PROGRESS REPORT - 1986

PROJECT: Analysis of the Ecosystem Structure and Vegetation of the Mack Lake Burn: A Framework for Understanding the Occurrence and Behavior of Kirtland's Warbler

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ECOSYSTEM STRUCTURE AND VEGETATION OF THE MACK LACK BURN
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Overview of Objectives

The general objective, as stated in the proposal, was "to establish a framework of landscape ecosystems as the basis for understanding warbler occurrence and behavior." Primary emphasis was placed on this objective, and a tentative ecosystem classification was developed. Two major landforms, outwash plain and ice-contact terrain, characterize the burned area. Ecosystem types were identified and sampled on each of these major zones. Kirtland's warblers began colonization of the Mack Lake burn in June 1986, and they showed a high preference for ecosystems of ice-contact terrain. Thus, it was demonstrated early in the study that colonization is strongly related to ecosystem type, especially physiography and soil and their effects on jack pine (Pinus banksiana Lamb.) growth.

The specific objectives of the study, as stated in the proposal, were:

(1) To determine the major landscape ecosystems of the Mack Lake burn by their physiographic, soil, and vegetative components;

(2) To identify and map the openings and the structure of young jack pine communities (occurrence, density, patchiness) by remote sensing techniques and field sampling within one or two major ecosystem types;

(3) To determine the tree structure and composition of jack pine communities; and

(4) To determine the composition and coverage of ground-cover vegetation in openings and in jack pine stands.

Research was directed to all four of these objectives, the primary ones being numbers 1 and 3.

Objective 1:

Nine different landscape ecosystem types were identified in the area, four on outwash terrain and five on ice-contact terrain. Forty-four ecosystem plots were established, sampled, and permanently located. Two approximations of the ecosystem classification were made -- one at the end of June, and one at the end of August. Taller jack pine trees and typically denser stands occur in the ice-contact zone. These factors, in part, may explain why Kirtland's warblers preferred this zone to that of the outwash plain.

Objective 2:

Considerable time was devoted to studying by reconnaissance and plot studies the size and occurrence of openings and the patchiness of jack pine regeneration. Four sections were identified for low-level aerial photography using a technique pioneered by Dr. Charles E. Olson, Jr. However, after considerable effort, Dr. Olson was unable to obtain the needed camera for the flights, and so we were unable to take the aerial photographs.

Objective 3:

The tree structure, composition, and density of jack pine seedlings were investigated on the ecosystem plots. Plots for determining the density and patchiness of jack pine were also established. Enormous differences in jack pine density were observed and recorded. The range of density was from 0 stems to 62,324 stems per acre, depending on sample plot size and the particular area sampled.

Objective 4:

The composition and ground-cover was determined in each ecosystem plot and density plot. The common and dominant shrubs and herbs of the area were present on most plots. Reconnaissance throughout the field season and plot sampling indicated that the coverage, density, and vigor of jack pine and northern pin oak (Quercus ellipsoidalis E. J. Hill) are probably more important factors in the recolonization of recent burns than differences in ground-cover vegetation. Marked differences occur in ground-cover vegetation between areas dominated by jack pine in the northern part of burn and those dominated by hardwoods (northern pin oak, red oak (Quercus rubra L.), red maple (Acer rubrum L.), bigtooth aspen (Populus grandidentata Michx.)) in the southern part of burn.

New objective:

Reconnaissance and examination of infrared photographs indicated that large scale salvage operations had apparently severely reduced the jack pine regeneration in many trees. Salvaged areas were examined, and a limited survey was conducted in salvaged and unsalvaged areas.

Procedure

Landscape ecosystems

Reconnaissance of the area was initiated May 20. The marked difference in physiography between the northern and southern parts of the burn became immediately apparent through reconnaissance coupled with study of topographic and soil maps. A relatively gradual transition separated the flat to gently sloping outwash plain of the northern part from the hilly ice-contact area of the south part. The identification of ecosystem types within each of these landform zones was accomplished by further reconnaissance and plot sampling. The soil map of the area, provided by Dave Clelland (Huron-Manistee N.F.), was particularly useful in our work. A first approximation of the ecosystem types was made in late June. Species-area curves, located away from roads, were used to help determine the size of sample plots. 200 m^2 was found to be an acceptable size for sampling ground-cover vegetation. 10 x 20-m plots were used to sample ecosystem types. A stratified-random system of plot location was used, i.e., the landscape was stratified into our hypothesized ecosystem types and sample plots established randomly within the types. A 5 x 20-m strip in the center of the plot was used to determine the coverage of ground-cover species. We attempted to determine the species and size (diameter breast height if standing and stump height at 5 cm if the tree was fallen or cut) of all pine trees. All understory species were measured at dbh in the entire plot. A soil pit was dug to about 130 cm and profile characteristics of texture, structure, depth, pH, color, rooting, and % pebbles and cobbles were determined. Soil samples of most horizons were taken for laboratory analysis. A soil auger was used in the bottom of the pit to reach a depth of approximately 4 m below the surface.

Species composition and jack pine density/coverage

Reconnaissance by foot and car revealed an enormous variation in the density of jack pine seedlings. A survey map of seedling density, provided by Bill Jarvis (Huron-Manistee N.F.), proved to be very useful in the density work. Local variation could be extremely great. Also, a marked difference in height of jack pines between the outwash and ice-contact zones, and also within each zone, was observed. To obtain some hard data on variation in jack pine density and height and size of openings, a sampling technique using 50-m^2 plots was developed and applied early in the study in Sections 22 and 12. The results of these data, results of further reconnaissance, and results of the Kirtland's warbler survey led to the decision to study the density and patchiness as a primary objective of the field season.

The finding of the Kirtland's warbler survey in June that 10 of the 14 male birds (71%) had colonized the ice-contact zone, with its relatively tall and dense stands of jack pine, suggested strongly that the stand structure and height of jack pines, rather than ground-cover vegetation, was a primary reason for colonization. Thus, further jack pine density/coverage reconnaissance and surveys (using 50-m^2 plots) were conducted. In June, four sections (in T25N, R3E) were identified as ones for the low-level photography that would help determine patchiness of jack pine over a relatively large area. However, we were unable to accomplish this objective. Using the results of the 50-m^2-plot surveys and our reconnaissance, we developed a plot sampling technique to sample three broad classes of jack pine density in the outwash and ice-contact zones. The classes are: low or sparse (0-18% coverage), medium (19-32%), and high or dense (over 32%). Because of the patchy nature of jack pine regeneration, very few areas 10 x 20-m in size have a coverage over 32%. The 10 x 20-m density plots were designed so they could also serve as ecosystem plots. A soil pit was not dug, but the soil profile was described by a single auger boring. The following data was taken on the density plots:

a) number of jack pine seedlings in each of the 8, 5 x 5-m^2 subplots of a 10 x 20-m plot.

b) the height class (at end of 1985 growing season = 1986 whorl) of all jack pines within subplots (classes: (1) less than 50 cm, (2) 50-100 cm, (3) 100-150 cm, (4) 150-200 cm, (5) 200-250 cm).

c) salvage status.

d) openness class (sparse, medium, dense).

e) size of the largest opening adjacent to any corner of the plot.

f) notes on patchiness.

g) data on 10 sample trees in two, 5 x 5-m^2 subplots; one plot was randomly selected at the north end of the main plot and one plot was randomly selected at the south end of the main plot. The following information was taken on the 10 trees nearest the plot stake:

(1) age.

(2) height (cm) at 1986 whorl (through the 1985 growing season).

(3) stem diameter at 15 cm above ground line.

(4) dbh if over 1.3-m tall.

(5) height (cm) of lowest branch above ground line.

(6) crown diameter (cm) at widest point (2 readings perpendicular to each other).

h) The following data were taken on the tree tallest jack pines in each subplot: height (cm) at each yearly whorl (1986, 1985, 1984, 1983, etc.); length (cm) of 4 main branches by whorl (1986, 1985, 1984, etc.); vertical distance between proximal and distal ends of 4 branches.

i) diameter stump height or breast height of each stump or snag.

j) number of northern pin oak clones and number of ramets (sprouts) per clone.

k) number of northern pin oak seedlings.

l) height (m) of tallest oak stem.

m) percent coverage of jack pine, northern pin oak, oak plus pine, other species.

n) coverage of all ground-cover species in the two randomly selected 5 x 5-m subplots.

o) average height of all ground-cover species in 2 randomly selected 1 x 1-m plots in each subplot.

Within the outwash zone small depressions with trapped air drainage proved to have different vegetation than adjacent uplands. In particular, northern pin oak was conspicuously lacking, jack pines were small, and their current leaders were damaged (deformed or killed) by frost. Following the major frost on May 19, the northern pin oak clones surrounding depressions were severely damaged -- all new foliage killed on many plants. In addition, serviceberry (*Amelanchier* spp.) and snowberry (*Symphoricarpas albus* (L.) Blake) were typically present to common in depressions but often absent or infrequent in the adjacent uplands. Serviceberry is one of the first shrubs/trees to flower and flush leaves in the spring and thus known to be highly resistant to frost.

Maximum-minimum thermometers were set up in shallow and deep depressions and on uplands adjacent to each depression. Minimums were always lower and maximums were always higher in the depressions than on the adjacent uplands. Below freezing temperatures were found in June, July, and August, even in the shallow depression (4.2 m below the upland).

Soil sampling and use of soil auger showed that the soils of the uplands and adjacent depressions were not different, except that some of the depressions were subirrigated. However, this moisture was at depths below the rooting zone of the ground-cover, and probably most of the young pines as well. Thus, widespread ecosystem types were identified in the outwash zone -- uplands and depressions with trapped air drainage. They differ primarily in physiography and microclimate and secondarily in vegetation.

Results and Discussion

Ecosystem types

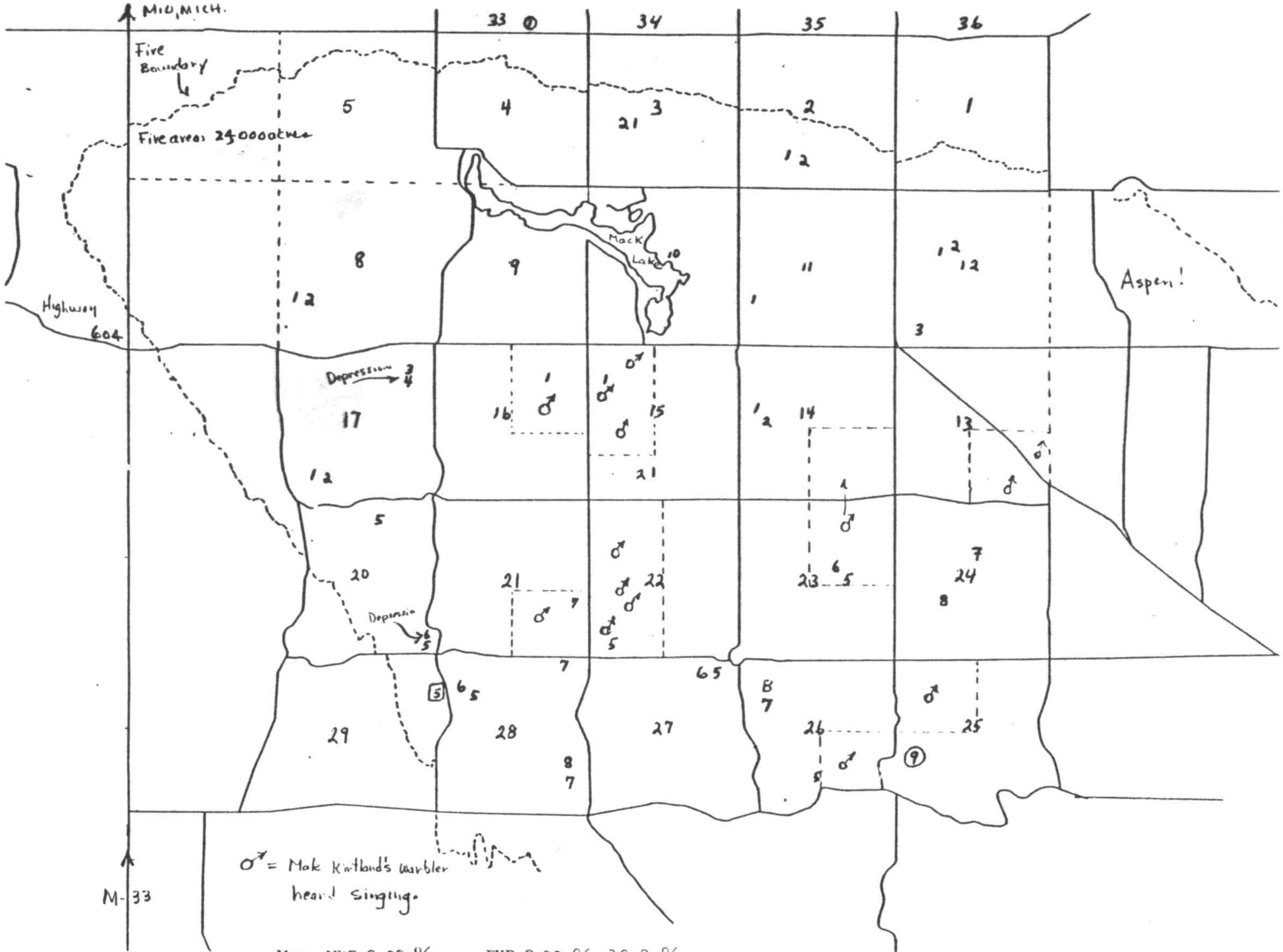
Forty-four, 10 x 20-m ecosystem plots were established and sampled. Thirty-eight of these plots also served as density plots. The location of ecosystem plots (by ecosystem type) is shown in Fig. 1. In addition, eight density plots were established and sampled. The ecosystem classification, based on field work through August, is presented in Table 1. Ecosystem unit 1 is broadly conceived as flat to gently sloping land occupying much of the outwash zone. Its soils are highly variable but in general are of sand texture with rapid drainage (excessively drained) and low nutrient status. Ecosystem 2 is a topographic unit in frost pockets -- primarily in trapped-drainage depressions. The soil is similar to that of Unit 1.

Ecosystems 3 and 4 are localized areas where a clay layer perches the water table at or below 2 meters. Unit 3 is on the upland and has substantial coverage of northern pin oak, whereas Unit 4 is found in depressions with oak absent.

The physiography of ecosystems in the outwash zone is flat to gently sloping (0 to 8%), rarely with moderate or steep slopes. Wet-mesic to wet ecosystems near and surrounding Mack Lake were noted but not included. Time constraints dictated that we concentrate on jack pine-dominated lands.

The soils encountered in most of the outwash zone (Units 1 and 2) were primarily deep sands. The upper 1-2 m are very high in sand content -- being rather thoroughly rinsed of silt and clay particles in the glacial outwash streams. Particle-size analyses show that percent sand typically ranges from 92-100%. Bands of pebbles occur at various depths such that the soils are highly variable over short distances. pH is typically strongly acidic in the E and B horizons and often becomes circumneutral between 3 and 4 meters.

Small bands of calcareous clay, gravel, and sand may occur sporadically below 2-3 meters. We hypothesize that northern pin oak roots can tap these sources of water and nutrients more easily than jack pine. As the root system of jack pines grows deeper with increasing age the pines also benefit from this water and nutrient source and may exhibit faster growth in such areas. Further research is necessary to determine if a new ecosystem type should be described for such sites. We did not observe any ground-cover plants indicating increased moisture or nutrients at this depth.



Map: MPB 9-22-86 BVB 9-23-86, 12-9-86

Fig 1. MAP OF PART OF THE MACK LAKE BURN AREA, OSCODA, CO., MICHIGAN.

Location of landscape ecosystems are shown together with the approximate location of singing, male Kirtland's warblers.

Table 1. Ecosystem type classification (second approximation, August 1986).

A. Outwash Plain. Flat to gently sloping terrain with shallow depressions (typically less than 6 m).

1. Deep sand in uplands on flat to gently sloping terrain. Jack pine with some northern pin oak.

2. Deep sand in depressions (frost pockets with trapped drainage) on flat to gently sloping terrain. Jack pine damaged (slow growth) by frost; no oak.

3. Sand over silty clay loam or clay loam (at 2 m or below) on flats, upper slopes, and low ridges. Jack pine and abundant northern pin oak.

4. Sand over silty clay loam or clay loam (at 2 m or below) in depressions. Jack pine damaged (slow growth) by frost; no oak.

B. Ice-Contact Terrain. Hilly topography with moderately steep to steep slopes and relatively deep depressions (frost pockets, over 6 m deep). Sand to sandy loam (rarely loam) textured soil with gravel or clay (typically calcareous gravel and clay) bands above or below 2 m.

5. Deep sand to loamy sand topsoil on all slope percents and slope positions except depressions. Field kit pH is typically 7.0 to 8.0 at 2-3 meters or below. Jack pine and northern pin oak.

6. Same as Unit 5 except in deep depressions (greater than 6 m). Similar range of soils as #5. Jack pine but no oak. Jack pine may show frost damage.

7. Loamy sand to sandy loam topsoil on all slope percents and slope positions except depressions. Field kit pH is typically 7.0-8.0 at 2 m or above. Few to many bands of gravel, and/or bands of silty clay loam to clay. Jack pine, northern pin oak, bigtooth aspen.

8. Same as Unit 7 but in deep depressions (greater than 6 m). Jack pine but no oak or bigtooth aspen. Jack pine may show frost damage.

9. Loamy sand/sandy loam topsoil with cobbles on flat-topped kamic ridge (only known in T25N, R3E; Section 25). Red oak, northern pin oak, red maple, bigtooth aspen.

Notes

1. Ecosystems 1 and 2 are typically "poor" quality (low moisture, low nutrients) outwash units.

2. Ecosystems 3 and 4 are slightly better in site quality than 1 and 2 due to clay bands.

3. Ecosystems 2 and 4 are frost pockets -- either trapped drainage in shallow depressions or deeper depressions where air may move slowly.

4. Ecosystems 5 and 6 are "poor" quality ice-contact units. They are analogous to Ecosystems 1 and 2 in outwash terrain but may have slightly better soil moisture and nutrient conditions because of slightly heavier soil textures in the top soil (upper 2 m).

5. Ecosystems 7 and 8 are "relatively good" quality ice-contact units.

6. Ecosystems with topographic, soil, and microclimatic conditions similar to Units 5 and 6 also appear to occur in the outwash area.

The boundary between the outwash and ice-contact zones has not been fixed and requires further study. A transition zone is identified between the 1200' and 1250' contours. Generally, three tiers of sections in T25N, R3E -- 1-5, 12-8, and 13-17 -- are the heart of the outwash zone. South of the lower tier, at elevations above about 1230-1250 feet, hilly ice-contact terrain with abrupt slopes predominates. However, relatively level outwash (tops of ridges) occurs at elevations of 1220-1240' in Sections 26, 27, and 28. South of these sections (25-29) the terrain becomes very dissected and hardwood forests (primarily aspens [bigtooth aspen and trembling aspen, P. tremuloides Michx.], red oak, and red maple) prevail, and jack pine is rare or absent.

In the ice-contact zone, hilly topography predominates, yet broad flats (apparently outwash) may also occur. Soil texture becomes heavier toward the south -- loamy sands and sandy loams in the E and B horizons. Ecosystem Units 5 and 6 (upland and depression) are the sandier units (sands to loamy sands) of the ice-contact zone -- analogous to Units 1 and 2 in the outwash. Units 7 and 8 (upland and depression) are distinguished by topsoil of somewhat heavier textures (loamy sand-sandy loam). Particle-size analyses to date bear out these generalizations.

Ecosystem 9 is a distinctive kamic ridge (T25N, R3E; Section 25) of more fertile soil supporting red oak, red maple, bigtooth aspen, and upland pin oak. As heavier soils and more dissected terrain predominate toward the south, jack pine is outcompeted by hardwoods. Lack of frequent, intense fires may be the primary reason for lack of jack pine. We did not attempt to identify ecosystems in these areas where jack pine was rare or absent except for ecosystem 9 which is surrounded by an area supporting abundant jack pine.

Soils of ecosystems 5-8 appears to have more gravel and clay bands between 2 and 4 meters than those in the outwash zone. pH values tend to be higher at a given depth. However, exceptions occur (for example, ecosystems 3 and 4 in the outwash zone), and more work needs to be done to characterize the correspondence of topography, soil conditions, occurrence of northern pin oak, and the height of jack pine seedlings.

Typically, it appears that the more dense and taller jack pines are in the ice-contact zone. However, there are exceptions. Local soil and stand differences probably explain the moderate to high jack pine coverage and the relatively tall pines in portions of Sections 15 and 16 in the outwash zone where Kirtland's warblers have colonized (Fig. 1).

Northern pin oak appears to be more prevalent in the ice-contact zone, but data are not yet available.

Jack pine density and coverage

Data is being compiled from 38 density plots, taken in low, medium, and high density stands. Both density (number of stems per unit area) and coverage (% of the area covered by jack pine foliage) are extremely variable over very short distances. In some areas, salvage operations may have eliminated a great deal of pine regeneration. Observations bear this out in several localities. However, we have yet to demonstrate this conclusively.

Two surveys, using 50-m^2 plots, gave the following results. In Section 12, 6 plots in salvaged and 6 plots in unsalvaged areas were sampled. An average of 11.6 trees were found per plot (939 trees per acre) on the salvaged plots, whereas 16.3 trees were found on unsalvaged plots (1,319 trees per acre). In Section 22, 10 salvaged and 10 unsalvaged plots were sampled. An average of 59.9 trees (4,848 trees per acre) were found on the salvaged plots, whereas 51.2 trees per plot (4,144 trees per acre) were found in unsalvaged plots.

A comparison of number of trees in all 50-m^2 salvage plots (18) vs. all unsalvaged plots (34) shows that there are slightly more trees in unsalvaged plots (46.6 or 3,772 trees per acre) than in salvaged plots (41.9 or 3,391 trees per acre). However, we did not sample the most devastated, machine-salvaged areas. Because of the extreme variation in density per plot (0 vs. 361 trees in 50-m^2 plots), many plots would need to be sampled to test the null hypothesis of no difference between salvaged and unsalvaged areas. However, the effects of the large-scale, machine salvage operations are confounded by the composition and density of the pre-burn stand. The number and size of jack pines present before the fire needs to be determined. Also, red pines (*Pinus resinosa* Ait.) in the jack pine stand may have markedly affected the regeneration of jack pine. These factors need more study.

The highest densities were found in the ice-contact zone. The range of densities for all 200-m^2 plots is 17 to 2,026 trees per plot (344 to 40,996 trees per acre). The range of densities for 50-m^2 plots is 0 to 361 trees per plot (0 to 29,219 trees per acre). The highest density for 25-m^2 subplots of 10 x 20-m plots is 385 trees per plot (62,324 trees per acre), and the highest density for two adjacent 25-m^2 subplots is 731 trees or 59,167 trees per acre.

Colonization by the Kirtland's warbler appears to be primarily in areas of medium to high coverage (over 20%), moderate to high density, and relatively tall trees. Because we do not know the nest sites of the warblers, it is difficult to determine whether tree coverage, density, or height is most important -- or what combination of these factors is most important. There appears to be a relatively strong relationship (negative power function) between jack pine density and the size of the largest opening adjacent to the sample plot.

Additional Studies

Further studies are needed to better define the ecosystem types, and the characteristics of areas colonized by the warblers. The inability to sample areas occupied by the warblers in June and July is a problem. It is especially difficult in determining the occurrence and coverage of ground vegetation. The vegetation is not well developed in May (coverage underestimated) and by August coverage of many species is difficult or impossible to estimate. Thus, primary attention will necessarily be given to the physical factors of ecosystems and the stand structure of jack pine and northern pin oak.

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