Development of an Ecological Classification System for the Wayne National Forest[1]

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Abstract: In 1991, a collaborative research project was initiated to create an ecological classification system for the Wayne National Forest of southeastern Ohio. The work focuses on the ecological land type (ELT) level of ecosystem classification. The most common ELTs are being identified and described using information from intensive field sampling and multivariate data analyses. The tentative ELT classification developed as a first approximation for Athens Unit (about one third of the entire forest) includes 17 ecological units defined by their slope position, steepness, aspect, and landform. A total of 62 relatively undisturbed, mature (> 70 years old) forest ecosystems have been sampled. Most ELTs are dominated by mixed forests of white oak (*Quercus alba* L.), northern red oak (*Q. rubra* L.), black oak (*Q. velutina* Lam.), shagbark hickory (*Carya ovata* (Mill.) K. Koch), sugar maple (*Acer saccharum* Marsh.), and yellow—poplar (*Liriodendron tulipifera* L.). Two of the ELTs are bottomland units. Ultimately, the functional relationships between climate, geology, physiography, soils, and vegetation (both herbaceous and woody) on all three units of the national forest will be separately and quantitatively investigated.

INTRODUCTION

The majority of Ohio's forestland is found in the southeastern part of the state. In this region, the dominant tree species are oaks, hickories, yellow-poplar, and maples. These forests are a very valuable natural resource. For instance, oak acorns are an extremely important food item for white-tail deer, wild turkey, and many other animal and bird species. These forests are also utilized by many recreational users, including hunters, bird watchers, and other outdoor enthusiasts.

A large proportion (42%) of the forest stands in southeastern Ohio are mature (Redett et al. 1982). It is becoming increasingly important for the stewards of these forests to base their management decisions on an ecosystem perspective (Brooks and Grant 1992). Research in the problem area of ecosystem classification and analysis is considered a high priority (Buckman and Loftus 1985, Sesco 1990, Gordon 1990). It is important to begin the necessary research to provide this information since only very limited research related to this subject has been accomplished.

On June 1, 1991, a collaborative project was initiated to create an ecological classification system for the Wayne National Forest of southeastern Ohio. The purpose is to identify the major forested ecological land types (ELTs) of southeastern Ohio. These ELTS will be assemblages of landscape ecosystems (Barnes et al. 1982, Barnes 1986) that are similar in physiography (landform), soil, and

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vegetation. These ELTs also have similar silvicultural potential, such as choices of species and cultural practices, and they have predictable pathways or patterns of early successional dynamics (Host et al. 1987, Hix and Lorimer 1991). Multi-factor ecological classification systems have been developed for other nearby regions (e.g., Cleland et al. 1985, Hix 1988, Archambault and Barnes 1990).

STUDY AREA

The Wayne National Forest is located in southeastern Ohio (Figure 1). It lies within the Unglaciated Allegheny Plateau physiographic region (Fenneman 1938). The landscape is a strongly dissected upland, characterized by hilly terrain, steep winding valleys, and outcroppings of bed-rock. Because of the differences in terrain compared with the glaciated portion of the state, this distinct region is often called the "Hill Country" (Lafferty 1979).

Figure 1.—The Wayne National Forest presently includes 205,000 acres in three units.

Most stands in southeastern Ohio are not the presettlement forests, i.e., they have been harvested one or more times since settlement by European immigrants in the 1800s (Gordon 1969). The history and management of many stands are known since the 1940s (Kincaid 1982). Many stands are of sprout-origin, having been established after clearcutting approximately 80-120 years ago (Ducey 1982). The area is part of the mixed mesophytic forest region delineated by Braun (1950). Gordon (1969) describes the original vegetation types of the area as mixed oak, mixed mesophytic, and beech forests. Presently, the two major forest type groups are oak-hickory and Appalachian mixed hardwoods (cove hardwoods). Appalachian mixed hardwoods includes the Society of American Foresters' cover types of yellow-poplar-white oak-northern red oak and yellow—poplar, while oak-hickory includes white oak-black oak-northern red oak, white oak, and black oak (Eyre 1980).

METHODS

The development of the ecological classification system (ECS) will be an iterative process composed of several steps in a repetitive sequence (Figure 2). Reconnaissance is not only done in the field; much useful information is available from the literature and from published maps and reports. Sampling is necessary during several field seasons to develop the several approximations of the

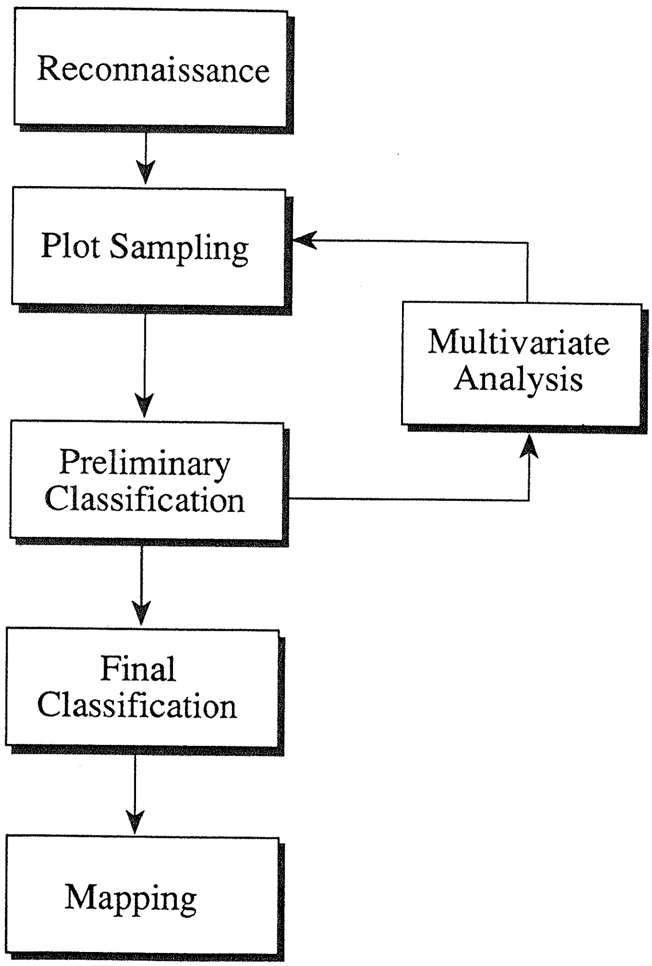

Figure 2.—Model of the system being used to develop the ecological classification system.

classification. Multivariate analyses will be used to corroborate the ECS. Finally, field mapping will be a possibility once the final classification has been developed.

A tentative ecological land type classification (Table 1) was used as the basis for stratifying the sampling during this first field season. This system is based primarily on physiography. The factors that are integrated include landform, slope of the terrain, aspect, and slope position. Most of the ELTs are uplands, but two types of bottomland ELTs were also proposed. Within this system, we also carefully consider the soil type, i.e., loess, colluvium, etc., and the interrelationships between physiography and soils. Relationships between the vegetation and the physiography and soils will be then studied. Old road maps and aerial photographs are often checked to determine the past use and history of an area.

The following criteria were used for identifying acceptable areas for sampling:

(1) living trees (> 10 cm dbh) are mature (at least 70 years old);
(2) no evidence of major disturbance by human beings within the last ,40 years (e.g., no stumps in plot, no underplanting);
(3) a minimum size of 0.4 ha (1.0 acre);
(4) a general absence of early successional species;
(5) no evidence of recent fire, windthrow, or unexplainable mortality;
(6) stand is "fully stocked";
(7) no extensive (multiple-tree) gaps in the canopy; and
(8) area is not an old field or old—pasture.

These criteria are similar to those being used to develop an ecological classification system for the Hoosier National Forest of southern Indiana
(Van Kley and Parker 1991).

Sampling Design

The USDA Forest Service database (Vegetative Management Information System) was searched for potential field sites, and lists of stands meeting the minimum criteria for stand age were created. Reconnaissance in the field permits the selection of areas apparently suitable for sampling. Cultural resource surveys are completed on these stands by the Forest Service before sampling.

Locations for sampling were randomly selected from the pool of qualified stands in the VMIS database. The goal was to select at least four areas for sampling from each type or stratum in the tentative Ecological Land Type classification system (Table 1). Within each representative stand, at least two sample plots were located.

First, a sketch map was drawn of each homogeneous area within a stand to be sampled. On this drawing, lines were added that divided each area into two parts approximately equal in size. These lines were the longest lines possible across the area parallel to the slope. The first plot was located at least 20 m from the start of the transect line; subsequent plots were located at least 30 m apart.

Table 1.—Tentative Ecological Land Type classification system and sample size for each tentative ELT

	Number of homogeneous areas	Number of plots
UPLANDS		
Level to gently sloping terrain (0-15%)		
1. Broad summits		
2. Narrow ridgetops	3	8
3. Benches	2	4
Moderately to steeply sloping terrain (16-30%) Northerly aspects (316°-135°)		
4. Upper slopes	2	5
5. Middles slopes	2	4
6. Lower slopes	1	2
Southerly aspects (136°-315°)		
7. Upper slopes	3	7
8. Middle slopes	5	10
9. Lower slopes	1	2
Very steeply sloping terrain (> 30%) Northerly aspects (316°-135°)		
10. Upper slopes		
11. Middle slopes	2	4
12. Lower slopes		
Southerly aspects (136°-315°)		
13. Upper slopes		
14. Middle slopes	1	2
15. Lower slopes	1	2
BOTTOMLANDS		
16. Narrow coves and ravines	4	8
17. Broad valleys	2	4

A sample "plot" consisted of a set of two nested, concentric, circular sub-plots (sizes = 500 m^2 and 100 m^2), and eight rectangular 1- by-2 m sub-sub-plots or quadrats (Figure 3). The centers of the quadrats were located 2 m beyond the outside edge of the 100 m^2 sub-plot in each cardinal direction. If a plot center coincided with a tree trunk or other obstruction, the plot center was extended by 2 m.

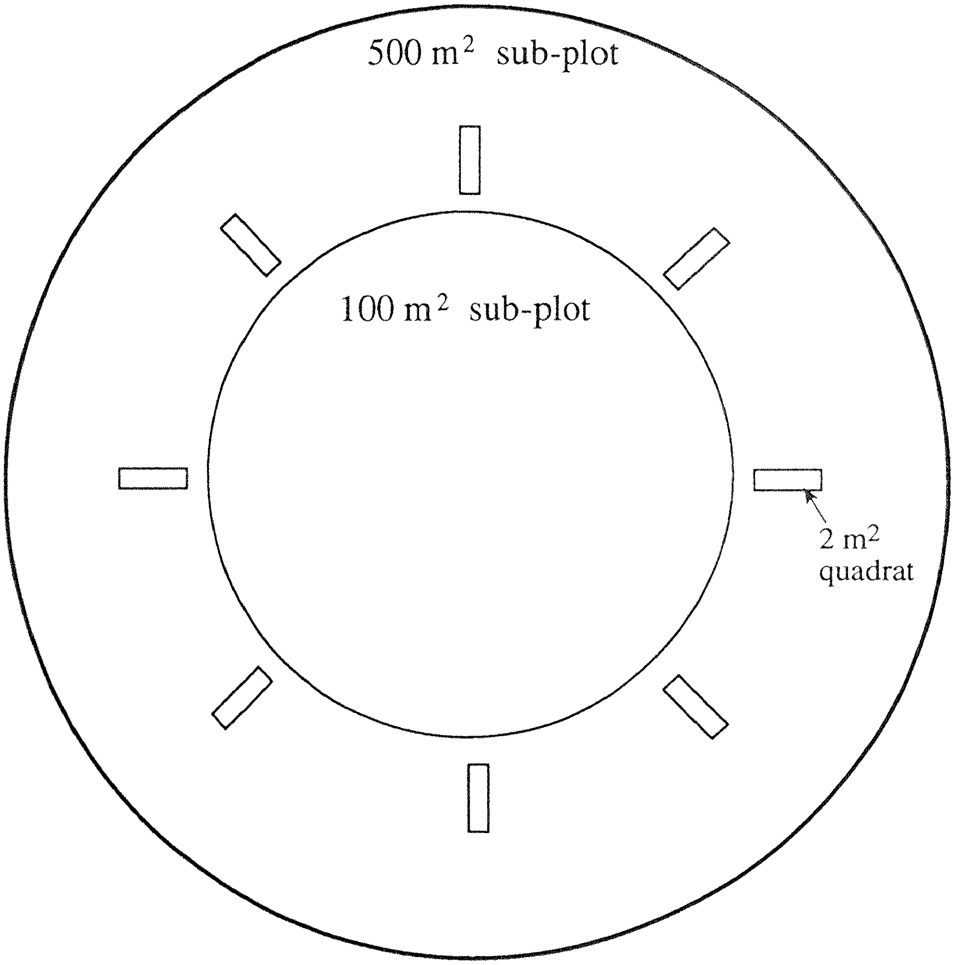

Figure 3.—Plot design being used for sampling of the vegetation.

Vegetation

Woody plants of different sizes were tallied in each plot:

Plot size	Size of individuals and Procedures
500 m^2	Living trees > 10 cm dbh were tallied by species.
100 m^2	Living saplings were tallied by species and dbh class: 0.1-5.0 cm or 5.1-10.0 cm.
2 m^2	Living seedlings were tallied by species and height class: 0.1-30.0 cm, 30.1-100.0 cm, or 100.1-136.0 cm. Sprouts upon woody plant stems were not included as separate individual seedlings.

In addition, the ground cover (up to 1 m in height) of seedlings, shrubs, vines, and herbs was sampled by species in each quadrat. The portion of a plant was included in the rating if that portion overhung the boundary, even if the plant was rooted outside the quadrat. Coverage was estimated visually, but a meter stick was used frequently in the estimations. The following cover classification system was used to measure the importance of each species:

Cover class code	Percent coverage
1	< 1
2	1-5
3	6-10
4	11-20
5	21-40
6	41-70
7	71-100

In each sampling unit, a list of the herbaceous species encountered on a random walk through the area, but not present in any of the quadrats on the plots, was compiled. Thus, a species presence list has been provided for the entire homogeneous area. If the occurrence of a particular species seemed to be related to some stand disturbance or other factor (e.g., unusual microenvironment like a rock outcropping), the distance and direction of that plant species from the disturbance was documented on a special form.

Voucher specimens were collected for every new species, species of uncertain identity, and species from unusual habitats, except when collecting would have eliminated a local population. All of the approximately 1000 specimens collected during the 1992 field season are being checked for proper identification as a means for assuring the overall quality of our final species identifications. Approximately 40% of the specimens are of grass or sedge species. The assistant curator of the Miami University Herbarium is cooperating in the verification of species identifications.

Physiography

The landform, percent slope, aspect, slope position, length of slope, distance to any surface water bodies, slope shape, distance from ridge, and nature of the general topography were all observed and (or) measured in the field. The following classes for landform were used: summit or level upland, hillslope, bench, and small protected valley or ravine. The elevation of each plot was estimated from a topographic map. Finally, schematic cross sections of each plot were drawn on the plot form.

Soils

The soils of each plot were examined in detail. First, points were located along the contour, one on each side of plot center at the perimeter of the 100 m^2 plot. Then, a second pair of points were similarly located, one on each side of plot center along an imaginary line running perpendicular to the contour through plot center. At these points, a soil-sampling tube was used to obtain profiles which were described and recorded.

A soil pit was excavated in the first plot of each transect at a point representative of the entire plot. It was dug just outside of the nearest quadrat, with the long axis of the pit parallel to the contour. A full profile description was taken from the uphill face of the pit. Bulk samples were collected and bagged from each horizon. After air-drying, each sample will be analyzed to determine textural class and selected chemical and physical properties. A sample was taken with a bucket auger through the pit floor to determine (if possible) the depth to hard bedrock. If the second or third plot along a transect appeared to be underlain by different soils than the first plot, a pit was also installed there and the soil profile was carefully and fully characterized, and samples were collected.

RESULTS AND DISCUSSION

Sample Size

From early June to mid-September, 22 areas were sampled for a total of 48 plots (Table 1). On an additional 14 plots (two each from 7 areas), only the woody vegetation and the physiography were measured; ground cover and soils will be examined during the next field season.

Climate

The Wayne National Forest is located in three separate geographic areas of southeastern Ohio (Figure 1). The Ironton Unit is found the farthest south of the three units, while the Marietta Unit is the farthest east. An analysis of the differences in macroclimate is yet to be completed. It will be important to determine if any distinct gradients in factors such as precipitation exist within the study area. For this reason, separate classifications will be developed for each unit, unless it is determined that some of the units are similar enough in climate to be grouped together.

Geology, Physiography, and Soils

At present, a total of 23 soil pits have been excavated and described, and soil characterizations have been made for forty-four other plots. The written descriptions have been edited and entered into a computer database.

A USDA Soil Conservation Service soil scientist verified a subset of the soil pits. He explained important soil-landscape relationships, such as the difference between the soils developed in loess, and the majority of the soils which either developed in colluvium or alluvium.

An ODNR Geological Survey Division geologist also has visited some of the soil pits to help us interpret certain aspects of the surficial geology. In general, the bedrock of the Athens and Ironton Units is non-calcareous shales and sandstones, while the Marietta Unit is underlain by calcareous shales and limestones. Some local areas such as ridgetops in the Athens Unit possess calcareous soils, and certain characteristic species have been found at these locations.

Vegetation

The overstory (stems > 10 cm dbh) on forty-six plots has been summarized (Table 2). For this presentation, the ELTs were grouped into four categories: narrow ridgetops, hillslopes with northerly aspects, hillslopes with southerly aspects, and narrow coves and ravines. For each species, the average importance value was computed, by averaging its relative density and relative basal area on plots of each group.

Table 2.—Average importance values for overstory tree species of four groupings of tentative ELTs

Species	Narrow ridgetops	Northerly aspects	Southerly aspects	Narrow coves and ravines
Acer rubrum	1.9	3.8	8.0	1.3
A. saccharum		6.9	3.9	9.3
Aesculus octandra	7.1	2.9	0.1	4.0
Carya glabra	2.1	2.0	5.2	1.0
C. ovata	8.9	2.5	1.8	
Fagus grandifolia		2.7	5.4	
Fraxinus americana	1.0	4.1	1.6	4.3
Juglans nigra		4.3		
Liriodendron tulipifera		6.8	5.1	6.8
Quercus alba	18.2	21.8	23.3	50.7
Q. coccinea	18.5	1.1	9.9	
Q. muehlenbergii		7.3		
Q. prinus	16.6	1.5	5.6	
Q. rubra	1.4	12.0	12.3	13.8
Q. velutina	19.2	3.5	9.9	2.8
Ulmus rubra	1.9	5.0	0.6	
Number of plots	8	11	21	6

For all four groups, at least one of the oaks was the most common species (Table 2). White oak dominates the overstory in the narrow coves and ravines. It is also the most common species on hillslopes of both north and south aspects (where all slope positions have been combined). On northerly aspects, northern red oak is a common associate, along with sugar maple. Two species unique in this sample to northerly aspects are chinquapin oak (*Quercus muehlenbergii* Engelm.) and black walnut (*Juglans nigra* L.). On southerly aspects, black oak and scarlet oak (*Quercus coccinea* Muenchh.) are common, as is red maple (*Acer rubrum* L.). Narrow ridgetops are heavily dominated by oaks (black, chestnut (*Quercus prinus* L.), white, and scarlet and shagbark hickory Further analyses of the vegetation, and the inter-relationships of all the major ecosystem components, are in progress.

Data Quality

Quality control and assurance are an important aspect of the project. During autumn, a subsample of the 500- and 100 m^2-plots were independently remeasured to identify errors in species identification, tree measurements, or physiographic data. During in the next field season, a subsample of quadrats will be remeasured to determine the variability in cover estimates.

CONCLUSIONS

This five-year study is scheduled to end in 1995. The ecological classification system for the forest, and those for the three units separately, will be finalized by 1994. Stands on all three units will then be sampled for verification of the classifications. Interpretations and descriptions of the ELTs will be prepared, and Forest Service personnel will be trained in the use of the system.

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