Island	3.2	1.3	0.10
Marsh, wetland, swamp, bog	133.9	54.2	2.0
Lakes and ponds	37.6	15.2	0.6

Pre-European Settlement Vegetation Cover	Acres	Hectares	% of KWWMA
Aspen-Birch Forest	259.3	104.9	3.9
Cedar Swamp	8.3	3.4	0.1
Grassland	90.8	36.7	1.4
Jack Pine- Red Pine Forest	4237.0	1714.7	64.4
Lake/ River	0.1	0.0	0.0
Mixed Confer Swamp	409.6	165.8	6.2
Mixed Hardwood Swamp	0.0	0.0	0.0
Oak/ Pine Barrens	208.8	84.5	3.2
Pine Barrens	1212.8	490.8	18.4
Shrub Swamp/ Emergent Marsh	35.5	14.4	0.5
White Pine- Red Pine Forest	119.4	48.3	1.8

Landtype Associations	Acres	Hectares	% of KWWMA
Highplains	2566.8	6342.6	96.4
Presque Isle	96.8	239.1	3.6

Soil Mapping Units/ Associations	Acres	Hectares	% of KWWMA
Graycalm- Kalkaska- Montcalm	307.00	124.40	4.7
Grayling- Graycalm- Au Gres	2286.00	925.10	34.7
Grayling- Rubicon- Au Gres	1340.00	542.10	20.4
Menominee- Markey- Montcalm	4.00	1.40	0.1
Rubicon- Croswell- Au Gres	202.00	81.90	3.1
Rubicon- Graycalm- Montcalm	226.00	91.50	3.4
Rubicon- Grayling- Croswell	2217.00	897.10	33.7

Part 3. Stand-level Assessment

Introduction

After completing the landscape-level assessment, we determined that the stands that comprise the KWWMA are surprisingly diverse. Although most were dominated by sandy soils in the Highplains Landtype Association, there were several stands that were dominated by wetland vegetation either on the current landscape or on the pre-European settlement landscape. Stand-level reconnaissance and discussions with SNWR personnel revealed that the age of the stands also varied considerably. Consequently, during the summers of 2004-2006, we completed a stand-level inventory of each of the 124 stands in the KWWMA. Our goal was to characterize the composition and structure of each stand so that an assessment of Kirtland's Warbler habitat potential could be made.

Methods

After examining digital aerial photographs and making a reconnaissance of each stand, we estimated the age of the dominant vegetation using either an increment borer or destructively sampling several stems in each stand. For stands $\leq$ 5 years old we followed standard sampling procedures for jack pine regeneration surveys as used by MDNR. Within each stand we established a series of 1/50th-acre (0.008 ha) plots (16.65 ft radius) that were distributed systematically across the stand; the number of plots was dependent on the size and homogenous nature of the stand. Due to financial and time constraints, we typically only sampled 1-3% of the total area in each stand (e.g., a 1% sample for a 10 ac stand would be 5 1/50th plots). However, if the composition and structure of the stand was heterogeneous, we increased the sampling intensity accordingly. In each plot, we counted the number of all woody tree species and classified each jack pine stem as either planted or volunteer if possible. We estimated the average height and age of the jack pine stems in each plot, and counted the number of seedlings (stems $\leq$ 1 inch (2.5 cm) dbh) by species in three nested 10.8-ft^2 (1-m^2) quadrats.

For those stands > 5 years old, we systematically established a series of 1/50th-acre plots across the stand so as to capture the variability in composition and structure in each stand. Again, due to financial and time constraints, we typically only sampled 1-3% of the total area in each stand; however, plots were distributed to capture the variability in stand composition and structure. Within each 1/50th-acre plot, we measured the diameter of every tree > 4 inches (10.0 cm) dbh by species. We also counted the number of understory trees (stems $\leq$ 4 inches (10.0 cm) dbh and > 1 inch (2.54 cm) dbh) by species on each 1/50th-acre plot. Finally, we counted the number of seedlings (stems $\leq$ 1 inch (2.5 cm) dbh) by species within three nested 10.8-ft^2 (1-m^2) quadrats.

Basic stand tables were developed for the overstory and understory, and estimates of stand density for each species calculated. Descriptive statistics were used to examine differences in structural characteristics by age class.

Results

After inventorying the 124 stands, we found that 41% of the stands (2,695 ac or 1,091 ha) were between 5-23 years old, while 14% (959 ac or 388 ha) were < 5 years old and 45% (2,298 ac or 1,185) were > 23 years old (Fig. 3). It is important to note that many of the stands have multiple cohorts; to determine the age of each stand we considered the most extensive cohort as indicative of the overall stand age.

Species Composition

Seventeen overstory (stems > 4 inches (10.0 cm) dbh) species were sampled, with jack pine, red pine (*P. resinosa* Soland), scarlet oak (*Quercus coccinea* Muenchh.), trembling aspen (*Populus tremuloides* Michx.), black cherry (*Prunus serotina* Ehrh.), black oak (*Quercus velutina* Lam.), northern red oak (*Quercus rubra* L.), and bigtooth aspen (*Populus grandidentata* Michx.) as common overstory species. Other less common species included eastern white pine (*P. strobus* L.), red maple (*Acer rubrum* L.), balsam fir (*Abies balsamea* (L.) P. Mill.), green ash (*Fraxinus pennsylvanica* Marsh.), black ash (*F. nigra* Marsh.), white spruce (*Picea glauca* (Moench) Voss), northern pin oak (*Quercus ellipsoidalis* Hill) and fire cherry (*Prunus pennsylvanica*) (Appendix B.1). The younger stands were dominated by several species including jack pine, trembling aspen, and black cherry, while the 5-23 year old stands were dominated by jack pine. In some instances (e.g., CL-2, OG-6, CR-2), the 5-23 year old stands occurred under sparsely distributed canopy of older red pine (Fig. 4). The older stands (> 23 years old) had variable composition but for the most part were dominated by mature jack pine. See Appendix B.2. for a list of overstory stem densities (trees acre^{-1}) by species and tract.

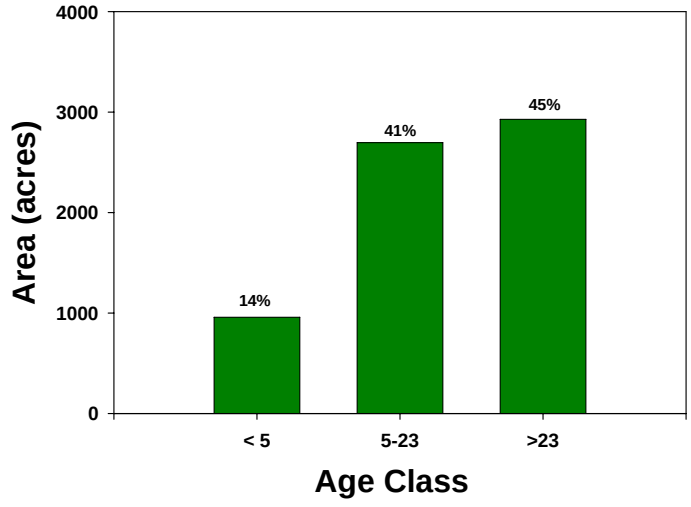

Fig. 3. Total area by age class for the 124 stands that comprise the KWWMA.

The understory (stems ≤ 4 inches (10.0 cm) dbh and > 1 inch (2.54 cm) dbh) species sampled included 23 species, the most frequent being jack pine, red pine white pine, black cherry, fire cherry, white oak (*Quercus alba* L.), scarlet oak, northern pin oak, northern red oak, black oak, trembling aspen, and bigtooth aspen. Although present, red maple, green ash, black ash, white ash (*Fraxinus americana* L.), balsam fir, white spruce, tag alder (*Alnus incana* L.), witch-hazel (*Hamamelis virginiana* L.) serviceberry (*Amelancier* spp.), hawthorn (*Craetegus* spp.), and birch (*Betula* spp.) were less common. Jack pine was the most common understory tree sampled and was characteristic of the understory in all three age classes. Black cherry, trembling aspen, and northern red oak were also common but were generally associated with those stands < 5 years

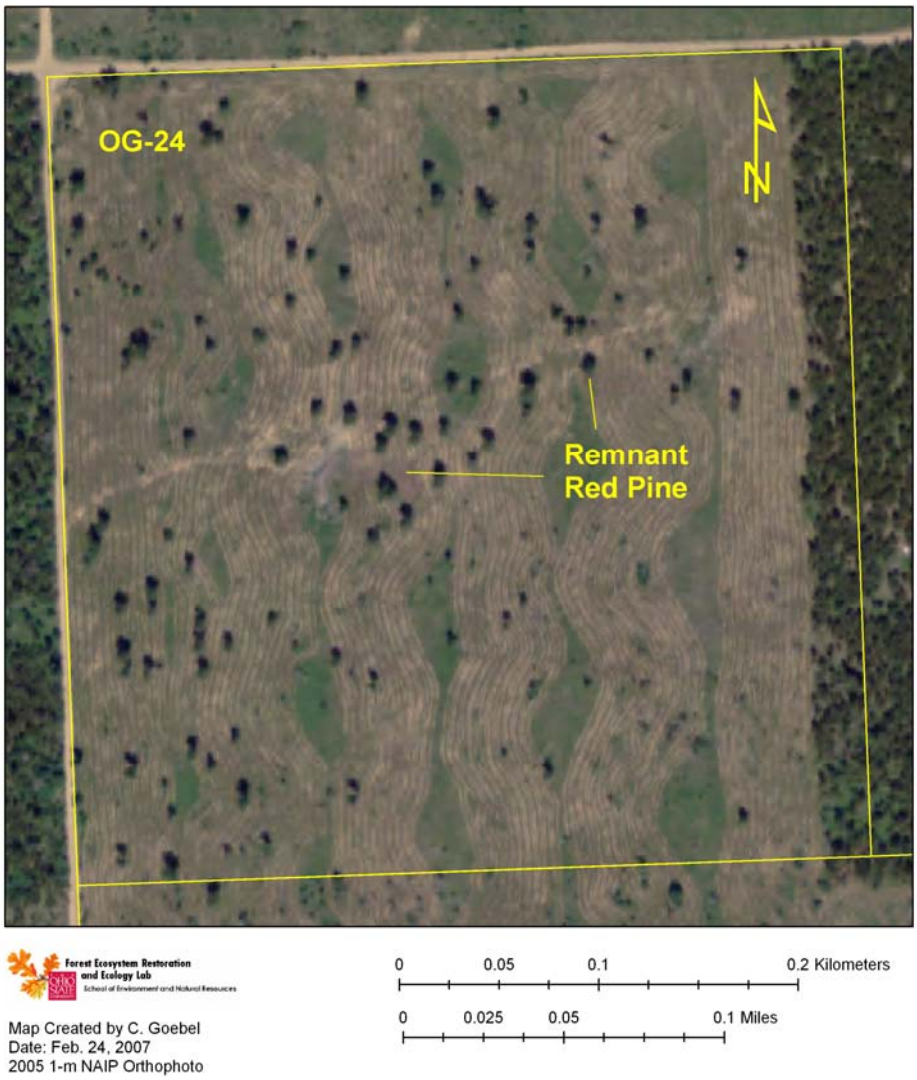

Fig. 4. Aerial photograph of OG-24, a stand classified as 5-23 years old with a sparse canopy of red pine and low stem densities. This tract was trenched in 2002 but not planted.

old and 5-23 years old. See Appendix B.3. for a list of understory stem densities (trees acre^{-1}) by species and tract.

The seedling layer (stems $\leq$ 1 inch (2.5 cm) dbh) was characterized by 29 woody plants including jack pine, red pine, eastern white pine, bigtooth aspen, trembling aspen, white oak, scarlet oak, northern pin oak, northern red oak, black oak, black cherry, fire cherry, choke cherry (*Prunus virginiana* L.), red maple, green ash, black ash, American basswood (*Tilia americana* L.), balsam fir, witch-hazel, serviceberry, alternate-leaf dogwood (*Cornus alternifolia* L. f.), dogwood (*Cornus* spp.), hawthorne, eastern hophornbeam (*Ostrya virginiana* (P. Mill.) K. Koch), willow (*Salix* spp.), honeysuckle (*Lonicera* spp.), currant or gooseberry (*Ribes* spp.), and two unknown species.

Stand Structure

In terms of stand structure, the primary interest for Kirtland's Warbler management is stem density. We found overstory stem density was highest in the older age class (> 23 years old) than the other two younger age classes (Fig. 5), while understory stem density tended to be highest on average in the youngest age class (< 5 years old) (Fig. 5). There was also considerable variability in overstory and understory stem density within each age group, especially the youngest age class. This trend is largely due to the range of conditions associated with recent harvest activities where portions of the stands may not have been harvested.

Most importantly to Kirtland's Warbler, mean (± 1 SE) total stem density in the 5-23 year old stands was low. For instance, average total stem density was 73.1 (10.8) stems ac^{-1} (180.7 (26.7) stems ha^{-1}) in the 5-23 year old stands and 333.0 (14.5) stems ac^{-1} (822.8 (35.8) stems ha^{-1}) in the older stands (Fig. 5). Similarly, jack pine densities (Fig. 6) in the stands 5-23 years old stands have on average 12.5 (5.2) overstory stems ac^{-1} (30.8 (12.8) stems ha^{-1}) and 24.7 (2.5) understory stems ac^{-1} (60.1 (6.2) stems ha^{-1}) for a total average of 37.2 (6.1) jack pine stems ac^{-1} (91.8 (15.0) stems ha^{-1}). While these estimates are indicative of under-stocking in these KWWMA stands, it is important to point out that the variability within a tract may "depress" these estimates when mean values are calculated. It is also important to realize that overstory and understory density tended to be quite "patchy" in many of the KWWMA stands. This is a markedly different characteristic than the surrounding MDNR and USFS lands (Fig. 2).

As observed in the overstory and understory stem density values, seedling densities were also quite variable

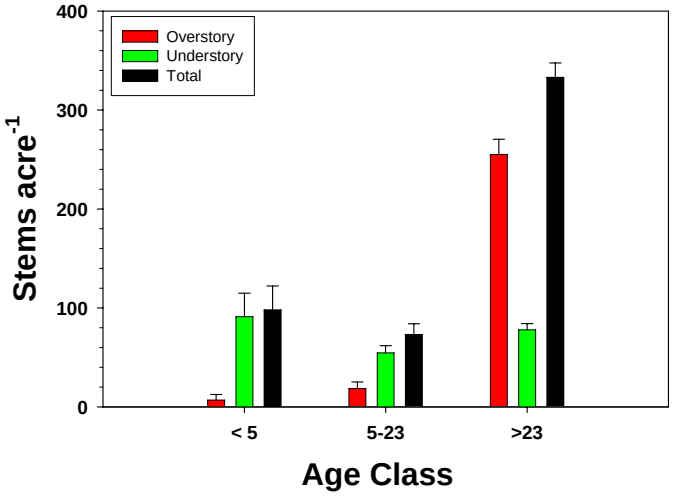

Fig. 5. Mean (± 1 SE) overstory, understory, and total stem density by age class for stands of the KWWMA.

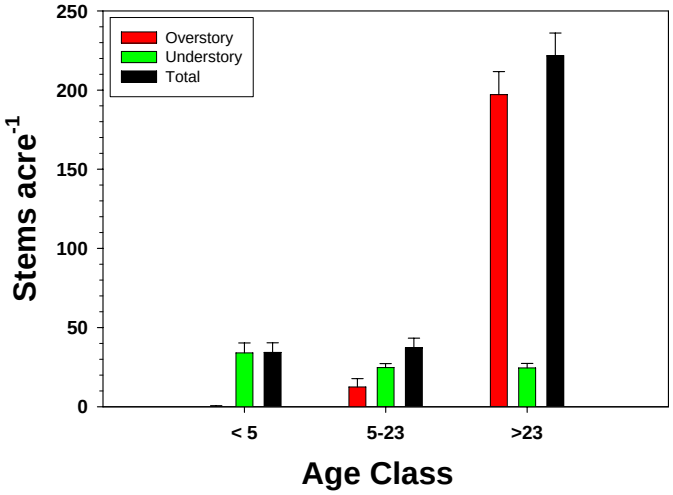

Fig. 6. Mean (± 1 SE) overstory, understory, and total jack pine stem density by age class for stands of the KWWMA

within age groups. We found an average of 1,779 (302) total seedlings ac^{-1} (4,395 (745) seedlings ha^{-1}) in the young age class (< 5 years old), 2,514 (155) seedlings ac^{-1} (6,210 (384) seedlings ha^{-1}) in the 5-23 year old class, and 2,804 (209) seedlings ac^{-1} (6,927 (515) seedlings ha^{-1}) in the oldest age class (> 23 years old) (Fig. 7). Jack pine seedling densities were considerably lower, comprising less than 25% of the total seedling community in all three age classes (Fig. 7).

Our inventory suggests that none of the stands between 5-23 years old in the KWWMA appear to have even close to adequate stocking for breeding Kirtland's Warbler (>1,012 stems ac^{-1} or 2,500 stems ha^{-1}). However, as mentioned previously, it is important to keep in mind that there is considerable variation between stands in terms of seedling density. These results suggest that past regeneration efforts, which appear to vary considerably in terms of the methods used, did not always provide the preferred stocking levels of jack pine for Kirtland's Warbler. In the future, other regeneration methods may be advisable, including direct seeding and the use of prescribed fire.

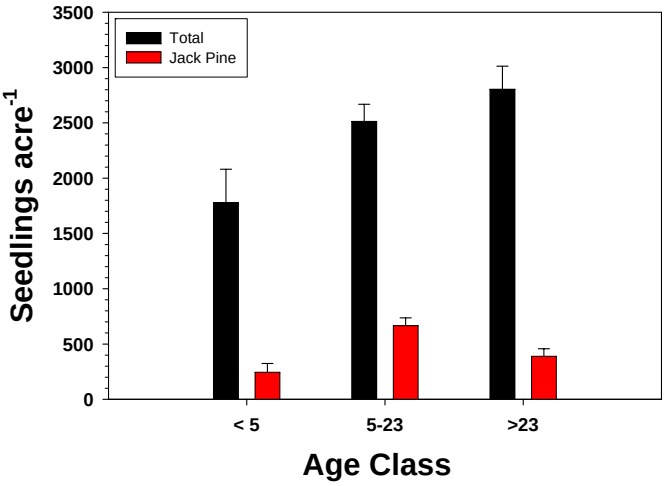

Fig. 7. Mean (± 1 SE) total and jack pine seedling density by age class for stands of the KWWMA.

It is also important to point out that the species composition and structure (including age structure) is not only variable among KWWMA stands, but also within individual stands. In some areas regeneration methods have left a "patchwork" pattern where small gaps have purposely been left unplanted in an effort to provide foraging habitat for nesting birds or have resulted from failed regeneration efforts. In other stands, natural disturbances (such as wildfire) have left a patchy distribution of overstory and understory stems. Finally, other stands may have wetland areas or different soil types that do not lend themselves to jack pine forest ecosystems. A good example of this pattern can be found in OS-2 located in Oscoda County (Fig. 8). Using the on-screen digitizing tool in ArcGIS® and 2005 1-m resolution NAIP orthophotography, we estimate that only 116 ac (50 ha) or 15% of the 780 ac (316 ha) total is considered Kirtland's Warbler habitat (between 5-23 years old). The remainder of the tract is dominated by wetlands in the interior (200 ac (81 ha) or 26%), older jack pine in the northwestern portion of the tract (200 ac (81 ha) or 26%), and mixed jack pine and hardwood in the eastern portion of the tract (265 ac (107 ha) or 33%). Notes were included in the GIS database as to the relative composition of the tracts where necessary. **However, due to the heterogeneous nature of some stands, we recommend that the digital imagery be examined or a site visit be made before making conclusions regarding the composition and structural characteristics of each stand.**

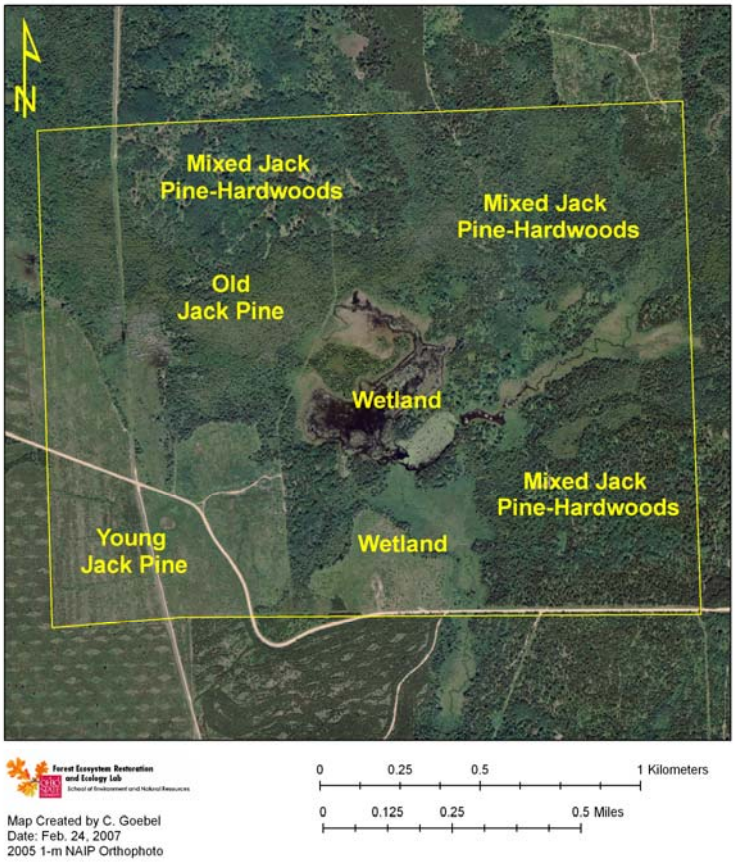

Fig. 8. Tract OS-2 in Oscoda County showing the diversity of habitat types that are characteristic of some stands in the KWWMA. Image is a 2005 1-m NAIP orthophotgraph. See text for details regarding the different habitat types in this stand. Young jack pine are stems < 5 years old, while old jack pine refers to stems > 23 years old, and wetland refers to water and wetlands associated with the small lake and stream flowing through the stand.

Differences between Planting Methods

Since 1994 when the first management activities were undertaken in the KWWMA, a variety of techniques have been used to regenerate jack pine following harvest activities on different stands of the KWWMA. Some of these techniques, including the use of prescribed fire, machine planting, hand planting, and direct seeding methods have been utilized on a variety of different stands (Fig. 2). Although the 5-23 year old stands of the KWWMA appear to lack adequate stocking for Kirtland's Warbler, we wished to examine if different planting methods result in different levels of stem densities. To explore this question, we selected a subset of the KWWMA tracts that were 1) classified as being 5-23 years old, and 2) had information on the planting methods used to establish the jack pine stand. After examining the data, we selected 32 stands – 20 stands that were hand-planted and 12 that were machine-planted between 1995 and 2001. While other regeneration systems have been used on stands in the KWWMA, there were not enough examples of these systems to adequately replicate each method for statistical analysis.

Table 2. Comparison of total stem density, jack pine density, total seedling density, and jack pine seedling density of hand-planted and machine-planted stands 5-23 years old in the KWWMA. Values are mean ± 1 standard error.

	Hand-Planted (*n* = 20)	**Machine-Planted (*n* = 12)**	***P*-value**
Total Stem Density	47.3 (7.9) stems ac^{-1} 116.7 (19.4) stems ha^{-1}	44.6 (12.8) stems ac^{-1} 116.7 (19.4) stems ha^{-1}	0.854
Jack Pine Density	28.8 (4.2) stems ac^{-1} 71.2 (10.5) stems ha^{-1}	20.7 (5.7) stems ac^{-1} 51.2 (14.1) stems ha^{-1}	0.259
Total Seedling Density	2527 (281) stems ac^{-1} 6241 (693) stems ha^{-1}	2710 (397) stems ac^{-1} 6695 (982) stems ha^{-1}	0.701
Jack Pine Seedling Density	704 (83) stems ac^{-1} 1739 (204) stems ha^{-1}	805 (159) stems ac^{-1} 1989 (394) stems ha^{-1}	0.537

We used a series of t-tests to examine whether there were any significant trends in the stem density data that could be related to establishment practices. In terms of total stem density, total seedling density, jack pine stem density, and jack pine seedling density there were no significant differences between hand-planting and machine-planting (Table 2). In general, the hand-planted sites tended to have higher stem densities of jack pine (28.8 (4.2) stems ac^{-1}or 71.2 (10.5) stems ha^{-1}) than the machine-planted sites (20.7 (5.7) stems ac^{-1}or 51.2 (14.1) stems ha^{-1}), however, the variation in stem density between stands was high. It is important to keep in mind that these results should be used with caution. No effort was made in this analysis to account for site differences or climate differences at the time of planting that may have influenced the establishment and survival of the jack pine seedlings. Further study is needed to determine if the current methods are meeting establishment and survival goals and if certain methods are superior to others in terms of jack pine establishment and survival.

Part 4. Breeding Bird Surveys

Introduction

In the early summer of 2006, breeding bird surveys were conducted in a subset of KWWMA stands to characterize usage not only within stands appropriate for Kirtland's Warbler, but across three age classes that represent the different successional stages of jack pine forest ecosystems relative to Kirtland's Warbler habitat. The methods and results presented here are intended to supplement a comprehensive spreadsheet of survey data which has also been submitted to the USFWS for use in developing a Comprehensive Conservation Plan for the KWWMA.

Methods

Survey Design

Utilizing GIS-based ArcView 3.2® software, 200 random points were created (Jenness 2005) within the boundaries of the KWWMA parcels. To minimize the likelihood of repeated enumeration of the same breeding bird, generated points were specified to be at least 820 ft (250 m) from each other (Ralph et al. 1993); to diminish the frequency of recording off-property individuals, points were also specified to be at least 164 ft (50 m) from parcel edges. As a database, these points – each with a precise latitude and longitude within KWWMA boundaries - were assigned random numerical values and sorted in ascension within an Excel spreadsheet. Each locus was then given a unique identification number (e.g., 'KW001') and a jack pine stand age designation extracted from our preliminary KWWMA database of stands sampled in 2004 and 2005 (*see Part 3*). Age classes included stands with trees < 5 years old, stands with trees 5-23 years old, and stands with trees > 23 years old. These three categories respectively reflect recently-harvested stands awaiting jack pine regeneration or colonization by Kirtland's Warbler, stands expected to provide appropriate Kirtland's Warbler habitat, and mature stands awaiting treatment (i.e., timber harvesting followed by regeneration). Importantly, this pre-existing database catalogued stand age on a stand-level basis only. Proceeding in the ascending (randomized) order of the spreadsheet, the GIS location of each generated point was then compared to an overlaid shapefile of statewide wetland areas (Michigan Geographic Data Library 2006). If a given point fell within wetland boundaries it was deleted from the associated database; otherwise it was incorporated as an official survey point and categorized by jack pine stand age as 'YOUNG' (< 5 years), 'KW' (5-23 years) or 'OLD' (> 23 years). This process was repeated until 40 survey points of each age class were established. The resultant list of 120 locations incorporated 42 KWWMA parcels in Clare (10 parcels), Crawford (7), Ogemaw (17), Oscoda (7) and Roscommon (1) counties.

Data Collection

Bird usage within KWWMA parcels was characterized via the 'unlimited point count' method of censusing (see Ralph et al. 1993). Briefly, each point was surveyed twice between 6 June and 9 July 2006 – a period coinciding with moderate to high levels of breeding activity for most terrestrial bird species in the northern Lower Peninsula of Michigan (Brewer et al. 1991). A minimum interval of two weeks was observed between visits. Counts were initiated no earlier than 15 minutes before sunrise (roughly 0545 – 0600 h) and were concluded no later than 1100 h. The second round of surveying replicated the daily routes from the initial round, but inverted the order of visitation so as to minimize bias in the average time of day in which points were bi-sampled. Counts were not executed in rain or in wind conditions exceeding 9.9 mph (16 kph). Counts were not conducted if a survey point proved to be in a wetland area or in wet coniferous forest; counts were conducted, however, if the survey point was located in mesic mixed forest or mesic deciduous forest containing little or no mature jack pine. Each count was conducted for five minutes, during which time all discrete breeding males were noted by aural manifestation of their song. A subset of species without identifiable song – primarily corvids, raptors and wood-

peckers – were also noted by aural manifestation of their call or by visual observation. If a recorded individual was unequivocally located off KWWMA property and within habitat markedly different from that proximately surrounding the survey point it was tallied in a separate 'OFF PARCEL' column on the field data sheet. The range of jack pine heights in this same proximate area (roughly a circle of 15 m radius) was also noted; the observed stand age for the survey point was recorded as 'YOUNG' if the upper limit of jack pine height was less than 1.4 m, as 'KW' if the upper limit was between 1.4 and 5.0 m, and 'OLD' if the upper limit was greater than 5.0 m.

Data Analyses

Collected data was entered into a Microsoft Excel® spreadsheet and subsequently combined, edited and supplemented. Individual species inventories for each survey point were assembled by selecting the higher of the values recorded during the two sampling efforts; individuals recorded as 'OFF PARCEL' were not included in these figures. Species numbers were then tallied and sorted by stand age into two metrics of occupancy: 'frequency' recorded the percentage of sampling points in a given age class in which a particular species was noted, while 'abundance' recorded the ratio of the total number of individuals documented in a given age class over the total number of survey points for that class. While frequencies – which sought to quantify overall species usage among various stand ages – were employed for all species documented in KWWMA parcels, abundance values – which sought to quantify the densities of breeding males in these stands – were compiled only for those species documented by song alone. See Appendix 3 for further details regarding the treatment of collected data.

We used the frequency data and Multi-Response Permutation Procedure (MRPP) to test the hypothesis that songbird composition among the three different age groups was not different. We used PC-ORD software (McCune and Mefford 1995) to conduct the MRPP, and a natural weighting factor and a Sørenson distance matrix was used as recommended by Mielke (1984). MRPP was supplemented with an Indicator Analysis based upon methods of Dufrêne and Legendre (1997) using PC-ORD software. This analysis uses both the proportional abundance of a species in a particular group with respect to its abundance in other groups and its relative frequency within a group (McCune and Grace 2002). Individual species are ranked from 0-100 with zero indicating no indication and 100 indicating perfect indication. The significance of Indicator Values (IV) was tested using a Monte Carlo permutation procedure.

To examine the relationships between songbird abundance and stand structural characteristics, we used canonical correspondence analysis (CCA), a direct gradient analysis ordination that is constrained by multiple regression of the factors used (ter Braak and Šmilauer 1997). Twelve variables representing stand characteristics were used in the CCA, including age class (as a binary variable), total overstory density, total understory density, total overstory density + total understory density, total seedling density, jack pine overstory density, jack pine understory density, total jack pine overstory density + total jack pine understory density, jack pine seedling density, and jack pine height. Prior to the analysis those songbird species that occurred on less than 5% of the plots were deleted from the dataset (20 species) and all stand characteristic variables were

relativized to ensure all variables were on the same relative scale. CCA was performed with CANOCO ver. 4 software and the significance of each axis was determined using a Monte Carlo permutation test (ter Braak and Šmilauer 1997).

Results

A total of 97 sampling sites were ultimately inventoried across 37 KWWMA parcels in Clare (10 parcels), Crawford (6), Ogemaw (15), and Oscoda (6) counties; 23 points went unsampled because of their location in wetland or wet coniferous forest habitat. While the original survey design assumed that the parcel-level information regarding stand age taken from a pre-existing KWWMA database accurately described jack pine age across entire tracts, surveying demonstrated that this assumption of parcel-level homogeneity was erroneous – almost one quarter of sampled points (23 of 97) expressed some discrepancy between expected and observed stand age. This fact reflects the heterogeneous nature of the KWWMA tracts and the classification into an age category based on the most "typical" or dominant age class. Owing to this incongruity, and to the disproportionate number of YOUNG points that were discovered to be wetland, the final register among the three stand ages was unbalanced: 21 YOUNG, 30 KW and 46 OLD.

Songbird Assemblages

Sixty bird species were documented during point counts (see Appendix 3.1); 75% were breeding species recorded on the evidence of singing males. Figure 8 compares indices of community similarity for these two species lists (all recorded birds and singing males) among the three surveyed jack pine age classes. Each index (ICS) was calculated by the formula ICS = 2a/b, where a = the number of species common to two age classes and b = the number of species recorded in either of the two compared classes. An ICS value of two indicates maximum community similarity, while a value of zero indicates no similarity. Predictably, ICS scores were higher between successionally-adjacent habitats (YOUNG + KW, KW + OLD) than between the successionally-disjunct YOUNG + OLD categories; values for the four successionally-adjacent comparisons were notably similar (range = 0.72-0.77), and were, on average, 45% greater than the two successionally-disjunct comparisons.

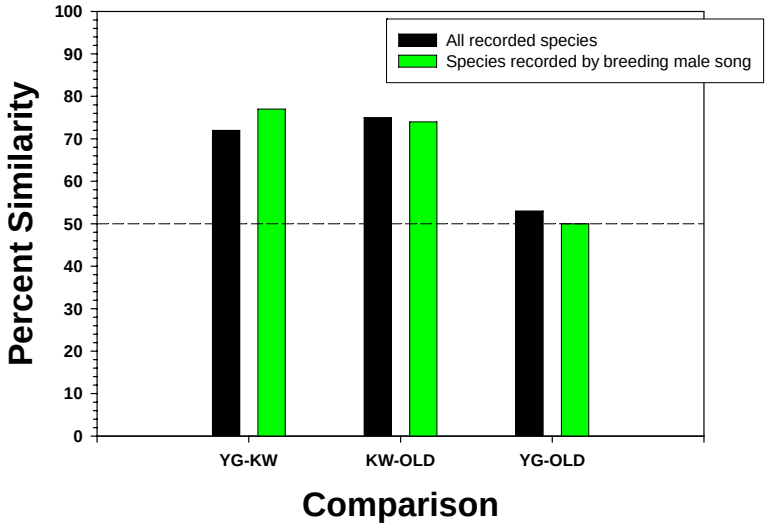

Fig. 8. Community similarity indices for bird species among three jack pine age classes in KWWMA stands.

Table 3. Songbird indicator species for young (< 5 years old), KW (5-23 years old), and old (> 23 years old) stands of the KWWMA.

Young (< 5 years old)	KW (5-23 years old)	Old (> 23 years old)
Indigo Bunting***	Kirtland's Warbler***	Eastern Wood-Pewee***
Eastern Bluebird***	Nashville Warbler***	Hermit Thrush***
Field Sparrow***	Eastern Towhee***	Ovenbird***
Lincoln's Sparrow***	Brown Thrasher**	Rose-breasted Grosbeak***
Black-billed Cuckoo*	Alder Flycatcher**	Red-breasted Nuthatch***
		Red-eyed Vireo***
		Black-capped Chickadee**
		Chipping Sparrow**
		Mourning Dove*

*$P \leq 0.05$; ** $P \leq 0.01$; *** $P < 0.001$.

MRPP suggests there are significant differences in songbird assemblages among the three age classes (T = -43.28; A = 0.192; $P < 0.0001$). The strong chance-corrected within group agreement (A) and test statistic (T) indicate that groups occupy different regions of species space, suggesting significant differences in the overall assemblage of species. Indicator species, or those species that are characteristic of the three age groups, are listed in Table 3. In the young stands, Indigo Bunting, Eastern Bluebird, Field Sparrow (*Spizella pusilla*), Lincoln's Sparrow (*Melospiza lincolnii)*, and Black-billed Cuckoo (*Coccyzus erythropthalmus*) were all strong indicators, while Kirtland's Warbler, Nashville Warbler (*Vermivora ruficapilla*), Eastern Towhee (*Pipilo erythrophthalmus*), Alder Flycatcher (*Empidonax alnorum*), and Brown Thrasher (*Toxostoma rufum*) were significant indicators of the stands 5-23 years old. Finally, Eastern Wood-Pewee (*Contopus virens*), Hermit Thrush (*Catharus guttatus*), Ovenbird (*Seiurus aurocapilla)*, Rose-breasted Grosbeak (*Pheucticus ludovicianus*), Red-breasted Nuthatch (*Sitta Canadensis*), Red-eyed Vireo (*Vireo olivaceus*), Black-capped Chickadee (*Poecile atricapilla*), Chipping Sparrow (*Spizella passerine)*, and Mourning Dove (*Zenaida macroura*) were indicators of the old stands in the KWWMA.

The primary management objective for KWWMA parcels is the creation of viable Kirtland's Warbler habitat. Among stands classified as KW on the basis of jack pine height, 12 of 13 stands (92.3%) contained singing Kirtland's Warbler males; among the 30 individual points sampled within these tracts, 27 (90%) registered at least one warbler. Table 4 documents the range of Kirtland's Warbler breeding abundances for all KWWMA tracts in which singing males were recorded – 12 KW parcels as well as two YOUNG parcels. The average number of males documented per sampling point among these 14 "warbler-positive" parcels was 3.07; the average number per sampling point among the 13 sampled KW parcels was 2.80.

This value – 2.80 singing males per sampling point – rendered the Kirtland's Warbler the most abundant breeding species within KW stands of jack pine (Figure 9). Three other species – Nashvile Warbler, Hermit Thrush and Field Sparrow – recorded abundance values exceeding an

Table 4. Parcel-level abundance values for singing male Kirtland's Warblers recorded in KWWMA tracts.

Stand Age Class	County	Tract-ID	Sampling Points	Singing KW per sampling point
KW	Clare	CL-08	2	3.00
KW	Clare	CL-11	1	3.00
KW	Clare	CL-18	3	4.33
KW	Clare	CL-21	2	5.00
KW	Crawford	CR-09	1	4.00
KW	Crawford	CR-10	1	3.00
KW	Oscoda	OS-02	6	2.50
KW	Oscoda	OS-03	2	3.50
KW	Oscoda	OS-14	1	2.00
KW	Oscoda	OS-18	1	1.00
KW	Ogemaw	OG-26	3	4.33
KW	Ogemaw	OG-28	4	1.75
YOUNG	Ogemaw	OG-01	1	1.00
YOUNG	Ogemaw	OG-25	1	4.00
		TOTAL	**29**	**3.07**

average of one singing male per sampling point. This abundance threshold was also exceeded by four total species in both YOUNG (Field Sparrow, Vesper Sparrow [*Poecetes gramineus*], Lincoln's Sparrow and Brown Thrasher) and OLD (Hermit Thrush, Ovenbird, Chipping Sparrow, and Nashville Warbler) jack pine stands (Figure 9). Across all sampled points, only Hermit Thrush and Nashville Warbler averaged greater than one singing male per point; the Kirtland's Warbler was the third most abundant species within all KWWMA stands, with 0.92 males per point.

Frequency percentages for different stand ages incorporated an additional 15 species not documented solely upon the basis of male song, and are highlighted in Figure 10. Among KW stands, only the Nashville Warbler (96.7%) was noted in a higher percentage of sampled points than the Kirtland's Warbler; Blue Jay (*Cyanocitta cristata*), Hermit Thrush and Field Sparrow were also recorded in over 80% of points. Field Sparrow, Brown Thrasher, Common Raven (*Corvus corax*) and Vesper Sparrow transcended 80% frequency in YOUNG points, while only Blue Jay and Hermit Thrush exceeded that level in OLD points. The five most frequently documented species across all KWWMA properties were Blue Jay, Nashville Warbler, Hermit Thrush, Common Raven and Mourning Dove.

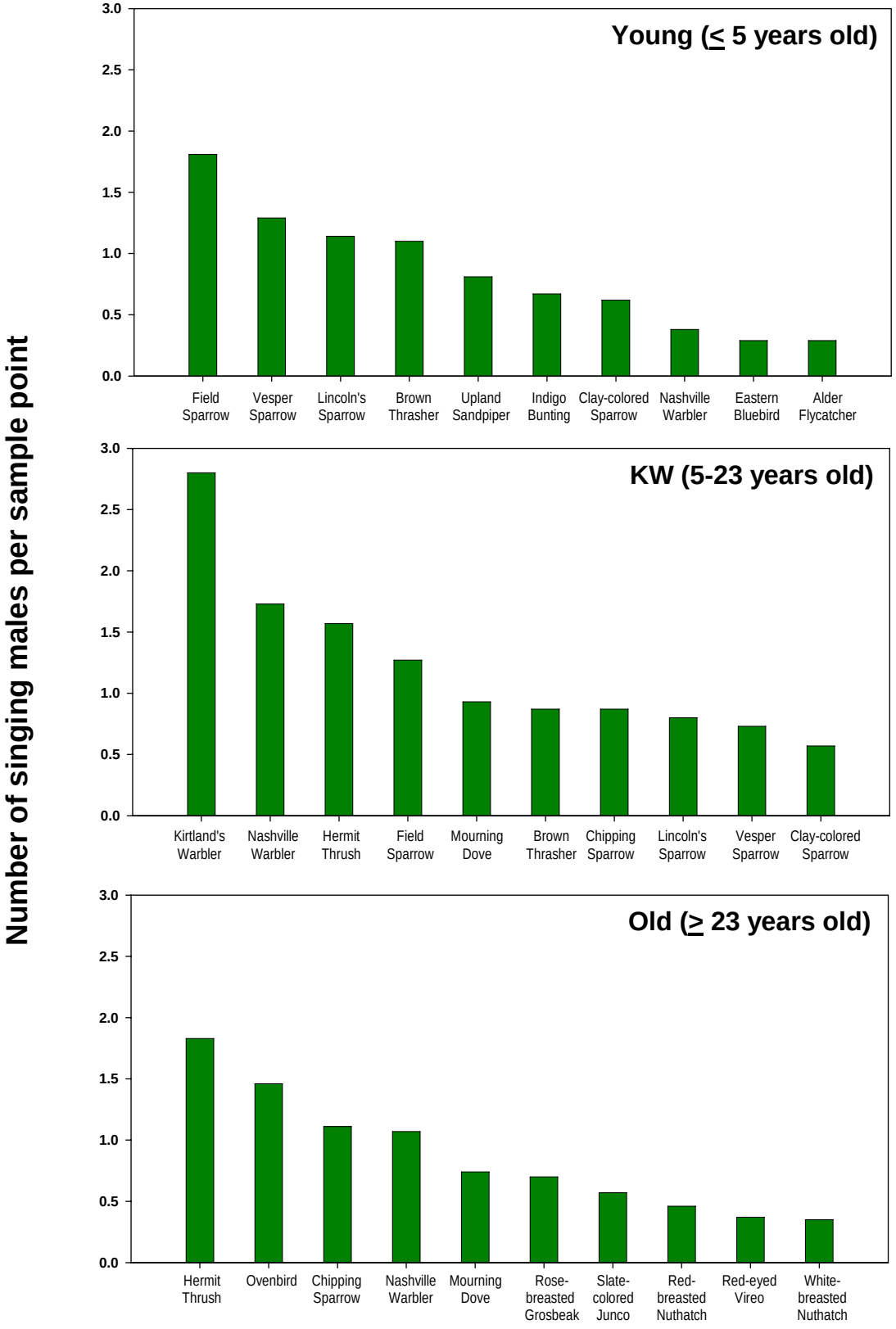

Fig. 9. Breeding bird species of greatest abundance in the young (≤ 5 years), KW (5-23 years old), and old (> 23 years old) KWWMA stands.

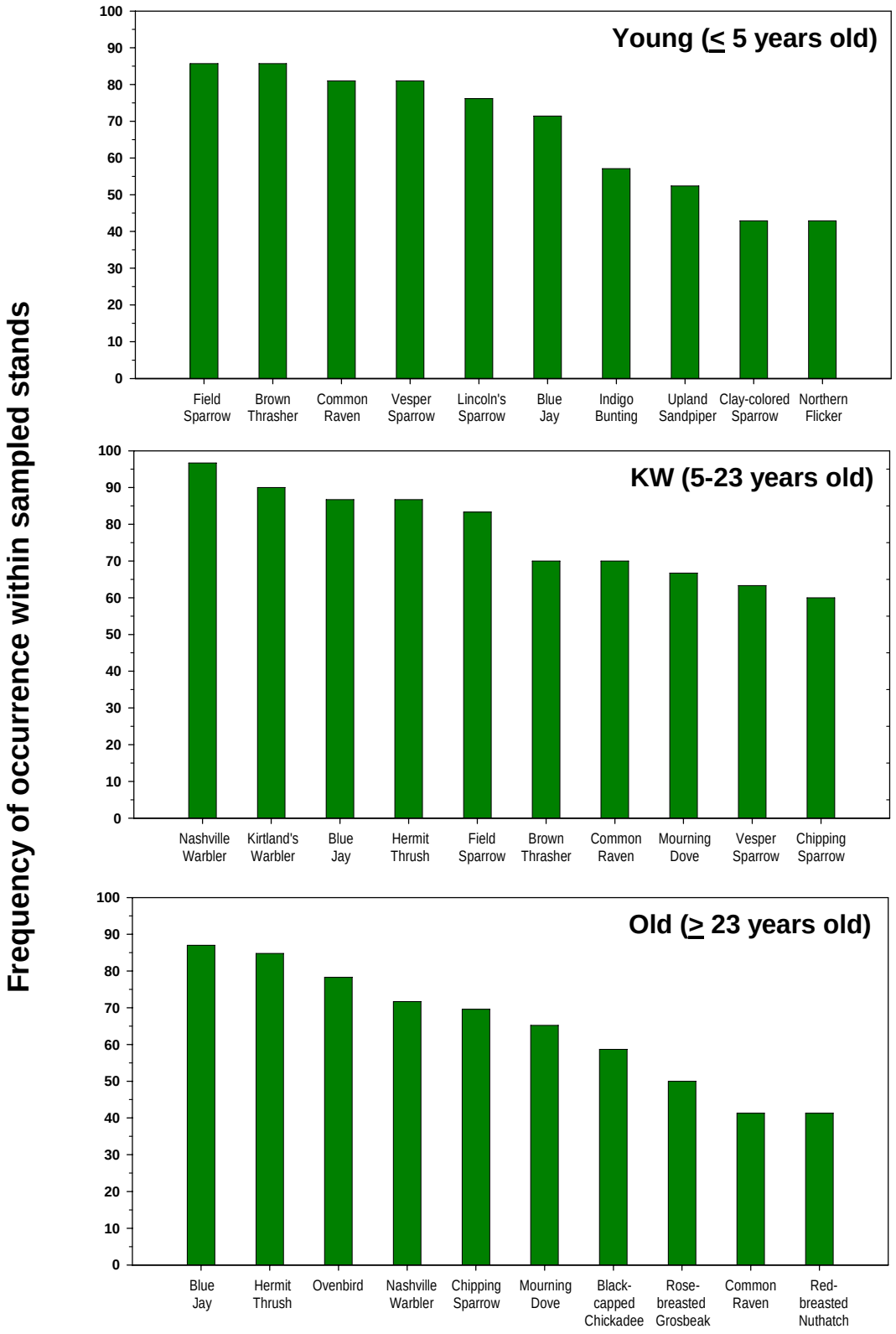

Fig. 10. Bird species of highest frequency of occurrence in the young (≤ 5 years), KW (5-23 years old), and old (> 23 years old) KWWMA stands.

Table 5. Frequency, abundance and conservation-value metrics for bird species among three jack pine age classes in KWWMA stands.

	Young	KW	Old
1a. Total species	29	40	51
1b. Total species per sampling point	1.38	1.33	1.11
1c. Total singing males per sampling point	10.2	14.1	10.8
2a. Sum of PIF (R12) RCS(b) scores for all species	346	474	593
2b. Sum of PIF (R12) RCS(b) scores for all species per sampling point	16.5	15.8	12.9
2c. Sum of PIF (R12) RCS(b) scores for all singing males per sampling point	127	192	122
3a. Total FWS (R3) Conservation Priority species	5	5	3
3b. Total FWS (R3) Conservation Priority species per sampling point	0.24	0.17	0.07
3c. Total FWS (R3) Conservation Priority singing males per sampling point	3.14	4.30	0.11

KWMMA stands are not depauperate in regards to the overall abundance of other breeding bird species. However, comparing the relative diversity among the three categories of jack pine stand age is somewhat complicated by the unequal number of sampled points between them. Nonetheless, Table 5 utilizes a variety of metrics in an attempt to draw general conclusions regarding bird diversity and conservation value across the three successional stages of habitat. Row 1a lists the total number of species documented in each age class, 1b divides these figures by the total-number of sampling points in each age class, and 1c expresses the total number of singing males per sampling point in each age class. Rows 2a-2c and 3a-3c employ the same format (total species, species per point, and singing males per point) with reference to conservation value: Rows 2a-2c multiply each enumerated unit (species or singing male) by the Partners In Flight (PIF) Combined Score for breeding species of Region 12, while Rows 3a-c assess stand age distribution only for the five KWWMA species identified by the USFWS service as Region 3 Conservation Priorities (Black-billed Cuckoo, Field Sparrow, Kirtland's Warbler, Upland Sandpiper [*Bartramia longicauda*] and Northern Flicker [*Colaptes auratus*]) (USFWS 2002, Partners In Flight 2006). For the purpose of analysis, the three documented species for which no Partners InFlight Combined Score was available (Spotted Sandpiper [*Actitis macularius*], Upland Sandpiper and Wilson's Snipe [*Gallinago delicata*]) each received the mean Combined Score (11.7) of the other 57 KWWMA species.

Because rows 1a, 2a and 3a reflect species totals tallied from unbalanced sample sizes (21 YOUNG, 30 KW and 46 OLD), each likely overestimates the diversity and conservation value of OLD stands and underestimates that of YOUNG stands (Table 5). Conversely, because intra-

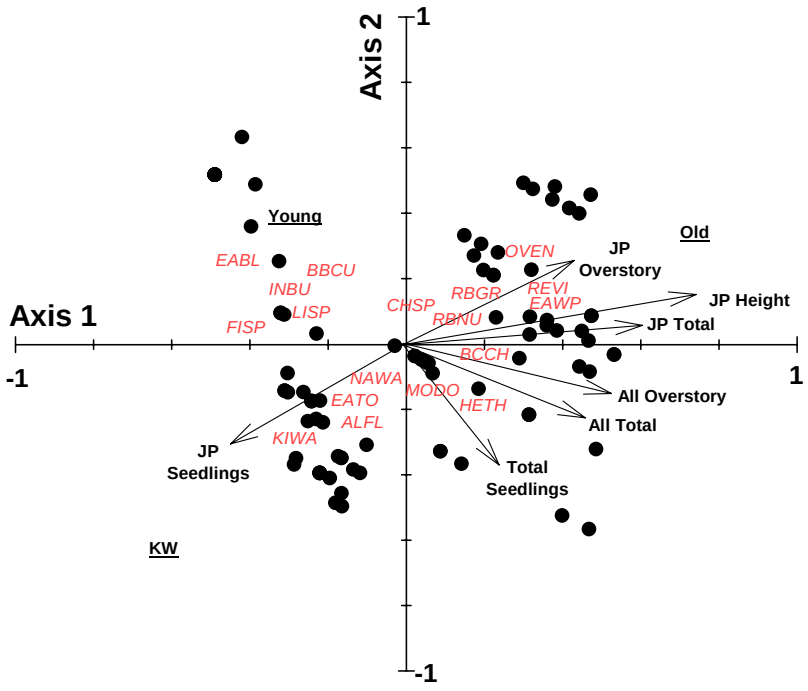

Fig. 11. CCA triplot relating songbird abundance with stand structural characteristics. Only those species determined to be significant indicators are included in the CCA triplot.

habitat species variety does not linearly correlate with point count sample size (Brewer 1991), rows 1b, 2b, and 3b likely overestimate the diversity and conservation value of YOUNG stands and underestimate that of OLD stands. Consequently, rows 1c, 2c and 3c – which record only breeding species, and do so on the "balanced" basis of singing males per sampling point – presumably represent the most accurate estimations within Table 5 of stand age diversity. The average number of singing males per sampling point in KW stands was 14.1, while averages for YOUNG and OLD stands were 10.2 and 10.8, respectively; the sum of PIF scores for singing males per sampling point in KW stands was 192, while scores for YOUNG and OLD stands were 127 and 122, respectively. Both metrics reflect notable similarity between YOUNG and OLD age classes. The average number of singing males per sampling point for KW stands was 33.8% higher than the combined average for YOUNG and OLD stands, while the average PIF score for singing males per sampling point in KW stands was 54.2% higher than the combined average for YOUNG and OLD stands. Lastly, the assessment of age class distribution of USFWS Region 3 Conservation Priority species – which involves an exceedingly limited number of species – favors KW stands moderately over YOUNG stands and heavily over OLD stands.

Relationships among songbirds and stand characteristics

The CCA of songbird abundance (Fig. 11) arranged the sample points along a significant gradient of stand age and structural characteristics along the first canonical axis ($P < 0.01$; eigenvalue=0.368). The density of jack pine seedlings was associated with the young and KW stands, and was negatively related to the density of jack pine in the overstory which was positively asso-

ciated with the old stands (Fig. 11). The CCA also confirms the MRPP and Indicator Analyses. For example, Kirtland's Warblers, Nashville Warblers, Eastern Towhees, and Alder Flycatchers were associated with the stands 5-23 years old with higher jack pine seedling densities, and shorter canopies of jack pine. The CCA also suggests that the variation in songbird assemblages was greater in the old stands than in the young or KW stands as evidenced by the large spread of sample points on the right side of the ordination. This variation in songbird assemblages is likely associated with differences in stand structural characteristics. For example, Ovenbirds, Red-eyed Vireos, Eastern Wood-Pewees, and Rose-breasted Grosbeaks tended to be associated with stands that had higher densities of jack pine in the overstory (Fig. 11).

Part 5. Conclusions

In general, through a concerted multi-agency recovery effort that includes the MDNR and the USFS (among others), the USFWS has been successful in meeting the goals of the KWWMA. Almost 7,000 ac (2838) of forestland has been acquired by the USFWS and many of these parcels are adjacent to existing jack pine forest ecosystems owned and managed by the MDNR. The characteristics of these tracts, however, are varied. Almost half of the area of the KWWMA is currently dominated by jack pine that is 5-23 years old. Our analysis also suggests that many of these stands are not optimally stocked to provide high-quality Kirtland's Warbler habitat. However, point counts executed on KWWMA parcels in 2006 do show the broad-based success of the multi-agency management practices in establishing habitat conducive for breeding Kirtland's Warblers. Furthermore, the diverse habitats that comprise the KWWMA in terms of stand age, species composition, and stand structure, may contribute significantly to avifaunal productivity and diversity in northern Lower Michigan.

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Appendix A.1. Soil Series Descriptions

LOCATION AU GRES MI+MA ME NH NY VT WI
Established Series
Rev. RWJ-WEF-MLK
05/2004

AU GRES SERIES

The Au Gres series consists of very deep, somewhat poorly drained soils formed in sandy glacial drift on stream terraces, outwash plains, lake terraces, lake plains, and ground moraines. These soils have rapid or very rapid permeability. Slope ranges from 0 to 6 percent. Mean annual precipitation is about 30 inches, and mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Sandy, mixed, frigid Typic Endoaquods

TYPICAL PEDON: Au Gres loamy sand - on a 2 percent slope in a forested area. (Colors are for moist soil unless otherwise stated.)

A--0 to 2 inches; black (10YR 2/1) loamy sand, gray (10YR 5/1) dry; weak fine granular structure; very friable; moderately acid; abrupt smooth boundary. (0 to 5 inches thick)

E--2 to 13 inches; pinkish gray (7.5YR 6/2) sand; single grain; loose; common fine distinct brown (7.5YR 5/4) iron accumulations throughout; moderately acid; abrupt irregular boundary. (0 to 12 inches thick)

Bhs--13 to 19 inches; dark reddish brown (5YR 3/3) sand; weak coarse subangular blocky structure; very friable; a few 1/2 to 2 inch diameter weakly cemented chunks of ortstein and iron concretions; common coarse prominent strong brown (7.5YR 5/6) iron accumulations throughout; strongly acid; clear irregular boundary. (0 to 12 inches thick)

Bs--19 to 30 inches; brown (7.5YR 4/4) sand; single grain; loose; common medium faint brown (7.5YR 5/4) and common medium distinct brown (10YR 5/3) iron accumulations throughout; moderately acid; clear irregular boundary. (4 to 26 inches thick)

BC--30 to 42 inches; brownish yellow (10YR 6/6) sand; single grain; loose; medium faint yellowish brown (10YR 5/6) iron accumulations throughout; moderately acid; gradual wavy boundary. (0 to 21 inches thick)

C--42 to 60 inches; brown (10YR 5/3) sand; single grain; loose; common medium distinct yellowish brown (10YR 5/6) iron accumulations throughout; moderately acid.

TYPE LOCATION: Emmet County, Michigan, about 3 miles north of Levering; 1,840 feet west and 300 feet north of the southeast corner, sec. 15, T. 38 N., R. 4 W.; Carp Lake Township, USGS Levering, MI. 7.5 minute topographic quadrangle; lat. 45 degrees 40 minutes 51 seconds N, long. 84 degrees 46 minutes 45 seconds W.

RANGE IN CHARACTERISTICS: The thickness of the solum ranges from 20 to 48 inches. Gravel content ranges from 0 to 10 percent throughout. The particle-size control section averages less than 50 percent fine sand. Mean annual soil temperature is 42 to 47 degrees F.

The A horizon has hue of 5YR to 10YR, or is neutral; value of 2 to 4, and chroma of 0 to 2. Texture is sand or loamy sand. Some pedons have an Ap horizon. Reaction of the A or Ap horizon ranges from extremely acid to neutral.

The E horizon has hue of 5YR to 10YR, value of 4 to 7, and chroma of 1 to 3. Texture is sand, coarse sand, or loamy sand or loamy coarse sand. In some pedons the A and E horizons are mixed. Reaction ranges from extremely acid to neutral.

The Bhs horizon when present has hue of 5YR to 10YR, and value and chroma of 2 or 3. Texture is sand, coarse sand, loamy sand or loamy coarse sand. Reaction ranges from extremely acid to moderately acid.

The amount of chunks of ortstein within the Bhs and Bs horizons commonly ranges from 0 to 30 percent, but pedons containing as much as 50 percent ortstein are considered within the range of the series. The ortstein is as random tongues, or as pieces of tongues up to 8 inches in diameter.

The Bs horizon has hue of 5YR to 10YR, value of 3 to 6, and chroma of 4 to 6. Pedons without a Bhs horizon have Bs or Bs1 horizons with hue of 5YR or 7.5YR, value of 3 or 4 and chroma of 4. Texture is sand, coarse sand, loamy sand or loamy coarse sand. Reaction is very strongly acid to moderately acid in the upper part and very strongly acid to neutral in the lower part.

The BC horizon has hue of 5YR to 2.5Y, value of 4 to 6; and chroma of 2 to 8. Texture is sand, coarse sand, loamy sand or loamy coarse sand. Reaction ranges from extremely acid to neutral.

The C horizon has hue of 5YR to 5Y, value of 4 to 7, and chroma of 1 to 8. Texture is sand or coarse sand. Reaction is very strongly acid to neutral.

COMPETING SERIES: These are the Battlefield, Kinross, Wainola, and Wormet series. Battlefield soils have gravelly sand in the lower part of the control section, and have free carbonates within 40 inches. Kinross soils are saturated for a period of 90 to 120 days when the soil temperature is above 5 degrees C. Wainola soils have a 10 to 40 inch particle-size control section that averages more than 50 percent fine sand. Wormet soils have a finer texture cap 10 to 20 inches thick.

GEOGRAPHIC SETTING: Au Gres soils are on stream terraces, outwash plains, lake plains, lake terraces and ground moraines. Au Gres soils formed in drift of Wisconsinan Age. Slope gradients are predominantly 0 to 3 percent and range from 0 to 6 percent. Elevations are 600 to 1,800 feet. Mean annual precipitation ranges from 27 to 34 inches, and the annual temperature is about 40 to 47 degrees F. The frost free period is 90 to 140 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Croswell, Kalkaska, Kinross, Roscommon, and Rubicon soils. The excessively drained Rubicon; somewhat excessively drained and well drained Kalkaska; the moderately well drained Croswell and the poorly drained or very poorly drained Roscommon and Kinross soils are in the same drainage sequence.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained. Depth to the seasonal high water table ranges from 0.5 to 1.5 feet below the surface at some time from October to June. The soil is saturated

for a period of 70 to 90 days when the soil temperature is above 5 degrees C. Potential surface runoff is negligible or very low. Permeability is rapid or very rapid.

USE AND VEGETATION: Only a small part is cultivated. Some areas are in permanent pasture and others are used for growing special crops such as blueberries and cucumbers. Many areas are in various stages of reforestation. Natural forests are northern white-cedar, balsam fir, hemlock, yellow birch, paper birch, aspen, and red maple.

DISTRIBUTION AND EXTENT: Northern Lower Peninsula and Upper Peninsula of Michigan, Minnesota, Wisconsin, New York, Vermont, New Hampshire, and Massachusetts. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana

SERIES ESTABLISHED: Franklin County, New York, 1955.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - from the surface to 13 inches (A and E horizons). Albic horizon - from 2 to l3 inches (E horizon).
Spodic horizon - from 13 to 30 inches (Bhs and Bs horizon).
Aquic conditions (endosaturation) - inferred form redox accumulations in the zone from 13 to 60 inches (Bhs, Bs, BC, and C horizons).

The loamy or clayey substratum phases of this soil are no longer within the series concept.

ADDITIONAL DATA: Soil Interpretation Record No.: MI0109

National Cooperative Soil Survey
U.S.A.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

LOCATION CROSWELL MI+WI
Established Series
Rev. WEF-MLK
06/2004

CROSWELL SERIES

The Croswell series consists of very deep, moderately well drained soils formed in sandy glacial drift on

stream terraces, lake terraces, low dunes, beach ridges, outwash plains, lake plains, and ground moraines. These soils have rapid permeability. Slopes range from 0 to 12 percent. Mean annual precipitation is about 29 inches, and mean annual temperature is about 45 degrees F.

TAXONOMIC CLASS: Sandy, mixed, frigid Oxyaquic Haplorthods

TYPICAL PEDON: Croswell sand - on a 3 percent slope in a wooded area. (Colors are for moist soil unless otherwise stated.)

A--0 to 1 inch; black (10YR 2/1) sand, dark grayish brown (10YR 4/2) dry; weak fine granular structure; very friable; many fine and medium roots; strongly acid; clear smooth boundary. (0 to 4 inches thick)

E--1 to 7 inches; pinkish gray (7.5YR 6/2) sand; weak medium granular structure; very friable; many fine and medium roots; strongly acid; clear irregular boundary. (0 to 15 inches thick)

Bs1--7 to 9 inches; strong brown (7.5YR 4/6) sand; weak medium subangular blocky structure; friable; many fine and medium roots; common (about 15 percent) distinct cracked coatings on sand grains; strongly acid; clear irregular boundary.

Bs2--9 to 16 inches; strong brown (7.5YR 5/6) sand; weak medium subangular blocky structure; friable; many fine and medium roots; common (about 15 percent) distinct cracked coatings on sand grains; slightly acid; clear irregular boundary. (Combined thickness of the Bs horizon is 9 to 28 inches.)

BC--16 to 39 inches; brownish yellow (10YR 6/6) sand; single grain; loose; common medium prominent strong brown (7.5YR 5/8) iron accumulations beginning at about 25 inches; common fine roots; slightly acid; gradual wavy boundary. (0 to 23 inches thick)

C--39 to 60 inches; light yellowish brown (10YR 6/4) sand; single grain; loose; few fine roots; slightly acid.

TYPE LOCATION: Cheboygan County, Michigan; about 3 miles northeast of the town of Alverno; 1,240 feet south and 700 feet west of the northeast corner of sec. 13, T. 37 N., R. 1 W. USGS Manning, MI 7.5 minute quadrangle; lat. 45 degrees 35 minutes 48 seconds N., long. 84 degrees 22 minutes 24 seconds W.

RANGE IN CHARACTERISTICS: The solum is 20 to 45 inches thick. Gravel content ranges from 0 to 15 percent throughout the pedon. Cobble content of the solum ranges from 0 to 30 percent. The depth to redox concentrations (Fe masses) ranges from 18 to 40 inches.

The A horizon has hue of 5YR to 10YR, or is neutral, value of 2 or 3, and chroma of 0 to 2. Cultivated areas have an Ap horizon that has a hue of 10YR to 5YR, value of 2 to 4, and chroma of 1 to 3. The A or Ap horizons are sand, loamy sand, cobbly sand or cobbly loamy sand. Reaction ranges from extremely acid to slightly acid.

The E horizon has hue of 5YR to 10YR, value of 4 to 7, and chroma is 1 or 2. The E horizon is sand, loamy sand, cobbly sand or cobbly loamy sand. Reaction ranges from extremely acid to slightly acid.

The Bs1 horizon has hue of 2.5YR to 7.5YR, value of 3 to 5, and chroma of 4 to 6. Pedons with hue of 7.5YR, value of 4 or 5 and chroma of 6 or 8 have common distinct cracked coatings on sand grains. It is

sand, loamy sand, cobbly sand or cobbly loamy sand. Reaction ranges from very strongly acid to moderately acid.

The Bs2 horizon has hue of 5YR to 10YR, value of 3 to 5, and chroma of 3 to 6. The Bs2 horizon does not have value and chroma of 3 occurring together. The Bs2 horizons are sand, loamy sand, cobbly sand, or cobbly loamy sand. Reaction ranges from very strongly acid to neutral. The Bs horizons contain from 0 to 30 percent ortstein.

The BC horizon has hue of 5YR to 10YR, value of 4 to 6, and chroma of 2 to 8. It is sand, loamy sand, cobbly sand or cobbly loamy sand. Reaction ranges from very strongly acid to neutral. Clay content of the the 10 to 40 inch control section is less than 15 percent.

The C horizon has hue of 5YR to 10YR, value of 4 to 7, and chroma of 2 to 8. It is sand. It ranges from strongly acid to moderately alkaline.

COMPETING SERIES: These are the Croswood, Cublake (T), Gilchrist, Halfaday, Heinz, Manitowish, Mattix, Neconish (T), and Noseum (T) series. Croswood soils have 2C horizons of loamy glacial till at 40 to 60 inches. Cublake soils are underlain by stratified loamy and sandy lacustrine materials. Gilchrist soils have 2C horizons of sandy loam glacial till at 20 to 40 inches. Halfaday soils are higher in sesquioxides and organic carbon. Manitowish soils have a loamy mantle 15 to 20 inches thick. Mattix soils have a loamy mantle 15 to 30 inches thick and are saturated from 0.5 to 1.5 feet during the winter. Neconish soils have a particle size control section that averages 50 percent or more fine sand. Noseum soils have a loamy mantle 10 to 20 inches thick.

GEOGRAPHIC SETTING: The Croswell soils are on sandy areas, such as low dunes, stream terraces, lake terraces, outwash plains, lake plains, or ground moraines. Slopes range from 0 to 12 percent. Mean annual precipitation ranges from 27 to 34 inches, and the mean annual temperature from 41 to 45 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Au Gres, Kalkaska, Manistee, Menominee, Roscommon, and Rubicon soils. The somewhat poorly drained Au Gres, somewhat excessively drained Kalkaska, poorly or very poorly drained Roscommon, and excessively drained Rubicon soils are the most common associates. Manistee and Menominee soils are associated in some areas where the sandy layers are underlain by loamy or clayey materials.

DRAINAGE AND PERMEABILITY: Moderately well drained. The representative depth to wet soil moisture status ranges from 2.0 to 3.5 feet below the surface at some time during the months of October through June. Surface runoff is negligible or very low. Permeability is rapid.

USE AND VEGETATION: Most of this soil is in forest, permanent pasture, or idle cropland; however, a small amount is cropped mainly to small grain and hay. Wooded areas support mixed hardwoods and conifers, including quaking aspen, black cherry, paper birch, bigtooth aspen, red pine, eastern white pine, jack pine, northern red oak, and red maple.

DISTRIBUTION AND EXTENT: Northern Lower Peninsula and Upper Peninsula of Michigan, northern Minnesota, and northern Wisconsin. The series is of large extent.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota.

SERIES ESTABLISHED: Sanilac County, Michigan, 1955.

REMARKS: Diagnostic horizons and features recognized in this pedon are: ochric epipedon - the zone from the surface to 7 inches (A and E horizons); albic horizon - the zone from 1 to 7 inches (E horizon); spodic horizon - the zone from 7 to 16 inches (Bs1 and Bs2 horizon).

The loamy substratum and till substratum phases are no longer within the concept of the series.

ADDITIONAL DATA: Soil Interpretation Records: MI0187; MI0570 (COBBLY)

National Cooperative Soil Survey
U.S.A.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

LOCATION GRAYCALM MI+MN WI
Established Series
Rev. NWS-WEF-MLK
05/2002

GRAYCALM SERIES

The Graycalm series consists of very deep, somewhat excessively drained soils formed in sandy deposits on moraines, kames, stream terraces, and outwash plains. These soils have rapid permeability. Slope ranges from 0 to 70 percent. Mean annual precipitation is about 30 inches, and mean annual temperature is about 44 degrees F.

TAXONOMIC CLASS: Mixed, frigid Lamellic Udipsamments

TYPICAL PEDON: Graycalm sand - on a 1 percent slope on an outwash plain in a forested area. (Colors are for moist soil unless otherwise stated.)

A--0 to 3 inches; very dark brown (10YR 2/2) sand, very dark grayish brown (10YR 3/2) dry; moderate medium granular structure; very friable; many fine roots; very strongly acid; clear wavy boundary. (1 to 5 inches thick)

Bw1--3 to 6 inches; brown (7.5YR 4/4) sand; weak fine granular structure; very friable; common fine roots; strongly acid; clear irregular boundary. (3 to 12 inches thick)

Bw2--6 to 13 inches; strong brown (7.5YR 5/6) sand; weak fine granular structure; very friable; few fine roots; moderately acid; gradual wavy boundary. (0 to 12 inches thick)

Bw3--13 to 22 inches; yellowish brown (10YR 5/6) sand; single grain; loose; few fine roots; slightly acid; gradual wavy boundary. (0 to 10 inches thick)

E--22 to 35 inches; light yellowish brown (10YR 6/4) sand; single grain; loose; very few fine roots; slightly acid; abrupt broken boundary. (0 to 25 inches thick)

E and **Bt**--35 to 60 inches; light yellowish brown (10YR 6/4) sand (E); single grain; loose; lamellae of brown (7.5YR 5/4) and reddish brown (5YR 5/4) loamy sand (Bt); weak very fine to medium subangular blocky structure; friable; lamellae are 1/4 to 2 inches in thickness with a total accumulation of 5 inches; about 5 percent gravel; slightly acid.

TYPE LOCATION: Clare County, Michigan; about 2310 feet west and 700 feet north of the southeast corner of sec. 6, T. 20 N., R. 4 W., Frost Township; USGS Cooperton, Michigan topographic quadrangle; lat. 44 degrees 8 minutes 55 seconds N. and long. 84 degrees 50 minutes 17 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Depth to the first lamella ranges from 25 to 48 inches. Depth to calcium carbonates is 50 to greater than 80 inches. Gravel content is 0 to 14 percent and cobble content is 0 to 3 percent throughout the pedon. The series control section (0 to 60 inches) averages from 20 to 50 percent fine sand and very fine sand. Mean annual soil temperature is 40 to 47 degrees F. The typifying pedon has an average sand distribution of about 55 percent medium sand, 26 percent fine sand, 16 percent coarse sand, 2 percent very coarse sand, and 1 percent very fine sand.

The A horizon has hue of 10YR or 7.5YR value of 2 to 4, and chroma of 1 to 3. In cultivated areas, the Ap horizon has hue of 10YR or 7.5YR, value of 3 or 4 and chroma of 2 or 3. Texture is sand, loamy sand, or loamy coarse sand. Reaction is extremely acid to slightly acid.

Some pedons have an E horizon above the B horizon, 1 to 4 inches thick. It has hue of 10YR or 7.5YR, value of 5 to 7, and chroma of 1 to 3. Texture is sand, loamy sand, or loamy coarse sand. Reaction is extremely acid to slightly acid.

The Bw horizons have hue of 7.5YR or 10YR, value of 3 to 7, and chroma of 4 to 8. Texture is sand or loamy sand. Content of acid-oxalate extractable Al plus 1/2 Fe is .10 to .25 percent. Reaction is extremely acid to neutral.

The E horizon below the B horizon and the E part of the E and Bt horizon have hue of 5YR, 7.5YR, or 10YR; value of 5 to 7; and chroma of 2 to 6. Texture is sand or loamy sand. Some pedons do not have an individual E horizon.

The Bt part of the E and Bt horizon consists of lamellae 1/16 to 3 inches thick. The total accumulation within a depth of 60 inches is less than 6 inches. The Bt horizon has hue of 10YR to 5YR, value of 3 to 6, and chroma of 4 to 6. Texture is loamy sand, sandy loam, sand or fine sandy loam. Reaction of the E horizon and E and Bt horizon is extremely acid to neutral.

Some pedons have a C horizon with hue of to 10YR or 2.5Y, value of 5 to 7, chroma of 2 to 6. Texture is sand or coarse sand. Some pedons have thin bands of loamy sand, loamy fine sand, or fine sand 1/16 to 1 inch thick. These bands have hue of 7.5YR or 5YR, and value and chroma of 4 to 6. Reaction ranges from moderately acid to moderately alkaline.

COMPETING SERIES: These are the Gerrish and Sissabagama series. Other similar soils are Eagleview(T), Faunce and Zimmerman. Eagleview and Faunce soils have calcium carbonates in the upper

parts of the control section. Gerrish soils contain 15 to 35 percent gravel. Sissahagama soils have stratified sediments in the lower parts of the particle-size control section. Zimmerman soils contain more than 50 percent fine sand and very fine sand in the particle size control section.

GEOGRAPHIC SETTING: Graycalm soils are on moraines, kames, stream terraces and outwash plains of Wisconsinan Age. These soils formed in sandy glacial material. Slopes are 0 to 70 percent. Elevations are 600 to 1,300 feet. Mean annual precipitation is 25 to 32 inches. The mean annual temperature is 38 to 47 degrees F. The frost free period is 90 to 140 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Au Gres, Grayling, Menahga, Montcalm, Roscommon, and Rubicon soils. Grayling and Menahga soils are more droughty and are on outwash plains and lake plains. Rubicon soils have spodic horizons and are on landscape positions similar to those of Graycalm soils. Montcalm soils have an argillic horizon and are on till plains and moraines. The somewhat poorly drained Au Gres soils and poorly drained Roscommon soils have zones of aquic conditions and may be in a drainage sequence with the Graycalm soils.

DRAINAGE AND PERMEABILITY: Somewhat excessively drained. The potential for surface runoff is negligible to low depending on slope. Permeability is rapid.

USE AND VEGETATION: A large part is in forestland. Forest vegetation consists chiefly of northern red oak with some white pine in the southern extent of the soil, and jack pine and scrub oak in the northern extent. A small part is cropped to small grains, corn, or hay.

DISTRIBUTION AND EXTENT: Central and northern part of Lower Michigan, the north-central part of Minnesota and in the northern part of Wisconsin. This series is of large extent.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana

SERIES ESTABLISHED: Clare County, Michigan, 1977.

REMARKS: This revision updates the classification from mixed, frigid, Argic Udipsamments to the present 8th Ed. Soil Taxomony.

Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - from the surface to a depth of 3 inches (A horizon).
Particle-size control section - the zone from 10 to 40 inches (part of the Bw2, the Bw3, E, and part of the E and Bt horizon). Lamellic feature - 5 inch cumulative thickness of lamellae in the 35 to 60 inch layer (E and Bt horizon). Within 80 inches, total lamellae thickness is less than 6 inches.

The moderately well drained phase is no longer within the series concept.

ADDITIONAL DATA: For laboratory data of the Graycalm series, refer to S74MI-35-1 (74B425-74B431) , S74MI-35-2 (74B432-436), S74MI-35-4 (74B445-74B452), Beltsville Lab; and S84MI-129-006, Michigan Technological University Soil Lab.

National Cooperative Soil Survey
U.S.A.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

LOCATION GRAYLING MI+WI
Established Series
Rev. LWB-WEF-MLK
05/2004

GRAYLING SERIES

The Grayling series consists of very deep, excessively drained soils formed in deep sandy glacial outwash deposits on outwash plains, deltas, kames, kame moraines, disintegration moraines and lake plains. These soils have rapid permeability. Slope ranges from 0 to 45 percent. Mean annual precipitation is 30 inches and mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Mixed, frigid Typic Udipsamments

TYPICAL PEDON: Grayling sand - on a 1 percent slope in a forested area. (Colors are moist soil unless otherwise stated.)

A--0 to 3 inches; black (N 2/0) sand with grayish brown (10YR 5/2) sand (E); coated and uncoated sand grains mixed throughout the horizon, giving a salt and pepper appearance; moderate organic matter content in upper part; weak medium granular structure; very friable; very strongly acid; abrupt smooth boundary. (0 to 4 inches thick)

Bw1--3 to 9 inches; brown (7.5YR 4/4) sand; weak coarse granular structure; very friable; strongly acid; clear smooth boundary.

Bw2--9 to 15 inches; strong brown (7.5YR 5/6) sand; very weak coarse granular structure; very friable; moderately acid; clear irregular boundary. (Combined thickness of the Bw horizons is 8 to 22 inches.)

BC--15 to 23 inches; brown (7.5YR 5/4) sand; single grain; loose; moderately acid; gradual smooth boundary. (0 to 11 inches thick)

C--23 to 60 inches; light brown (7.5YR 6/4) sand; single grain; loose; moderately acid.

TYPE LOCATION: Delta County, Michigan; about 2 miles west of Ensign; 1,420 feet east and 300 feet north of the southwest corner, sec. 34, T. 41 N., R. 21 W.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from about 15 to 35 inches. Gravel content ranges from 0 to 10 percent by volume throughout the pedon. The 10 to 40 inch control section contains less than 20 percent coarse sand and very coarse sand.

Some pedons have an 0 horizon, 1/2 to 1 1/2 inches thick. It is composed of oak leaves or jack pine needles, and some twigs and roots in various stage of decomposition. The A and E horizons are normally in-

termixed in a single layer, but some pedons have a separate E horizon. The A horizon has hue of 5YR, 7.5YR, 10YR, or is neutral; value of 2 to 4; and chroma of 0 to 3. The E horizon has hue of 5YR, 7.5YR, or 10YR; value of 5 to 7; and chroma of 2. Reaction of the A and E horizons ranges from extremely acid to strongly acid.

The Bw1 horizon has hue of 5YR, 7.5YR, or 10YR; and value and chroma of 3 to 6. Value and chroma of 3 do not occur together. The Bw2 horizon has similar hue but value ranges from 4 to 6, and chroma of 6. Reaction of the Bw horizon ranges from extremely acid to strongly acid.

Some pedons have a BC horizon that has hue of 10YR or 7.5YR, value of 5 or 6, and chroma of 4 to 6.

The C horizon has hue of 2.5YR, 5YR, 7.5YR, or 10YR; value of 5 to 7; and chroma of 2 to 6. It is sand or coarse sand. Dark minerals are more common in the northwestern part of the soils range. Some pedons have color bands below 40 inches that do not qualify for lamella. Reaction ranges from moderately acid to neutral.

Some pedons have banded substratums below 80 inches.

Some pedons have loamy substratums below depths of 60 inches.

Calcareous phases recognized.

Deep water table phases are recognized.

COMPETING SERIES: These are the Claire, Mahtomedi, Menahga, Nymore, Omega, Plainbo, Sartell, Serden, Shawano, and Sunday series. Claire and Serden soils are dominantly neutral to moderately alkaline throughout. Mahtomedi soils have greater than 15 percent rock fragments within the 10 to 40 control section. Menahgan soils contain greater than 20 percent coarse and very coarse sand in the 10 to 40 inch control section. Nymore soils have less than 50 percent medium sand. Omega soils have loamy sand or loamy fine sand B horizons. Plainbo soils have bedrock at depths of 20 to 40 inches. Sartell and Shawano soils are fine sand in the 10 to 40 inch control section. Sunday soils do not have a B horizon and are in a more moist climate.

GEOGRAPHIC SETTING: Grayling soils are on outwash plains, deltas, and lake plains, kames and disintegration moraines of Wisconsinan Age. Slope gradients are dominantly less than 8 percent but range from 0 to about 45 percent. These soils formed in sandy glaciofluvial sediments. Average annual precipitation ranges from 27 to 34 inches, and mean annual temperature from 40 to 47 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Rubicon and Croswell series and the somewhat poorly drained Au Gres and poorly and very poorly drained Roscommon series. Au Gres and Roscommon soils are in lower landscape positions.

DRAINAGE AND PERMEABILITY: Excessively drained. The potential surface runoff is negligible to low depending on the slope. Permeability is rapid.

USE AND VEGETATION: Used for woodland. Jack pine is the principal tree species in the Upper Peninsula of Michigan, whereas jack pine and scrub oak are principal tree species in the northern part of the Lower Peninsula. Ground cover includes blueberries, lichens, mosses, sweetfern, and wintergreen.

DISTRIBUTION AND EXTENT: Northern Lower Peninsula and the Upper Peninsula of Michigan and northern Wisconsin. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana

SERIES ESTABLISHED: Alger County, Michigan, 1929.

REMARKS: Diagnostic horizons and features recognized in this pedon are: ochric epipedon - zone from the surface to 3 inches (A horizon).

ADDITIONAL DATA: Soil Interpretation Record No. MI0097; LOAMY SUBSTRATUM PHASE (MI0652); BANDED SUBSTRATUM PHASE (MI0653).

National Cooperative Soil Survey
U.S.A.

LOCATION KALKASKA MI

Established Series
Rev. EPW-WEF-MLK
04/1999

KALKASKA SERIES

The Kalkaska series consists of very deep, somewhat excessively drained soils formed in sandy deposits on outwash plains, valley trains, moraines, and stream terraces. These soils have rapid permeability. Slopes range from 0 to 70 percent. Mean annual precipitation is about 30 inches, and mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Sandy, mixed, frigid Typic Haplorthods

TYPICAL PEDON: Kalkaska sand on a 1 percent west-facing slope in a forested area. (Colors are for moist soil unless otherwise stated.)

0i-1 to 0 inches; undecomposed forest litter

A-0 to 1 inches; black (7.5YR 2.5/1) sand; black (10YR 2/1) dry; weak fine granular structure; very friable; many fine, few medium and coarse roots; about 5 percent fine gravel; strongly acid; abrupt smooth boundary. (0 to 4 inches thick)

E-1 to 4 inches; brown (7.5YR 5/2) sand, gray (10YR 6/1) dry; weak fine granular structure; very friable; common fine, few medium and coarse roots; about 5 percent fine gravel; strongly acid; clear irregular boundary. (2 to 13 inches thick)

Bhs-4 to 6 inches; dark reddish brown (5YR 3/3) sand; weak fine granular structure; very friable; common fine, few medium and coarse roots; about 5 percent fine gravel; moderately acid; clear irregular boundary. (1 to 23 inches thick)

Bs1-6 to 21 inches; dark brown (7.5YR 3/4) sand; weak fine granular structure; very friable; few fine and medium roots; about 5 percent fine gravel; moderately acid; clear wavy boundary.

Bs2-21 to 35 inches; strong brown (7.5YR 4/6) sand; weak fine granular structure; very friable; few fine roots between ortstein columns; columns of weakly cemented, dark reddish brown (5YR 2/2) ortstein 3 to 5 inches wide extend through this horizon into the BC horizon; ortstein columns are 19 to 24 inches apart; ortstein occupies 7 percent of the horizon; about 5 percent fine gravel; slightly acid; gradual wavy boundary. (Combined thickness of the Bs horizons 0 to 30 inches)

BC-35 to 50 inches; yellowish brown (10YR 5/6) sand; weak fine granular structure; very friable; few fine roots between ortstein colums; columns of weakly cemented, dark reddish brown (5YR 2/2) ortstein 3 to 5 inches wide extend into this horizon from the Bs2 horizon; ortstein columns are 19 to greater than 40 inches apart; ortstein occupies 11 percent of the horizon; about 5 percent fine gravel; slightly acid; gradual wavy boundary. (0 to 21 inches thick)

C-50 to 80 inches; light yellowish brown (10YR 6/4) sand; single grain; loose; about 5 percent fine gravel; slightly acid.

TYPE LOCATION: Kalkaska County, Michigan; about 4 miles northwest of Darragh; 1900 feet north and 100 feet east of the southwest corner, sec. 13, T.28 N., R.7 W., USGS Westwood topographic quadrangle; lat.44 degrees 49 minutes 13 seconds N. and long. 85 degrees 6 minutes 35 seconds W.; Rapid River Township

RANGE IN CHARACTERISTICS: The depth to the C horizon ranges from 24 to 55 inches. Gravel content ranges from 0 to 10 percent. Cobbles range from 0 to 3 percent throughout. Stones covering the surface range from 0 to 0.1 percent. The B horizons contain 0 to 45 percent of cemented material (ortstein).

The Oi horizon is undecomposed forest litter. Some pedons have Oe or Oa horizons of partially and well decomposed forest litter.

The A horizon has hue of 10YR to 5YR; value of 2 or 3; and chroma of 1 to 3. Some pedons have Ap horizons with hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 1 or 2. The A horizons are sand or loamy sand. Reaction of the A or Ap horizon ranges from extremely acid to moderately acid.

The E horizon has hue of 10YR to 5YR, value of 5 to 7, and chroma of 1 or 2. It is sand or loamy sand. Reaction of the E horizon ranges from extremely acid to moderately acid. In some pedons the A and E horizons are mixed together.

The Bhs horizon has hue of 5YR or 7.5YR, value of 2 or 3, and chroma of 1 to 3. It is dominantly sand, but the range includes loamy sand. Reaction ranges from extremely acid to moderately acid.

The Bs horizon has hue of 7.5YR or 5YR, value of 3 to 5, and chroma of 4 to 6. It is sand. Reaction ranges from very strongly acid to moderately acid.

The BC horizon has hue of 10YR or 7.5YR and value and chroma of 4 to 6. Reaction ranges from very strongly acid to moderately acid.

The C horizon has hue of 10YR or 7.5YR, value of 5 to 7, and chroma of 3 to 6. It ranges from very strongly acid to slightly acid.

COMPETING SERIES: These are the Adams, Deerton, Furlong, Garlic, Liminga, McMillian (T), Omega, Pence and Springlake soils. Adams soils have isotic mineralogy and a soil moisture section that is dry for less than 20 days during the 120 days following the summer solstice. Deerton and Furlong have bedrock within a depth of 40 inches. Garlic soils have more fine sand throughout and have more than 50 percent ortstein. Springlake soils have carbonates within 60 inches. Liminga soils are fine sand throughout. McMillian (T) soils have a loamy cap and stratification in the lower part of the series control section. Omega soils have redder hues in the lower part of the profile and the soil moisture control section is dry for 20 to 35 consecutive days during the 120 days following the summer solstice. Pence soils have finer textures in the upper part of the profile.

GEOGRAPHIC SETTING: Kalkaska soils are on outwash plains, valley trains, moraines, and stream terraces. Slope gradients range from 0 to 70 percent. Mean annual precipitation ranges from 27 to 34 inches, and the mean annual temperature ranges from 40 to 47 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Au Gres, East Lake, Halfaday, Roscommon, and Rubicon soils. Au Gres, Halfaday, Kinross, and Roscommon soils are wetter members of a drainage sequence with Kalkaska soils. Rubicon soils are common associates on the moraines. Roscommon and East Lake soils are common associates on outwash plains.

DRAINAGE AND PERMEABILITY: Somewhat excessively drained Surface runoff is low or medium depending on slope. Permeability is rapid.

USE AND VEGETATION: Most of the Kalkaska soils are in forest. The natural vegetation is sugar maple, American beech, red pine, quaking aspen, bigtooth aspen, and eastern white pine. Cut over areas are largely aspen. Some are in pasture, cropland, or idle cropland. The principal crops are small grain, hay, and potatoes; and a small amount is in corn and vegetables.

DISTRIBUTION AND EXTENT: Northern Lower Peninsula, the Upper Peninsula of Michigan and northern Wisconsin. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana

SERIES ESTABLISHED: Kalkaska County, Michigan, 1927.

REMARKS: This update moves the pedon to an area that better represents the series. It also updates the competing series and removes old beach ridges from the landforms.

Diagnostic horizons and other features recognized in this pedon are: albic horizon - the zone from 1 to 4 inches (E horizon); spodic horizon - the zone form 4 to 35 inches (Bhs and Bs horizons).

The well drained phase of the series is no longer in the series concept. Bands of loamy sand or sandy loam below depths of 60 inches in some pedons is no longer in the series concept.

This series was named the State Soil of Michigan in 1991.

National Cooperative Soil Survey
U.S.A.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

LOCATION MARKEY MI+ME MN ND VT WI
Established Series
Rev. RWJ-WEM-WEF-KDS
05/2001

MARKEY SERIES

The Markey series consists of very deep, very poorly drained organic soils. They formed in herbaceous organic material 16 to 51 inches thick overlying sandy deposits in depressions on outwash plains, lake plains, flood plains, river terraces valley trains and moraines. Permeability is moderately slow to moderately rapid in the organic layers and rapid or very rapid in the sandy material. Slopes range from 0 to 2 percent. Mean annual precipitation is about 30 inches. Mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Sandy or sandy-skeletal, mixed, euic, frigid Terric Haplosaprists

TYPICAL PEDON: Markey muck - on a slope of 1 percent in a bog with marsh vegetation. (Colors are for moist soil unless otherwise stated.)

Oa1--0 to 9 inches; very dark brown (10YR 2/2), black (10YR 2/1) rubbed muck (sapric material); about 10 percent fibers, less than 5 percent rubbed; weak thin platy structure; fibers are primarily herbaceous; slightly alkaline (pH 7.5 in water); clear smooth boundary.

Oa2--9 to 12 inches; very dark grayish brown (10YR 3/2), very dark brown (10YR 2/2) rubbed muck (sapric material) about 20 percent fiber, less than 5 percent rubbed; weak thin platy structure; fibers are primarily herbaceous; slightly alkaline (pH 7.5 in water); clear smooth boundary.

Oa3--12 to 24 inches; very dark brown (10YR 2/2) on broken face and rubbed muck (sapric material); about 10 percent fiber, less than 5 percent rubbed; moderate thick platy structure; fibers are primarily herbaceous; about 20 percent mineral soil material; slightly alkaline (pH 7.5 in water); gradual wavy boundary.

Oa4--24 to 32 inches; very dark brown (10YR 2/2), black (10YR 2/1) rubbed muck (sapric material); about 5 percent fiber, less than 5 percent rubbed; weak coarse subangular blocky structure; primarily herbaceous fibers; less than 10 percent mineral soil material; slightly alkaline (pH 7.5 in water); abrupt smooth boundary. (Combined thickness of Oa horizons is 16 to 51 inches.)

Cg--32 to 60 inches; gray (N 5/0) sand; single grain; loose; slightly alkaline.

TYPE LOCATION: Clare County, Michigan; about 2 miles north of Clare; 660 feet east and 891 feet north of the southwest corner, sec. 13, T. 17 N., R. 4 W.

RANGE IN CHARACTERISTICS: The depth to the sandy C horizon is commonly 24 to 42 inches and ranges from 16 to 51 inches. The organic material is primarily derived from herbaceous plants. There are no free carbonates in the organic material. Some pedons contain as much as 15 percent by volume of fragments of twigs, branches, or logs that range from about 1/8 to 6 inches in diameter. Some pedons have a 1 to 4 inch layer of sphagnum moss at the surface.

The organic soil layers have hue of 10YR, to 2.5YR, or are neutral, value of 2 to 4 and chroma of 0 to 3. Broken face, rubbed, and pressed soil material may vary by one unit in color value or chroma or both. The surface tier is mainly sapric material, but some pedons have either sapric or hemic material or both in varying proportions. It commonly has weak platy or granular structure, but in some pedons is massive. The organic layers within the subsurface tier are dominantly sapric material, but some pedons have as much as 10 inches of hemic material or 5 inches of fibric material within this depth. The organic part of the subsurface and bottom tiers is commonly massive, but in some pedons it has weak, thick to thin platy, weak coarse granular, or blocky structure. The pH ranges from 6.5 to 7.5 in 0.01M calcium chloride but the full range is from pH 4.5 to 7.8. Commonly the organic layer just above the C horizon contains more mineral soil material than overlying organic layers, and in some pedons mineral.

Some pedons have thin A horizons.

Typically the C horizon has hue of 7.5YR to 5Y, or is neutral, value of 4 to 6 and chroma of 0 to 4. It is sand, fine sand, coarse sand, loamy sand, or the gravelly analogs of loamy sand, sand and coarse sand, and contains 0 to 35 percent gravel by volume. Thin layers of loamy materials overlying the sand included. Some pedons in floodplains have thin layers of organic deposits. The C horizon is dominantly moderately acid, but includes very strongly acid in some areas and ranges to moderately alkaline.

COMPETING SERIES: These are the Grandjean (T) and Tawas series. Grandjean soils have more than 15 percent rock fragments in the Cg horizon. Tawas soils are formed primarily from woody material.

GEOGRAPHIC SETTING: Markey soils are in depressions within outwash plains, lake plains, flood plains, river terraces, valley trains and moraines. Slopes are 0 to 2 percent. Soils on nearby uplands are predominantly sandy. The mean annual precipitation ranges from about 15 to 44 inches. Mean annual temperature ranges from 36 to 47 degrees F. Frost free days are 70 to 145 days. Elevation is 600 to 2,800 feet above sea level.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Carbondale, Greenwood, and Rifle soils and the Deford, Kinross, and Roscommon soils. Carbondale soils have hemic soil material within 51 inches. The Greenwood and Rifle soils formed in hemic soil material 51 inches or greater. The Greenwood soils are also dysic. Deford, Kinross, and Roscommon soils are poorly drained sandy soils near the edge of the bogs.

DRAINAGE AND PERMEABILITY: Very poorly drained. Depth to the seasonal high water table ranges from plus 1.0 to 0.5 feet during November to June in most years. Commonly flooded and frequently flooded phases are recognized. Surface runoff is negligible. Permeability is moderately slow to moderately rapid in the organic material and rapid or very rapid in the sandy material.

USE AND VEGETATION: Most of this soil is in native vegetation. Some areas are in cattails, marsh grasses, reeds, and sedges. Most areas are forested with black ash, quaking aspen, balsam fir, black spruce, tamarack, northern white-cedar, and paper birch. A small part is used for permanent pasture.

DISTRIBUTION AND EXTENT: Michigan, Wisconsin, Minnesota and the New England states. Extensive.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota

SERIES ESTABLISHED: Grand Traverse County, Michigan, 1963.

REMARKS: Diagnostic horizons and features recognized in this pedon: well decomposed organic soil materials (sapric) from the surface to a depth of 32 inches (Oa1, Oa2, Oa3, and Oa4); terric subgroup - a mineral layer 30cm or more thick within a depth of 51 inches.

ADDITIONAL DATA: Soil Interpretation Record No.: MI0030; FREQUENTLY FLOODED -MI0619; MAAT < 44 - MI0629; COMMONLY FLOODED -MI0635; LOW PRECIPITATION - MI0387

National Cooperative Soil Survey
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Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

LOCATION MENOMINEE MI+WI
Established Series
Rev. NWS-WEF-TWH
09/2003

MENOMINEE SERIES

The Menominee series consists of very deep, well drained soils on ground moraines, end moraines, outwash plains, and lake plains. The soils formed in sandy glaciofluvial material over loamy glacial till or lacustrine sediments. Permeability is rapid in the sandy materials and moderate or moderately slow in the loamy materials. Slope ranges from 6 to 70 percent. Mean annual precipitation is about 30 inches, and mean annual temperature is about 44 degrees F.

TAXONOMIC CLASS: Sandy over loamy, mixed, active, frigid Alfic Haplorthods

TYPICAL PEDON: Menominee sand - on a northwest-facing, convex 16 percent slope in forest at an elevation of 910 feet. (Colors are for moist soil unless otherwise stated. When described on August 30, 1994 the soil was dry in the upper 20 inches and moist below.)

A--0 to 4 inches; very dark grayish brown (10YR 3/2) sand, grayish brown (10YR 5/2) dry; moderate medium granular structure; friable; many medium and fine and few coarse roots; extremely acid; clear smooth boundary. (0 to 5 inches thick)

E--4 to 7 inches; grayish brown (10YR 5/2) sand, very pale brown (10YR 8/2) dry; weak medium subangular blocky; very friable; many fine and medium and few coarse roots; extremely acid; clear smooth boundary. (1 to 5 inches thick)

Bs1--7 to 18 inches; brown (7.5YR 4/4) sand; weak medium subangular blocky structure; very friable; many fine and medium and few coarse roots; extremely acid; clear wavy boundary.

Bs2--18 to 23 inches; dark yellowish brown (10YR 4/6) sand; weak medium subangular blocky structure; very friable; many medium and few coarse roots; very strongly acid; clear wavy boundary. (combined thickness of the Bs horizons is 10 to 24 inches)

2B/E--23 to 39 inches; brown (7.5YR 5/4) clay loam (Bt) occupies 70 percent of the horizon surrounded by light brownish gray (10YR 6/2) sandy loam, light gray (10YR 7/1) dry; strong medium angular blocky structure; firm; few fine roots; common distinct brown (7.5YR 5/4) clay films; strongly acid; clear wavy boundary. (0 to 18 inches thick)

2Bt--39 to 59 inches; reddish brown (5YR 4/4) clay loam; weak coarse subangular blocky structure; firm; few fine roots; common distinct reddish brown (5YR 4/4) clay films on faces of peds; neutral; clear wavy boundary. (0 to 25 inches thick)

2C--59 to 80 inches; brown (7.5YR 5/4) loam; massive; firm; common very pale brown (10YR 8/2) carbonate coats in cracks; slightly effervescent throughout; moderately alkaline.

TYPE LOCATION: Iosco County, Michigan; about 6 miles nortwest of Hale, about 300 feet north and 2,200 feet east of the southwest corner of section 30, T. 24 N., R. 5 E.; USGS South Branch topographic quadrangle; lat. 44 degrees 26 minutes 14 seconds N. and long. 83 degrees 52 minutes 34 seconds W.; Plainfield Township.

RANGE IN CHARACTERISTICS: Depth to free calcium carbonate ranges from 24 to 60 inches. The thickness of sandy sediments ranges from 20 to 40 inches. Cobble content ranges from 0 to 7 percent throughout the pedon. The soil moisture control section is dry for 0 to 20 days. Mean annual soil temperature is 43 to 47 degrees F.

The upper part of the particle-size control section averages 5 to 12 percent clay and 0 to 25 percent coarse fragments, dominantly gravel. The lower part averages 18 to 35 percent clay, 35 to 50 percent fine and coarser sand, and 0 to 10 percent coarse fragments.

The A horizon has hue of 10YR, 7.5YR or is neutral, value of 2 or 3 moist, 4 or 5 dry, and chroma of 1 or 2, moist or dry. Cultivated areas have an Ap horizon up to 10 inches thick that has hue of 10YR or 7.5YR, value of 3 or 4 moist, 6 dry, and chroma of 2 or 3, moist or dry. The A or Ap horizon is sand, fine sand, loamy sand, loamy fine sand, or the gravelly analogues of these textures. Reaction of the A or Ap horizon ranges from extremely acid to slightly acid.

The E horizon has hue of 10YR to 5YR, value of 4 to 7 moist, 6 to 8 dry, and chroma of 2 or 3, moist or dry. It is sand, fine sand, loamy sand, loamy fine sand, or the gravelly analogues of these textures. Reaction of the E horizon ranges from extremely acid to slightly acid.

Some pedons have Bhs horizons up to 4 inches thick with hue of 2.5YR to 7.5YR and value and chroma of 2 or 3. Texture is sand, fine sand, loamy sand, loamy fine sand, or the gravelly analogues of these textures. Reaction ranges from very strongly acid to moderately acid.

The upper part of the Bs horizon (spodic horizon) has hue of 7.5YR or 5YR, value of 3 to 5, and chroma of 3 or 4. Value and chroma of 3 do not occur together. Texture is sand, fine sand, loamy fine sand, loamy sand, or the gravelly analogues of these textures. Acid-oxalate extractable Al plus 1/2 Fe is 0.5 to 1.5 percent. Reaction is extremely acid to moderately acid.

The lower part of the Bs horizon has hue of 10YR to 5YR, value of 4 or 5, and chroma of 4 to 6. Texture is sand, fine sand, loamy fine sand, loamy sand, or the gravelly analogues of these textures. Fragments of ortstein are in some pedons. Acid-oxalate extractable Al plus 1/2 Fe is 0.2 to 0.5 percent. Reaction is veryn strongly acid to slightly acid.

Some pedons have a separate E' horizon imediately below the Bs horizon. The E' horizon has hue of 10YR or 7.5YR, value of 4 to 7, and chroma of 2 to 4. Texture is sand, loamy sand, or the gravelly analogues of these textures. Reaction is very strongly acid to slightly alkaline.

Some pedons have 2E/Bt horizons, as much as 10 inches thick, just above the 2Bt/E horizon. The E part has similar colors and textures as the E' horizon, and the Bt part has similar colors and textures as the Bt part of the 2Bt/E horizon.

The E part of the 2Bt/E horizon (glossic horizon) has hue of 10YR or 7.5YR, value of 4 to 7 moist, 6 to 8 dry, and chroma of 2 or 3, moist or dry. Texture is loamy sand or sandy loam. Reaction of the 2B/E horizon is strongly acid to slightly alkaline.

The Bt part of the 2Bt/E and the 2Bt horizons have hue of 5YR to 2.5Y, value of 3 to 5, and chroma of 2 to 6. Texture is clay loam, sandy clay loam, sandy loam, loam, silt loam, or silty clay loam. Clay content is 18 to 35 percent. Reaction is strongly acid to slightly alkaline.

Some pedons have 2BC horizons as much as 5 inches thick, with similar colors to the 2Bt horizon. They are loamy sand, sandy loam, or loam. Reaction is strongly acid to slightly alkaline.

The 2C horizon has hue of 10YR to 2.5YR, value of 4 to 6, and chroma of 2 to 6. Texture is clay loam, sandy clay loam, sandy loam, loam, silt loam, or silty clay loam. Some pedons have 1/2 to 3 inch thick strata of silt, fine sand, very fine sand, fine sandy loam, very fine sandy loam, loamy fine sand, or loamy very fine sand. Reaction is slightly acid to moderately alkaline.

COMPETING SERIES: These are the Cutaway(T) and Guenther series. Cutaway soils have mean annual soil temperature less than 43 degrees F., and are dry in the moisture control section for greater than 20 days. Guenther soils do not have free carbonates within 60 inches.

GEOGRAPHIC SETTING: The Menominee soils are on ground moraines, end moraines, outwash plains, and lake plains. Slopes range from 12 to 70 percent. The soils formed in sandy glaciofluvial material over loamy glacial till or lacustrine sediments. Elevations are 600 to 1,400 feet. Mean annual precipi-

tation is 28 to 32 inches, and the mean annual temperature ranges from 41 to 45 degrees F. The frost free period is 100 to 150 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Breckenridge, Brevort, Iosco, Kalkaska, Manistee, Ubly and Sims soils. The somewhat poorly drained Iosco and poorly drained Brevort soils have a zone of aquic conditions and are in lower landscape positions on the landscape and form a drainage sequence with the Menominee soils. Rubicon and Kalkaska soils are sandy throughout, and are on similar landscape positions. Manistee soils are clayey in the lower part, and are on similar landscape poitions. Ubly soils are loamy throughout and are on similar landscape positions. Breckenridge and Sims soils have aquic moisture regimes
and are nearby in narrow drainageways on ground moraines in lower lying areas.

DRAINAGE AND PERMEABILITY: Well drained. Surface runoff is very slow to medium, depending on slope. Permeability is rapid in the sandy material and moderately slow or moderate in the underlying material.

USE AND VEGETATION: A small part is used for the production of small grain, grass-legume hay, and potatoes. A large part is in permanent pasture or forest. A considerable proportion is idle cropland. Native vegetation was northern hardwoods and conifers, including sugar maple, red pine, yellow birch, and white ash.

DISTRIBUTION AND EXTENT: Northern lower Michigan, upper Michigan, and northeastern Wisconsin. The series is of large extent.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana

SERIES ESTABLISHED: Menominee County, Michigan, 1925.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - from the surface to 7 inches (A and E horizons) Albic horizon - from 4 to 7 inches (E horizon).
Spodic horizon - from 7 to 18 inches (Bs1 horizon).
Glossic horizon - from 23 to 39 inches (2B/E horizon). Argillic horizon - from 23 to 59 inches (2B/E and 2Bt horizons).
Particle-size control section - the zone from 10 to 40 inches (part of the Bs1, the Bs2, 2Bt/E, and part of the 2Bt horizon).

The moderately well drained phase of this soil is no longer within the series concept.

ADDITIONAL DATA: Soil Interpretation Record No.: MI0193; MODERATE PERMEABILITY - MI0254.

National Cooperative Soil Survey
U.S.A.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

LOCATION MONTCALM MI
Established Series
Rev. LWB-WEF-MLK
11/1999

MONTCALM SERIES

The Montcalm series consists of very deep, well drained soils formed in sandy and loamy glacial drift material on ground moraines, end moraines, and outwash plains. Permeability is moderately rapid. Slopes range from 0 to 45 percent. Mean annual precipitation is about 30 inches, and mean annual temperature is about 44 degrees F.

TAXONOMIC CLASS: Coarse-loamy, mixed, semiactive, frigid Alfic Haplorthods

TYPICAL PEDON: Montcalm loamy sand - on a slope of 4 percent in a cultivated field. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 7 inches; dark grayish brown (10YR 4/2) loamy sand, light brownish gray (10YR 6/2) dry; weak fine granular structure; very friable; about 2 percent gravel; slightly acid; abrupt smooth boundary. (6 to 10 inches thick)

E--7 to 9 inches; light gray (10YR 7/2) loamy sand, light brownish gray (10YR 6/2) dry; weak fine granular structure; very friable; about 2 percent gravel; slightly acid; abrupt smooth boundary. (0 to 10 inches thick)

Bs--9 to 15 inches; brown (7.5YR 4/4) loamy sand; weak fine granular structure; very friable; about 1 percent gravel; moderately acid; clear wavy boundary. (5 to 12 inches thick)

E'--15 to 26 inches; light brownish gray (10YR 6/2) loamy sand, grayish brown (10YR 5/2) dry; very weak thin platy structure; very friable; about 1 percent gravel; moderately acid; clear wavy boundary. (0 to 18 inches thick)

Bt--26 to 33 inches; reddish brown (5YR 4/4) sandy loam; weak medium subangular blocky structure; friable; about 1 percent gravel; moderately acid; abrupt smooth boundary. (6 to 14 inches thick)

E and **Bt**--33 to 60 inches; light brownish gray (10YR 6/2) medium sand (E), grayish brown (10YR 5/2) dry; single grain; loose; with thin bands, layers and lenses, 1/2 to 4 inches thick of reddish brown (5YR 4/4) sandy loam (Bt); massive; friable; about 2 percent gravel; moderately acid; clear wavy boundary. (15 to 30 inches thick)

C--60 to 66 inches; pale brown (10YR 6/3) loamy sand; single grain; loose; slightly effervescent; slightly alkaline.

TYPE LOCATION: Osceola County, Michigan; about 1 mile east and 3 miles south of Tustin; 1,140 feet north and 450 feet west of the southeast corner, sec. 1, T. 19 N., R. 10 W.; USGS LeRoy, MI 7.5 minute topographic quadrangle; lat. 44 degrees 03 minutes 45.6 seconds N and long. 85 degrees 26 minutes 44.3 seconds W.

RANGE IN CHARACTERISTICS: Gravel and cobbles range from 0 to 15 percent by volume throughout.

The Ap horizon has hue of 10YR or 7.5YR, value of 2 to 4, and chroma of 2. Some pedons have an A horizon 1 to 3 inches thick with hue of 10YR or 7.5YR; value of 2 or 3, and chroma of 1 to 2. The A horizons are loamy sand, sandy loam, or fine sandy loam. Reaction of the A horizons ranges from strongly acid to neutral.

The E horizon has hue of 10YR, 7.5YR or is neutral; value of 5 to 7, and chroma of 0 to 3. It is sand, loamy sand, gravelly loamy sand, or sandy loam. Reaction of the E horizon ranges from strongly acid to slightly acid.

The Bs or Bs1 horizons have hue of 7.5YR, and value and chroma of 3 or 4. Value and chroma of 3 do not occur together. Reaction of the Bs or Bs1 horizons ranges from strongly acid to moderately acid. Some pedons have Bs2 horizons with hue of 10YR or 7.5YR, value of 4 or 5 and chroma of 4 to 6. The Bs2 horizon ranges from strongly acid to slightly acid. The Bs horizons are sand or loamy sand.

The E' horizon has hue of 10YR or 7.5YR, value of 5 to 7, and chroma of 2 to 4. It is sand or loamy sand. In some pedons the upper E' horizon occurs as thick coatings on peds and fillings in cracks in the upper part of the Bt horizon.

The Bt horizon has hue of 10YR, 7.5YR, or 5YR; value of 3 to 5, and chroma of 3 to 6. It is sandy loam or sandy clay loam. The depth to the upper Bt horizon ranges from 20 to about 40 inches. Reaction of the Bt horizon ranges from strongly acid to slightly acid.

The E part of the E and Bt horizon has colors and textures similar to those of the E' horizon above. The Bt part of the E and Bt horizon has colors similar to the Bt horizon above. It is dominantly sandy loam, but can range to loamy sand. The thickness of the Bt bands between the E horizons range from 1/8 to 5 inches in thickness. Reaction of the E and Bt horizon ranges from strongly acid to neutral.

The C horizon has hue of 10YR or 7.5YR, value of 5 or 6, and chroma of 2 to 4. It is dominantly loamy sand but ranges to sand. Reaction ranges from moderately acid to slightly acid.

COMPETING SERIES: These are the Sagola and Trenary series. Sagola soils are dominated by glossic horizons. Trenary soils do not have E and Bt horizons.

GEOGRAPHIC SETTING: The Montcalm soils are on ground moraines, end moraines, and outwash plains. Slopes are dominantly 2 to 18 percent but range from 0 to 45 percent. Mean annual precipitation ranges from 28 to 32 inches. The mean annual temperature ranges from 41 to 47 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Graycalm, McBride, Nester, Otisco, Roscommon and Rubicon series. The somewhat poorly drained Otisco and the poorly drained Roscommon soils are in the same drainage sequence. They occur on lower landscape positions. Rubicon and Graycalm soils are coarser textured associates while the McBride and Nester soils are finer textured associates. They occur on similar landscape positions.

DRAINAGE AND PERMEABILITY: Well drained. The potential surface runoff is low or medium depending upon slope. Permeability is moderately rapid.

USE AND VEGETATION: A relatively small amount is cropped to hay, potatoes, and small grains. Most of the soils are in permanent pasture, idle cropland, or in woodland. Native forest vegetation was northern red oak, red pine, sugar maple, yellow birch, and some eastern white pine.

DISTRIBUTION AND EXTENT: Northern part of Lower Peninsula of Michigan.

MLRA OFFICE RESPONSIBLE: Indianapolis, Indiana

SERIES ESTABLISHED: Kent County, Michigan, 1926.

REMARKS: This soil was previously classified to Eutric Glossoboralfs based on the former chemical criteria for spodosols. The series now qualifies as a spodosol based on morphological features.

Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - the zone from the surface to 9 inches (Ap and E horizons);
Albic horizon - the zone from 7 to 9 inches, from 15 to 26 inches, and from 33 to 60 inches (E, E' and E part of E and B horizon);
Spodic horizon - the zone from 9 to 15 inches; argillic horizon - the zone from 26 to 60 inches (Bt and B part of E and B horizon).

ADDITIONAL DATA: For laboratory data supporting classification change refer to S78MI-085-2, Sample Nos. 78P 112-121, Michigan Technological University, Ford Forestry Center, L'Anse, Michigan.

Soil Interpretation Record No.: MI0217.

National Cooperative Soil Survey
U.S.A.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

LOCATION RUBICON MI+WI

Established Series
Rev. REV-WEF-MLK
03/2000

RUBICON SERIES

The Rubicon series consists of very deep, excessively drained soils formed in sandy deposits on disintegration, ground, end and kame moraines, lake plains, outwash plains, stream terraces, beach ridges, and sand dunes. These soils have rapid permeability. Slopes range from 0 to 70 percent. Mean annual precipitation is about 30 inches, and mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Sandy, mixed, frigid Entic Haplorthods

TYPICAL PEDON: Rubicon sand - on a 3 percent convex south-facing slope in a red pine plantation at an elevation of 859 feet. (Colors are for moist soil unless otherwise stated).

A--0 to 1 inch; black (10YR 2/1) sand, flecked with light brownish gray (10YR 6/2),dark gray (10YR 4/1) dry; weak fine granular structure; very friable; common roots; very strongly acid; abrupt smooth boundary. (0 to 3 inches thick).

E--1 to 6 inches; light brownish gray (10YR 6/2) sand; very weak medium granular structure; very friable; common roots; very strongly acid; clear smooth boundary. (1 to 7 inches thick)

Bs1--6 to 10 inches; dark brown (7.5YR 4/4) sand; weak medium granular structure; very friable; many roots; common (about 15 percent) distinct cracked coatings sand grains; moderately acid; clear wavy boundary.

Bs2--10 to 18 inches; dark yellowish brown (10YR 4/4) sand; weak coarse granular structure; very friable; common roots; common (about 15 percent) faint cracked coatings on sand grains; moderately acid; clear irregular boundary. (4 to 32 inches thick).

BC--18 to 36 inches; yellowish brown (10YR 5/6) sand; very weak coarse subangular blocky structure; very friable; moderately acid; chunks of ortstein occur at depths of 18 to 24 inches and represent about 15 percent of the surface area of the horizon exposed; chunks are 4 to 6 inches in diameter; colors are yellowish brown (10YR 5/6) representing 60 percent of the mass and dark reddish brown (5YR 3/4) and pale brown (10YR 6/3) representing the remaining colors; massive; few roots; weakly to strongly cemented; moderately acid; clear irregular boundary. (0 to 20 inches thick)

C--36 to 60 inches; light yellowish brown (10YR 6/4) sand with some coarse sand in upper portion; single grain; loose; slightly acid.

TYPE LOCATION: Cheboygan County, Michigan; about 5 miles northeast of Afton; 300 feet north and 2440 feet east of the southwest corner, sec. 5, T. 35 N., R. 1 W. USGS Legrand, MI 7.5 minute topographic quadrangle; lat. 45 degrees 26 minutes 13.6 seconds N. and long. 84 degrees 27 minutes 39.9 seconds W., east part of Koehler Township.

RANGE IN CHARACTERISTICS: The thickness of the solum ranges from 20 to 50 inches. Coarse fragments range from 0 to 15 percent throughout the pedon. Calcareous substratum phases are recognized.

The A and Ap horizons have hue of 10YR, 7.5YR, 5YR, or is neutral; value of 2 to 4; and chroma of 0 to 3. The A or Ap horizon is sand or loamy sand. Reaction ranges from very strongly acid to moderately acid.

The E horizon has hue of 10YR, 7.5YR, or 5YR; value of 4 to 7; and chroma of 1 to 3. The E horizon is sand or loamy sand. Reaction ranges from very strongly acid to moderately acid.

The Bs1 horizon has hue of 7.5YR, or 5YR; value of 3 or 4; and chroma of 2 to 4. Values and chromas of 2 and 3 do not occur together.

The Bs2 horizon has hue of 10YR, 7.5YR, or 5YR; value of 4 or 5 and chroma of 3 to 8.

Reaction of the Bs horizons ranges from very strongly acid to moderately acid.

The BC horizon has hue of 10YR, 7.5YR, or 5YR; value of 4 to 6; and chroma of 3 to 8. The amount of ortstein occurring in the Bs and BC horizons range from 0 to 20 percent. Reaction ranges from very strongly acid to moderately acid.

The C horizon has hue of 10YR, 7.5YR, or 5YR; value of 4 to 7; and chroma of 3 to 8. It is medium or coarse sand. Thin color bands are in some pedons. The reaction ranges from very strongly acid to neutral.

COMPETING SERIES: These are the Duel, East Lake, Fernlake (T), Hartwick, Ishpeming, Karlin, Kiva, Missiquoi, Rousseau, Sayner, Sultz (T), and Vilas series. Duel soils are underlain by limestone bedrock. East Lake soils are underlain by gravelly sand within the control section. Fernlake (T) soils are underlain with loamy sand. Hartwick soils have one or more horizons that average 15 to 35 percent gravel within the series control section. Ishpeming soils have igneous bedrock at a depth of 20 to 40 inches. Karlin soils have loamy fine sand or sandy loam in the 10 to 40 inch control section. Kiva soils have stratified coarse sand and gravel at depths ranging from 10 to 24 inches. Missisquoi soils have more gravel in the substratum. Rousseau soils developed in fine sands. Sayner soils contain more gravel in the lower part of the profile. Sultz (T) soils are stratified with loamy, or loamy and sandy material in the lower part of the series control section. Vilas soils have loamy sand textures in the Bs horizon.

GEOGRAPHIC SETTING: Rubicon soils are on outwash and lake plains, stream terraces, and moraines and to a lesser extent on old beach ridges and sand dunes along the Great Lakes. Slopes range from 0 to 70 percent. The mean annual precipitation is 27 to 34 inches, and annual temperature is about 40 to 47 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: Croswell, Au Gres, and Roscommon soils form a common drainage sequence with Rubicon. Kalkaska, Grayling, and Montcalm soils are common well drained to excessively drained associates.

DRAINAGE AND PERMEABILITY: Excessively drained. Surface runoff is slow or very slow. Permeability is rapid.

USE AND VEGETATION: The greater proportion of this soil is forested, including tree plantations. Some areas are idle cropland or in pasture. Only a very small proportion is used for small grains and hay

crops. The native vegetation and present natural vegetation is dominantly red pine and quaking aspen with some eastern white pine and jack pine. Ground cover consists of blueberries, wintergreen, sweet fern, and bracken fern.

DISTRIBUTION AND EXTENT: Northern half of lower Michigan, upper Michigan, and northern Wisconsin. The series is of large extent.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota

SERIES ESTABLISHED: Ontonagon County, Michigan, 1922.

REMARKS: Diagnostic horizons and features recognized in this pedon are: albic horizon - the zone from 1 to 6 inches (E horizon); spodic horizon - the zone from 6 to 18 inches (Bs1 and Bs2 horizons). The Bs2 qualifies on the basis of cracked coatings.

The dark subsoil and banded subsoil phases (that have 1/16 to 1/4 inch bands of loamy sand at depths of 40 to 60 inches) are no longer in the series concept.

ADDITIONAL DATA: Soil Interpretation Record No.: MI0050.

National Cooperative Soil Survey
U.S.A.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 27 July 2004].

Appendix A.2. NLCD Land Cover Class Definitions

Water - All areas of open water or permanent ice/snow cover.

11. *Open Water* - all areas of open water, generally with less than 25% cover of vegetation/land cover.
12. *Perennial Ice/Snow* - all areas characterized by year-long surface cover of ice and/or snow.

Developed Areas characterized by a high percentage (30 percent or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

21. *Low Intensity Residential* - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
22. *High Intensity Residential* - Includes highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80 to100 percent of the cover.
23. *Commercial/Industrial/Transportation* - Includes infrastructure (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential.

Barren - Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. *Bare Rock/Sand/Clay* - Perennially barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, beaches, and other accumulations of earthen material.
32. *Quarries/Strip Mines/Gravel Pits* - Areas of extractive mining activities with significant surface expression.
33. *Transitional* - Areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.).

Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25-100 percent of the cover.

41. *Deciduous Forest* - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
42. *Evergreen Forest* - Areas dominated by trees where 75 percent or more of the tree species `maintain their leaves all year. Canopy is never without green foliage.
43. *Mixed Forest* - Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. *Shrubland* - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-Natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. *Orchards/Vineyards/Other* - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland - Upland areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.
71. *Grasslands/Herbaceous* - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated - Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. *Pasture/Hay* - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
82. *Row Crops* - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
83. *Small Grains* - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.
84. *Fallow* - Areas used for the production of crops that do not exhibit visable vegetation as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.
85. *Urban/Recreational Grasses* - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. *Woody Wetlands* - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
92. *Emergent Herbaceous Wetlands* - Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Reference

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979. Classification of Wetlands and Deepwater Habitat of the United States, Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

Similarities and differences between Anderson and NLCD systems are as follows:

Urban or built-up classes: Commercial, Industrial, Transportation, and Communications/Utilities (all separate Anderson Level II classes) were treated as one NLCD class (Commercial/Industrial/Transportation). No attempt was made to derive Anderson Level III classes in NLCD. "Recreational" grasses, such as those that occur in golf courses or parks (treated as an urban class by Anderson) are considered to be a non-urban class in NLCD (a subdivision of "Herbaceous Planted/Cultivated). Residential (an Anderson Level II class) was divided into Low and High Intensity classes in NLCD.

Water: Anderson Level II Water classes (Streams/Canals, Lakes/Ponds, Reservoirs, Bays, Open Marine) were classed as a single class (Open Water) in NLCD.

Agriculture: Agricultural areas that are herbaceous in nature (Cropland and Pasture; Anderson Level II) are subdivided into four NLCD classes: Pasture/Hay, Row Crops, Small Grains and Fallow.

Rangeland: No rangeland class (Anderson Level I) is identified by NLCD. Rather, "rangeland" is subdivided by NLCD into Grasslands/Herbaceous and Shrubland classes.

Forest land: Evergreen Forest, Deciduous Forest and Mixed Forest are the same in both Anderson and NLCD. Clearcut and burned areas are classed as "Transitional Bare" areas in NLCD.

Wetlands: Two classes are defined by NLCD. These are Woody wetlands and Emergent/Herbaceous wetlands. These are very analogous to the Anderson Level II wetland classes.

Bare: Three NLCD classes are recognized. These are: Bare Rock/Sand Clay, Quarries/Strip Mines/Gravel Pits and Transitional Bare. These represent a consolidation of Anderson Level II classes.

Tundra: While “tundra” is treated as a distinct Anderson Level I class, tundra (including arctic/alpine vegetation) is considered to be either “Grasslands/Herbaceous” or “Shrubland” classes by NLCD.

Appendix B.1. List of Woody Species and Codes

Code	Scientific Name	Common Name
ABBA	*Abies balsamea*	balsam fir
ACRU	*Acer rubrum*	red maple
ALIN	*Alnus incana*	tag alder
AMXX	*Amelanchier spp.*	serviceberry spp.
BEXX	*Betula spp.*	birch spp.
CRXX	*Crataegus spp.*	hawthorn spp.
FRAM	*Fraxinus americana*	white ash
FRNI	*F. nigra*	black ash
FRPE	*F. pennsylvanica*	green ash
HAVI	*Hamamelis virginiana*	witch-hazel
PIBA	*Pinus banksiana*	jack pine
PIGL	*Picea glauca*	white spruce
PIRE	*Pinus resinosa*	red pine
PISY	*P. sylvestris*	Scots pine
PIST	*P. strobus*	white pine
POGR	*Populus grandidentata*	bigtooth aspen
POTR	*P. tremuloides*	trembling aspen
PRPE	*Prunus pennsylvanica*	pin cherry
PRSE	*P. serotina*	black cherry
PRVI	*P. virginiana*	chokecherry
QUAL	*Quercus alba*	white oak
QUCO	*Q. coccinea*	scarlet oak
QUEL	*Q. ellipsoidalis*	northern pin oak
QURU	*Q. rubra*	northern red oak
QUVE	*Q. velutina*	black oak

Appendix B.2. Overstory Density Values (trees per acre) by species for KWWMA Stands

Tract	ABBA	ACRU	FRNI	FRPE	PIBA	PIGL	PIRE	PIST	POGR	POTR	PRPE	PRSE	QUAL	QUCO	QUEL	QURU	QUVE		TPA	TPH
CL-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-11	0.0	0.0	0.0	0.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		300.0	741.0
CL-12	0.0	0.0	0.0	0.0	257.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.6	0.0	0.0	0.0		285.7	705.7
CL-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-24	0.0	0.0	0.0	0.0	87.5	0.0	0.0	0.0	0.0	125.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		212.5	524.9
CL-25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		12.5	30.9
CL-26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CL-3	0.0	0.0	0.0	0.0	368.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0		375.0	926.3
CL-4	0.0	0.0	0.0	0.0	292.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0		314.3	776.3
CL-5	0.0	6.3	0.0	0.0	187.5	0.0	0.0	0.0	0.0	18.8	0.0	3.1	0.0	21.9	0.0	0.0	0.0		237.5	586.6
CL-6	0.0	0.0	0.0	0.0	500.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0		516.7	1276.2
CL-7	0.0	75.0	0.0	0.0	12.5	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	25.0	0.0	50.0	0.0		212.5	524.9
CL-8	0.0	0.0	0.0	0.0	312.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0		325.0	802.8
CL-9	0.0	0.0	0.0	0.0	275.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		275.0	679.3
CR-1	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	31.3	0.0	18.8	0.0	0.0	0.0	0.0	0.0		150.0	370.5
CR-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CR-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CR-12	0.0	0.0	0.0	0.0	216.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0		233.3	576.3

Tract	ABBA	ACRU	FRNI	FRPE	PIBA	PIGL	PIRE	PIST	POGR	POTR	PRPE	PRSE	QUAL	QUCO	QUEL	QURU	QUVE		TPA	TPH
CR-13	0.0	0.0	0.0	0.0	316.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		316.7	782.2
CR-14	0.0	0.0	0.0	0.0	233.3	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		250.0	617.5
CR-15	0.0	0.0	0.0	0.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		300.0	741.0
CR-16	0.0	0.0	0.0	0.0	166.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		166.7	411.7
CR-17	0.0	0.0	0.0	0.0	237.5	0.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		387.5	957.1
CR-18	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		12.5	30.9
CR-19	0.0	0.0	0.0	0.0	262.5	0.0	206.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0		481.3	1188.7
CR-2	0.0	0.0	0.0	0.0	275.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0		281.3	694.7
CR-20	0.0	0.0	0.0	0.0	316.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		316.7	782.2
CR-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CR-22	0.0	0.0	0.0	0.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		150.0	370.5
CR-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CR-24	0.0	0.0	0.0	0.0	283.3	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		300.0	741.0
CR-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CR-4	25.0	0.0	0.0	0.0	200.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		250.0	617.5
CR-5	0.0	0.0	0.0	0.0	216.7	0.0	83.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0		316.7	782.2
CR-6	0.0	0.0	0.0	0.0	162.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0		175.0	432.3
CR-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CR-8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
CR-9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
KA-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
MO-1	0.0	0.0	0.0	0.0	31.3	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0		50.0	123.5
OG-1	0.0	0.0	0.0	0.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	12.5	0.0	50.0		275.0	679.3
OG-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-12	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	133.3	0.0		200.0	494.0
OG-13	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0		37.5	92.6
OG-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-15	0.0	0.0	0.0	0.0	150.0	0.0	30.0	10.0	0.0	0.0	0.0	0.0	0.0	60.0	0.0	0.0	30.0		280.0	691.6
OG-16	0.0	0.0	0.0	0.0	187.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	62.5		262.5	648.4
OG-17	0.0	0.0	0.0	0.0	150.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	12.5	12.5	0.0	50.0		237.5	586.6
OG-18	0.0	0.0	0.0	0.0	233.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		233.3	576.3

Tract	ABBA	ACRU	FRNI	FRPE	PIBA	PIGL	PIRE	PIST	POGR	POTR	PRPE	PRSE	QUAL	QUCO	QUEL	QURU	QUVE		TPA	TPH
OG-19	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		25.0	61.8
OG-2	0.0	0.0	0.0	0.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		150.0	370.5
OG-20	0.0	0.0	0.0	0.0	75.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		125.0	308.8
OG-21	0.0	0.0	0.0	0.0	400.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		425.0	1049.8
OG-22	0.0	0.0	0.0	0.0	166.7	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		183.3	452.8
OG-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-24	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		25.0	61.8
OG-25	0.0	0.0	0.0	0.0	0.0	0.0	12.5	25.0	12.5	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0		62.5	154.4
OG-26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	75.0	0.0	0.0	0.0	25.0		150.0	370.5
OG-27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-3	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		100.0	247.0
OG-30	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		12.5	30.9
OG-31	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		16.7	41.2
OG-32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-34	0.0	0.0	0.0	0.0	243.8	0.0	0.0	0.0	0.0	6.3	6.3	0.0	18.8	0.0	0.0	31.3	0.0		306.3	756.4
OG-35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-38	0.0	0.0	0.0	0.0	116.7	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		133.3	329.3
OG-39	0.0	0.0	0.0	0.0	150.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	75.0	0.0	0.0	0.0		262.5	648.4
OG-4	0.0	0.0	0.0	0.0	337.5	0.0	43.8	0.0	0.0	0.0	0.0	0.0	6.3	162.5	0.0	0.0	31.3		581.3	1435.7
OG-40	0.0	0.0	0.0	0.0	283.3	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	50.0		466.7	1152.7
OG-41	0.0	0.0	0.0	0.0	150.0	0.0	87.5	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0		250.0	617.5
OG-42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-44	0.0	0.0	0.0	0.0	33.3	0.0	133.3	0.0	0.0	0.0	0.0	16.7	0.0	50.0	0.0	0.0	0.0		233.3	576.3
OG-45	0.0	0.0	0.0	0.0	66.7	0.0	0.0	3.3	0.0	50.0	0.0	6.7	0.0	0.0	0.0	13.3	0.0		140.0	345.8
OG-46	0.0	0.0	0.0	0.0	187.5	0.0	9.4	0.0	0.0	0.0	0.0	0.0	6.3	37.5	0.0	0.0	37.5		278.1	687.0
OG-47	0.0	0.0	0.0	0.0	257.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		257.1	635.1

Tract	ABBA	ACRU	FRNI	FRPE	PIBA	PIGL	PIRE	PIST	POGR	POTR	PRPE	PRSE	QUAL	QUCO	QUEL	QURU	QUVE		TPA	TPH
OG-48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-5	0.0	0.0	0.0	0.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		150.0	370.5
OG-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OG-9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OS-1	0.0	0.0	0.0	0.0	81.3	0.0	0.0	0.0	0.0	50.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0		137.5	339.6
OS-10	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	62.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0		112.5	277.9
OS-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OS-12	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	133.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0		183.3	452.8
OS-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OS-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OS-15	0.0	0.0	0.0	0.0	83.3	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0		100.0	247.0
OS-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OS-17	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		33.3	82.3
OS-18	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	35.7	0.0	3.6	0.0	0.0	0.0		60.7	150.0
OS-19	14.3	0.0	0.0	0.0	192.9	7.1	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		221.4	546.9
OS-2	0.0	0.0	0.0	0.0	406.3	0.0	0.0	0.0	0.0	100.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0		556.3	1373.9
OS-20	0.0	0.0	0.0	0.0	162.5	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0		181.3	447.7
OS-21	0.0	0.0	0.0	0.0	218.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		218.8	540.3
OS-22	0.0	0.0	0.0	0.0	256.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		256.3	632.9
OS-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
OS-4	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0		25.0	61.8
OS-5	0.0	0.0	0.0	0.0	66.7	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0		100.0	247.0
OS-6	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0		50.0	123.5
OS-7	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	12.5	0.0	0.0	0.0		62.5	154.4
OS-8	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0		25.0	61.8
OS-9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
PI-1	12.5	5.0	5.0	5.0	2.5	0.0	0.0	2.5	15.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0		50.0	123.5
RO-1	0.0	0.0	0.0	0.0	275.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0		287.5	710.1

Appendix B.3. Understory Density Values (trees per acre) by species for KWWMA Stands

Tract	ABBA	ACRU	ALIN	AMXX	BEXX	CRXX	FRAM	FRNI	FRPE	HAVI	PIBA	PIGL	PIRE	PISY	PIST	POGR	POTR	PRPE	PRSE	PRVI	QUAL	QUCO	QUEL	QURU	QUVE	TPA	TPH
CL-1	5.0	7.5	2.5	2.5	2.5	0.0	0.0	2.5	2.5	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	2.5	0.0	5.0	0.0	0.0	2.5	0.0	2.5	40.0	98.8
CL-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CL-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	0.0	0.0	0.0	0.0	43.8	0.0	31.3	0.0	0.0	0.0	0.0	12.5	0.0	0.0	131.3	324.2
CL-12	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	25.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	12.5	0.0	118.8	293.3
CL-13	18.8	12.5	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	43.8	0.0	0.0	12.5	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0	150.0	370.5
CL-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	52.9
CL-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	185.3
CL-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	66.7	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	200.0	494.0
CL-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
CL-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	50.0	123.5
CL-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	0.0	0.0	0.0	0.0	50.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137.5	339.6
CL-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	50.0	123.5
CL-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	0.0	0.0	0.0	0.0	75.0	0.0	62.5	0.0	0.0	0.0	0.0	0.0	25.0	0.0	225.0	555.8
CL-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.5	216.1
CL-22	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	33.3	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3	205.8
CL-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	41.2
CL-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	12.5	0.0	0.0	0.0	0.0	0.0	25.0	61.8
CL-25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	16.7	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3	205.8
CL-26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CL-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CL-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	0.0	0.0	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.1	79.4
CL-5	14.3	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	7.1	0.0	21.4	0.0	0.0	0.0	14.3	0.0	0.0	14.3	0.0	0.0	28.6	0.0	128.6	317.6
CL-6	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	6.3	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	6.3	0.0	0.0	62.5	154.4
CL-7	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	18.8	0.0	0.0	0.0	18.8	0.0	0.0	6.3	0.0	0.0	18.8	0.0	100.0	247.0
CL-8	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	100.0	247.0
CL-9	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	0.0	0.0	6.3	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	81.3	200.7
CR-1	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	0.0	18.8	0.0	0.0	81.3	200.7
CR-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
CR-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	16.7	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
CR-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
CR-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Tract	ABBA	ACRU	ALRU	AMXX	BEXX	CRXX	FRAM	FRNI	FRPE	HAVI	PIBA	PIGL	PIRE	PISL	PIST	POGR	POTR	PRPE	PRSE	PRVI	QUAL	QUCO	QUEL	QURU	QUVE	TPA	TPH
CR-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3	0.0	0.0	116.7	288.2
CR-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	12.5	30.9
CR-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	50.0	123.5
CR-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
CR-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3	0.0	0.0	100.0	247.0
CR-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	33.3	0.0	0.0	100.0	247.0
CR-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3	0.0	0.0	100.0	247.0
CR-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
CR-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	18.8	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	6.3	0.0	0.0	50.0	123.5
CR-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	82.3
CR-8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	61.8
CR-9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	150.0	370.5
KA-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	30.9
MO-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	16.7	0.0	116.7	288.2
OG-1	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	16.7	0.0	16.7	0.0	0.0	33.3	0.0	0.0	100.0	247.0
OG-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	12.5	0.0	0.0	62.5	154.4
OG-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
OG-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG-13	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	10.0	0.0	10.0	0.0	0.0	20.0	0.0	0.0	60.0	148.2
OG-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	12.5	0.0	62.5	154.4
OG-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	12.5	0.0	87.5	216.1
OG-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	100.0	247.0
OG-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0	10.0	20.0	0.0	0.0	20.0	0.0	80.0	197.6
OG-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	12.5	0.0	62.5	154.4
OG-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	12.5	0.0	87.5	216.1
OG-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	100.0	247.0
OG-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	12.5	0.0	0.0	0.0	75.0	185.3
OG-21	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	25.0	25.0	0.0	0.0	50.0	0.0	225.0	555.8

Tract	ABBA	ACRU	ALRU	AMXX	BEXX	CRXX	FRAM	FRNI	FRPE	HAVI	PIBA	PIGL	PIRE	PISL	PIST	POGR	POTR	PRPE	PRSE	PRVI	QUAL	QUCO	QUEL	QURU	QUVE	TPA	TPH
OG-22	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	50.0	0.0	175.0	432.3
OG-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	16.7	50.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	50.0	0.0	166.7	411.7
OG-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG-25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	92.6
OG-26	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	25.0	0.0	0.0	12.5	12.5	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	12.5	0.0	137.5	339.6
OG-27	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	25.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0	0.0	225.0	555.8
OG-28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
OG-29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	154.4
OG-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	25.0	61.8
OG-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG-32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	30.9
OG-33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	35.7	88.2
OG-34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	0.0	0.0	0.0	0.0	6.3	6.3	12.5	0.0	0.0	0.0	0.0	25.0	0.0	0.0	81.3	200.7
OG-35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	50.0	0.0	0.0	16.7	0.0	116.7	288.2
OG-36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	25.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	12.5	0.0	0.0	0.0	0.0	75.0	185.3
OG-37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	66.7	164.7
OG-38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	25.0	12.5	0.0	0.0	0.0	12.5	0.0	12.5	25.0	0.0	0.0	0.0	0.0	125.0	308.8
OG-39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	6.3	0.0	0.0	6.3	0.0	0.0	6.3	0.0	31.3	77.2
OG-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	16.7	0.0	0.0	16.7	0.0	0.0	16.7	0.0	83.3	205.8
OG-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	16.7	0.0	0.0	16.7	0.0	0.0	16.7	0.0	83.3	205.8
OG-41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	3.3	0.0	6.7	0.0	6.7	3.3	0.0	0.0	0.0	6.7	0.0	0.0	36.7	90.6
OG-42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.4	0.0	3.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	43.8	108.1
OG-43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	154.4
OG-44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.7	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	7.1	0.0	0.0	0.0	50.0	123.5
OG-45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG-46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	12.5	0.0	56.3	138.9
OG-47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	7.1	0.0	28.6	70.6
OG-48	0.0	9.4	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	3.1	0.0	6.3	0.0	9.4	0.0	0.0	9.4	0.0	0.0	0.0	0.0	46.9	115.8
OG-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
OG-6	0.0	37.5	0.0	12.5	0.0	0.0	12.5	0.0	0.0	12.5	0.0	0.0	0.0	0.0	12.5	12.5	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	112.5	277.9
OG-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	25.0	0.0	0.0	25.0	0.0	100.0	247.0
OG-8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	37.5	92.6
OG-9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	12.5	0.0	0.0	75.0	185.3

Tract	ABBA	ACRU	ALRU	AMXX	BEXX	CRXX	FRAM	FRNI	FRPE	HAVI	PIBA	PIGL	PIRE	PISL	PIST	POGR	POTR	PRPE	PRSE	PRVI	QUAL	QUCO	QUEL	QURU	QUVE	TPA	TPH
OS-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	50.0	123.5
OS-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	7.1	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	52.9
OS-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	154.4
OS-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	50.0	123.5
OS-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	25.0	0.0	100.0	247.0
OS-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	61.8
OS-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	66.7	164.7
OS-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	75.0	185.3
OS-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
OS-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.8	78.6
OS-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	92.6
OS-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	87.5	216.1
OS-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
OS-21	25.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	25.0	0.0	50.0	0.0	37.5	0.0	0.0	0.0	0.0	37.5	0.0	0.0	250.0	617.5
OS-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	123.5
OS-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	12.5	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	77.2
OS-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	43.8	108.1
OS-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	77.2
OS-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	150.0	370.5
OS-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	200.0	494.0
OS-8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	100.0	247.0
OS-9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	12.5	0.0	12.5	0.0	0.0	25.0	0.0	0.0	75.0	185.3
PI-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	77.2
RO-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0	12.5	0.0	12.5	0.0	18.8	6.3	0.0	0.0	0.0	12.5	0.0	0.0	81.3	200.7

Appendix 3.1 Bird species documented within KWWMA parcels, June-July 2006.

			NEST		YOUNG		KW		OLD		ALL	
AOU	common name	scientific name	LOC1	LOC2	FREQ	ABUND	FREQ	ABUND	FREQ	ABUND	FREQ	ABUND
ALFL	Alder Flycatcher [11]	*Empidonax alnorum*	SH		23.8%	0.29					5.2%	0.06
AMCR	American Crow * [10]	*Corvus brachyrhynchos*	DT	SH	14.3%				6.5%		6.2%	
AMGO	American Goldfinch [13]	*Carduelis tristis*	SH	TR			10.0%	0.10	2.2%	0.02	4.1%	0.04
AMRE	American Redstart [12]	*Setophaga ruticilla*	DT	SH					2.2%	0.02	1.0%	0.01
AMRO	American Robin [9]	*Turdus migratorius*	DT	CT	14.3%	0.14	3.3%	0.03	13.0%	0.15	10.3%	0.11
BDOW	Barred Owl * [10]	*Strix varia*	DT	SH					2.2%		1.0%	
BBCU	Black-billed Cuckoo [16, CP]	*Coccyzus erythropthalmus*	DT	SN	28.6%	0.29	10.0%	0.10	4.3%	0.04	11.3%	0.11
BCCH	Black-capped Chickadee * [11]	*Poecile atricapillus*	SN		4.8%		40.0%		58.7%		41.2%	
BLJA	Blue Jay * [10]	*Cyanocitta cristata*	DT	GR	71.4%		86.7%		87.0%		83.5%	
SOVI	Blue-headed Vireo [11]	*Vireo solitarius*	CT						13.0%	0.13	6.2%	0.06
BRCR	Brown Creeper [11]	*Certhia americana*	CT	DT					6.5%	0.07	3.1%	0.03
BRTH	Brown Thrasher [14]	*Toxostoma rufum*	SH	GR	85.7%	1.10	70.0%	0.87	6.5%	0.07	43.3%	0.54
BHCO	Brown-headed Cowbird [12]	*Molothrus ater*	SH	GR			3.3%	0.03	2.2%	0.04	2.1%	0.03
CEDW	Cedar Waxwing * [13]	*Bombycilla cedrorum*	DT	CT			13.3%		15.2%		11.3%	
CHSP	Chipping Sparrow [11]	*Spizella passerina*	CT	DT	14.3%	0.19	60.0%	0.87	69.6%	1.11	54.6%	0.84
CCSP	Clay-colored Sparrow [12]	*Spizella pallida*	DT	CT	42.9%	0.62	43.3%	0.57			22.7%	0.31
COGR	Common Grackle * [9]	*Quiscalus quiscula*	GR		19.0%		10.0%		10.9%		12.4%	
CONI	Common Nighthawk [13]	*Chordeiles minor*	CL	CT			10.0%	0.13	10.9%	0.13	8.2%	0.10
CORA	Common Raven * [9]	*Corvus corax*	GR		81.0%		70.0%		41.3%		58.8%	
COYE	Common Yellowthroat [14]	*Geothlypis trichas*	SH		9.5%	0.10	16.7%	0.17	8.7%	0.11	11.3%	0.12
EABL	Eastern Bluebird [10]	*Sialia sialis*	SN		23.8%	0.29					5.2%	0.06
EAKI	Eastern Kingbird [13]	*Tyrannus tyrannus*	DT	SH	4.8%	0.05	3.3%	0.03			2.1%	0.02
EAPH	Eastern Phoebe [10]	*Sayornis phoebe*	BR	CL					2.2%	0.02	1.0%	0.01
EATO	Eastern Towhee [13]	*Pipilo erythrophthalmus*	GR	SH	4.8%	0.05	33.3%	0.33	2.2%	0.02	12.4%	0.12
EAWP	Eastern Wood-Pewee [13]	*Contopus virens*	DT						30.4%	0.33	14.4%	0.15
FISP	Field Sparrow [15, CP]	*Spizella pusilla*	GR	SH	85.7%	1.81	83.3%	1.27	6.5%	0.07	47.4%	0.81
GCKI	Golden-crowned Kinglet [12]	*Regulus satrapa*	DT	SN					2.2%	0.02	1.0%	0.01
GCFL	Great Crested Flycatcher [13]	*Myiarchus crinitus*	CT				6.7%	0.07	15.2%	0.15	9.3%	0.09
HAWO	Hairy Woodpecker * [11]	*Picoides villosus*	DT	SN			3.3%		8.7%		5.2%	
HETH	Hermit Thrush [9]	*Catharus guttatus*	GR	TR	9.5%	0.19	86.7%	1.57	84.8%	1.83	69.1%	1.39
HOWR	House Wren [10]	*Troglodytes aedon*	DT	SN					4.3%	0.07	2.1%	0.03
INBU	Indigo Bunting [10]	*Passerina cyanea*	SH	TR	57.1%	0.67	3.3%	0.03	8.7%	0.09	17.5%	0.20
KIWA	Kirtland's Warbler [22, CP]	*Dendroica kirtlandii*	GR		9.5%	0.24	90.0%	2.80			29.9%	0.92

			NEST		YOUNG		KW		OLD		ALL	
AOU	common name	scientific name	LOC1	LOC2	FREQ	ABUND	FREQ	ABUND	FREQ	ABUND	FREQ	ABUND
LEFL	Least Flycatcher [14]	*Empidonax minimus*	DT	SH					2.2%	0.02	1.0%	0.01
LISP	Lincoln's Sparrow [10]	*Melospiza lincolnii*	GR		76.2%	1.14	43.3%	0.80	8.7%	0.11	34.0%	0.55
MODO	Mourning Dove [6]	*Zenaida macroura*	TR	GR	19.0%	0.24	66.7%	0.93	65.2%	0.74	55.7%	0.69
MOWA	Mourning Warbler [16]	*Oporornis philadelphia*	GR						2.2%	0.02	1.0%	0.01
NAWA	Nashville Warbler [13]	*Vermivora ruficapilla*	CT		28.6%	0.38	96.7%	1.73	71.7%	1.07	70.1%	1.12
NOFL	Northern Flicker * [15, CP]	*Colaptes auratus*	GR		42.9%		40.0%		23.9%		33.0%	
OVEN	Ovenbird [13]	*Seiurus aurocapilla*	SN		4.8%	0.05	6.7%	0.10	78.3%	1.46	40.2%	0.73
PIWA	Pine Warbler [10]	*Dendroica pinus*	GR						2.2%	0.04	1.0%	0.02
RBNU	Red-breasted Nuthatch [9]	*Sitta vireo*	CT						41.3%	0.46	19.6%	0.22
REVI	Red-eyed Vireo [11]	*Vireo olivaceus*	DT	SH			3.3%	0.03	34.8%	0.37	17.5%	0.19
RTHA	Red-tailed Hawk * [9]	*Buteo jamaicensis*	CT				10.0%		6.5%		6.2%	
RWBL	Red-winged Blackbird [9]	*Agelaius phoeniceus*	SH	DT			3.3%	0.03	4.3%	0.07	3.1%	0.04
RBGR	Rose-breasted Grosbeak [16]	*Pheucticus ludovicianus*	DT	CL	4.8%	0.05	3.3%	0.03	50.0%	0.70	25.8%	0.35
SCTA	Scarlet Tanager [13]	*Piranga olivacea*	RD						23.9%	0.24	11.3%	0.11
SCJU	Slate-colored Junco [11]	*Junco hyemalis*	GR	BK			16.7%	0.20	37.0%	0.57	22.7%	0.33
SOSP	Song Sparrow [12]	*Melospiza melodia*	DT	CT	23.8%	0.24	6.7%	0.07	4.3%	0.04	9.3%	0.09
SPSA	Spotted Sandpiper *	*Actitis macularius*	GR	SH					2.2%		1.0%	
TRES	Tree Swallow * [13]	*Tachycineta bicolor*	CT	DT			6.7%		2.2%		3.1%	
TUVU	Turkey Vulture * [8]	*Cathartes aura*	GR				3.3%				1.0%	
UPSA	Upland Sandpiper [CP]	*Bartramia longicauda*	SN		52.4%	0.81	13.3%	0.13			15.5%	0.22
VESP	Vesper Sparrow [12]	*Pooecetes gramineus*	CL	SN	81.0%	1.29	63.3%	0.73			37.1%	0.51
WBNU	White-breasted Nuthatch [11]	*Sitta carolinensis*	GR				3.3%	0.03	30.4%	0.35	15.5%	0.18
WTSP	White-throated Sparrow [12]	*Zonotrichia albicollis*	GR				13.3%	0.20	2.2%	0.02	5.2%	0.07
WITU	Wild Turkey * [9]	*Meleagris gallopavo*	DT		9.5%						2.1%	
COSN	Wilson's Snipe	*Gallinago delicata*	GR						6.5%	0.07	3.1%	0.03
YBSA	Yellow-bellied Sapsucker * [14]	*Sphyrapicus varius*	GR	SH					2.2%		1.0%	
MYWA	Yellow-rumped Warbler [9]	*Dendroica coronata*	DT				6.7%	0.07	2.2%	0.02	3.1%	0.03

Appendix 3.1 lists all 60 bird species recorded during point counts within KWWMA parcels in June and July 2006. The 'AOU' column records the species' four-letter code as designated by The American Ornithologists' Union (2006). An asterisk after the common name of the species indicates that during surveying it was recorded by call or visual observation; a lack of asterisk indicates that the species was recorded only by song. The number in brackets after the common name lists the Partners in Flight (PIF) Regional Combined Score for the breeding season for Region 12 species. A 'CP' in brackets after the common name indicates that the species is a US Fish & Wildlife Service Region 3 Conservation Priority. The 'NEST' columns provide alphabetic code for the primary (LOC1) and secondary (LOC2) nest site locations commonly utilized by the species (Ehrlich et al. 1988); the designations are as follows:

BK – bank	GR – ground
BR – bridge	RD – reeds
CL – cliff	SH – shrub
CT – coniferous tree	SN – snag
DT – deciduous tree	TR – tree

The four sets of paired columns on the right half of Appendix 1 – 'YOUNG', 'KW', 'OLD' and 'ALL' – each record two different measures of species occurrence within the KWWMA parcels: 'FREQ' expresses the percentage of sampling points for the given age class (or for 'ALL' 97 sampling points combined) in which the species was recorded; 'ABUND' expresses the ratio of the total number of individuals recorded for the given age class over the total number of survey points for that class. For example, Kirtland's Warbler was recorded in 27 of the 30 'KW' survey points, so 'FREQ' = 90%; the total number of individuals recorded within these 30 points was 84, so 'ABUND' = 2.80. While 'FREQ' percentages relate to the presence or absence of all 60 species recorded during surveying, 'ABUND' values relate only those 45 species that were documented by song alone.

Appendix 3.2. Supplement to KWWMA spreadsheet data.

All survey data was compiled and combined within a Microsoft Excel® spreadsheet (KWWMA_0701_data) which has been submitted with this report; this appendix describes and elaborates upon the information contained therein. In delineating the contents of the eight separate worksheets it proceeds from right to left across their tabular arrangement within the file. The bracketed letters (e.g., '[A]') under each bold-faced worksheet name (e.g., 'STAGE1') refer to the column of the worksheet; a column title described below (e.g., 'KW PT') that is repeated in subsequent worksheets is assumed to convey identical information unless otherwise noted.

STAGE1: lists data for both sampling events at all 97 KWWMA points surveyed in 2006

- [A] KW PT: alphanumeric identification for the randomly-generated sampling point within a KWMMA tract
- [B] TRACT: alphanumeric identification for the KWWMA tract (or 'parcel') in which the [A] KW PT is located; utilized in prior KWWMA work
- [C] LAT: latitude of sampling point expressed in decimal degrees under NAD83 projection
- [D] LONG: longitude of sampling point expressed in decimal degrees under NAD83 projection
- [E] AGE CLASS: numeric code for age of jack pine stand within KWWMA parcel as established by prior KWWMA work
- [F] TRACT AGE: alphabetic code for presumptive age of jack pine stand proximately surrounding sampling point as taken from [E] AGE CLASS data; age class 1 = tract age 'YNG' (<5 years old), age class 2 = 'KW' (5-23 years old), age classes 3 and 4 = 'OLD' (>23 years old)
- [G] PT AGE: alphabetic code for estimated age of jack pine stand proximately surrounding sampling point as determined during surveying; categorically identical to [F] TRACT AGE above
- [H] ?: '?' indicates disparity between [F] TRACT AGE and [G] PT AGE; an empty value indicates agreement
- [I] JP: estimated height range (in feet) among jack pines proximately surrounding sampling point; 'NO JP' indicates an absence of jack pines surrounding sampling point
- [J] ALFL: four-letter American Ornithologists' Union (AOU) species code for Alder Flycatcher (*Empidonax alnorum*); a value indicates the number of Alder Flycatchers identified during a five-minute surveying event
- [K] ~: indicates the number of birds, if any, identified in [J] ALFL which were unequivocally located a) beyond the KWWMA parcel boundary and b) in habitat markedly different from that proximately surrounding the survey point
- [L-DY] replicate the paired data structure of [J] and [K], with species arranged in ascending alphabetical order according to AOU coding

STAGE2: combines data from both sampling events for all 97 KWWMA points in highlighted yellow rows; see the Data Treatment section in the main report for details on data combination

STAGE3: refines sampling data by eliminating original survey values from which the combined data rows of STAGE 2 were compiled; discards all '~' columns adjacent to AOU species columns

[K] AVG DATE: averaged date of the two survey efforts at the sampling point

[L] AVG TIME: averaged military time of the two survey efforts at the sampling point

[M] AVG SKY: averaged value of a numeric code designating sky conditions during the two survey efforts at the sampling point; 1 = CLEAR, 2= MOSTLY CLEAR, 3 = PARTLY CLOUDY, 4 = MOSTLY CLOUDY, 5 = CLOUDY

[N] AVG WIND: averaged value of a numeric code designating wind conditions during the two survey efforts at the sampling point; 1 = CALM, 2 = MOSTLY CALM, 3 = LIGHT WIND, 4 = LIGHT/MODERATE WIND, 5 = MODERATE WIND

TRACTS: lists basic habitat information on KWWMA parcels as recorded during point surveying

[J] JP AVG: averaged height (in feet) of the jack pine range listed in [I] JP

[K] TRACT INFO: basic habitat information regarding surveyed and unsurveyed portions of KWWMA parcels

SUMMARY: summarizes species data from STAGE3 by stand age category; adds additional habitat and conservation information for recorded species

[A] AOU: four-letter American Ornithologists' Union species code

[B] COMMON: common name for recorded species

[C] TYPE: alphabetic code for manner in which species was recorded during surveying; S = by song only, V = by song, call or visual observation

[D] R3 CP: an 'x' indicates that the species is a US Fish & Wildlife Service Region 3 Conservation Priority

[E] PIF RCS-B: the Partners in Flight (PIF) Regional Combined Score for breeding species in Region 12; see Results for further details

[F] (NESTING) LOC1: alphabetic code for the primary nest site location commonly utilized by the species; see Appendix 1 for further details

[G] (NESTING) LOC2: alphabetic code for the secondary nest site location, if any, commonly utilized by the species; sees Appendix 1 for further details

[H] (YOUNG) FR: the total number of survey points in YOUNG jack pine stands in which the species was recorded

[I] (YOUNG) FREQ: the percentage of survey points in YOUNG jack pine stands in which the species was recorded

[J] (YOUNG) AB: the total number of individuals recorded at survey points in YOUNG jack pine stands

[K] (YOUNG) ABUND: the ratio of the total number of individuals recorded at survey points in YOUNG jack pine stands over the total number of YOUNG survey points

[L] (YOUNG) PIF: the product of [E] PIF RCS-B and [J] (YOUNG) ABUND; see the Results section in the main report for further details

[M-Q] replicate the formatting of [H-L] for KW jack pine stands

[R-V] replicates the formatting of [H-L] for OLD jack pine stands

[W-AA] replicate the formatting of [H-L] for all 97 KWWMA survey points

UPSA: summarizes survey data for Upland Sandpipers (*Bartramia longicauda*) recorded in KWWMA tracts

[B] KW PT: same as [A] in STAGE1; an empty value indicates that sandpipers were noted visually on a KWWMA parcel while in transit to or from a sampling point

[F] SONG: the number of Upland Sandpipers recorded by song during formal surveying at a KWWMA sampling point

[G] VISUAL: the number of Upland Sandpipers recorded visually on a KWWMA parcel while in transit to or from a sampling point

LIST: condenses species information expressed in SUMMARY; see Appendix 1 for further details

LIST EXPORT: replicates LIST with formatting utilized for export (as Appendix 1) into Microsoft Word