Mapping Soils, Vegetation, and Landforms: An Integrative Physical Geography Field Experience*

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Students in a graduate seminar at Michigan State University produced a series of detailed vegetation, soils, and landform maps of a 1.5-square-mile (3.9 km^2) study area in southwest Lower Michigan. The learning outcomes (maps) and skill development objectives (sampling strategies and various GIS applications) of this field-intensive mapping experience were driven by the assumption that students learn and understand relationships among physical landscape variables better by mapping them than they would in a classroom-based experience. The group-based, problem-solving format was also intended to foster collaboration and camaraderie. The study area lies within a complex, interlobate moraine. Fieldwork involved mapping in groups of two or three, as well as soil and vegetation sampling. Spatial data products assembled and used in the project included topographic maps, a digital elevation model (DEM), aerial photographs, and NRCS (National Resource Conservation Service) soil maps. Most of the soils are dry and sandy, with the main differentiating characteristic being the amount of, and depth to, subsurface clay bands (lamellae) or gravelly zones. The presettlement (early 1830s) vegetation of the area was oak forest, oak savanna, and black oak "barrens." Upland sites currently support closed forests of white, black, and red oak, with a red maple, dogwood, and sassafras understory. Ecological data suggest that these oak forests will, barring major disturbance, become increasingly dominated by red maple. This group-based, problem-solving approach to physical geography education has several advantages over traditional classroom-based teaching and could also be successfully applied in other, field-related disciplines. **Key Words: pedagogy, fieldwork, mapping, problem-based learning, vegetation.**

Introduction

Partly to foster collaboration and camaraderie and partly to apply a problem-solving approach to the teaching of physical geography (Maguire and Edmondson 2001), eight graduate students at Michigan State University mapped a complex, 1.5-square-mile (3.9 km^2) area, as part of the requirements for a graduate-level course (Geography 871: Seminar in Physical Geography). Geography 871 is designed to provide an integrative field experience within the realm of physical geography, but the group-oriented, largely field-based approach used for this particular offering was novel. We report on the efficacy and utility, advantages, and shortcomings of this group-effort mapping project. In so doing, the article provides information to educators, especially those in geography, geology, soil science, and ecology, who are seeking an integrative and field-oriented learning experience. We assumed that mapping the soils, vegetation, and landforms of a complex area would engender a number of learning outcomes as well as accentuate long-term retention of data and concepts.

Geographers have a long history of working and learning integratively in the field and from each other (Sauer 1956; Bolton and Newbury 1967; Healey et al. 1996; Kent, Gilbertson, and Hunt 1997; Pawson and Teather 2002). Students benefit from fieldwork because their understanding of a subject is deepened as theory and practice become integrated (Haigh and Gold 1993). Because in the field they are active participants in the learning process, students become more empowered concerning the

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subject matter and the learning experience becomes more meaningful (Simm and David 2002). This, in turn, increasingly motivates them toward academic inquiry and encourages the development of independent research skills (Walcott 1999).

Unlike other fieldwork-related class projects in geography that are research or hypothesis-testing endeavors per se, we viewed our project primarily as a mapping exercise. The course goal was to make a series of large-scale maps, accompanied by a research report/paper outlining the physical characteristics of the landscape, focusing mainly on the landforms, soils, and vegetation. In this follow-up article, we outline our methods and some of the more important results for the study area—a small, representative parcel in the southwest Michigan interlobate moraine in the Barry State Game Area, Barry County. Information on this area, especially in the detail with which we report it, is scarce. Although many midwestern landscapes are often perceived of as nearly featureless, this Barry County landscape shatters these preconceptions; large amounts of relief, very steep slopes, diverse landforms, and a wide variety of soils are found throughout. Indeed, the definitive characteristic of the study area, and the main reason this particular area was chosen for study, is its high degree of geomorphic and pedogenic complexity. Our findings could be extended to nearby areas and used as a springboard for other, more extensive research on the soils, landforms, and vegetation of complex and unique areas.

Materials and Methods

Prior to entering the field, several lectures were given on the soils, vegetation, and geomorphology of the region and methods were discussed. A number of assigned research papers were also read and discussed in a seminar-type format. A digital elevation model (DEM) of the study area was then generated to help visualize the study area and assist in the all-important field-planning phase of the project (Falk, Martin, and Balling 1978; Warburton and Higgitt 1997). The DEM was created by first scanning sections of the Middleville and Cloverdale 1:24,000 topographic maps, with ten-foot contours, in a Universal Transverse Mercator (UTM) projection (Zone 16 North, Units Meters, NAD1927 datum) at high (1200 dpi) resolution. We georectified this scanned image of Sections 18 and 19 of T3N and R9W using a heads-up process with a resulting RMSE (root mean square error) of three meters, and from this image, the ten-foot contour lines were digitized. We next reprojected all digitized contour lines to match the Michigan GeoRef projection with the NAD 1983 datum. The raster DEM was interpolated from elevation points derived from the nodes of the digitized contour lines. We interpolated by kriging, in which values between points are interpolated by considering the nearest eight points covaried within a circular kernel. Kriging assumes a relationship between distance and variation in elevation and works by fitting a mathematical function to the number of points the method is commanded to consider. It is frequently used for geologic and soils purposes (ESRI 2003). We set the interpolation to output a DEM with a cell resolution of one meter because the study area is only 1.6 × 2.4 km in area. The combined horizontal error in the final DEM, including the accuracy of the source data (which has an accuracy of +/– 6 meters—typical for a USGS topographic quad) and georectification (which has an accuracy of +/– 3 meters), does not exceed ten meters (Lewis et al. 1999).

For the purpose of conducting fieldwork, the class first spent a day in the field with the professor, doing reconnaissance mapping and field-testing the various sampling protocols. Next, the class of eight was divided into groups of two and three. The students had varying topical strengths and backgrounds, with only two being physical geographers. Thus, the makeup of the groups needed to be balanced, with at least one physical geographer (or quasi-physical geographer) in each group, if possible. Group compositions (deliberately) changed as the semester progressed to provide opportunities for different skills—and personality—pairings. Rotating and changing the composition of the field groups also fostered camaraderie and forced the students to learn from each other. Some parts of the analysis, for example, GIS and spreadsheet work, were necessarily delegated to only a subset of the class that had experience in these areas.

In an attempt to conduct reconnaissance research as well as mapping, the groups initially mapped along predetermined, one-mile-long (1.6 km) E-W transects, that were spaced approximately 200 meters apart. Later, after soil and landform patterns had emerged and it had become clear that certain parts of the landscape were more complex than others, field efforts were concentrated in those subregions where initial mapping efforts still had not provided adequate understanding of the soil and vegetation patterns. For example, kettles, rolling upland plains, and the highly kettled upland areas in the southwest part of the study area were reexamined during this second round of mapping. In both cases, soils and vegetation were sampled at relatively regular intervals, at sites that were deemed representative of the surrounding landscape, or when the terrain features changed.

Field data collection primarily consisted of identifying and mapping soils and collecting information on forest vegetation. We used a two-meter auger to sample and classify the soil at each site to series level; no samples were recovered for further lab work. We also used a two-meter, steel-rod probe to measure the thickness of organic materials (O horizons) in Histosol map units. After augering and classifying a site to series level, notes were also recorded on possible competing soil series on that landform; we also annotated the degree of certainty of our soil classification. Vegetation data were quantitatively obtained using the point-quarter sampling method (Cottam and Curtis 1956), and semiquantitatively by noting the vegetation type (dominant and common tree species, approximate age of stand, disturbance indicators, etc.) at each site. Sites were selected for vegetation sampling if they were deemed typical of the larger community; that is, atypical sites and ecotones were avoided. Wetland areas typically did not have a forest cover and were not sampled.

Point-quarter sampling and analysis involved, first, dividing the area around each randomly selected point into four quadrants. We then identified the closest tree (>10 cm dbh) and sapling (>2.5 and <10 cm) in each quadrant to species, using leaf and bark characteristics, and determined the distance to each from the point-center, using a metal tape or an acoustic range finder. For each of the trees, we measured the diameter at breast height (dbh) in cm, to arrive at its basal area (cm^2). Point-quarter vegetation data were next entered into a spreadsheet and various descriptive statistics derived for the trees and saplings, including (1) relative dominance (trees only), (2) relative frequency, (3) relative density, and (4) importance values for each tree species. Relative dominance is calculated as the total basal area for each species divided by the cumulative basal area for all species, and multiplied by 100 (Cottam and Curtis 1956). Large dominance values generally indicate that a species has a large amount of canopy coverage relative to other species. Frequency is the number of sampling points at which a species has occurred, divided by the total number of points sampled. To arrive at relative frequency, the frequency value for each species is divided by the sum of the frequency values for all species and then multiplied by 100. Density refers to the spacing of individual trees. Relative density is calculated as the number of sampled trees of each species, divided by the total number of trees, multiplied by 100. In order to examine contemporary forest dynamics, relative density data for each species were calculated on subsets of the total data set; we split the data set into four basal area intervals: (1) saplings, (2) trees 10–30 cm dbh, (3) trees 31–50 cm dbh, and (4) trees >50 cm dbh. Importance values for each species are arrived at by summing the relative density, dominance, and frequency values and dividing by three.

The location of each soil and/or vegetation sampling point was recorded using a handheld Global Positioning System (GPS) unit. All groups used either point averaging or real–time differential correction, and occasionally both, to mitigate locational errors. Students in the class made fifteen trips to the study area, sampling 289 sites for soils and 136 sites for vegetation.

Coordinates of the soil and vegetation sampling points were input into a GIS to create a point coverage with soil series and vegetation community as attribute data. Soil series labels were overlaid onto the DEM to assist in delineating soil map unit boundaries that had been roughed in in the field. Inclusions of unlike soils were expected in a landscape as complex as this; use of a GIS to identify and locate the types of inclusions was useful in ascertaining the purity of soil map units.

The penultimate soil map, which showed consociations and map unit complexes, was further subdivided based on slope categories. To obtain a slope estimate of each raster cell, we resampled the DEM to a ten-meter resolution using bilinear interpolation and calculated the percent slope from this product. Next, we coarsened the DEM to eliminate discrete but small polygons, as we had set our minimum soil map unit to one acre (0.5 hectares). We then reclassified this DEM into a map of six distinct slope categories, using standard NRCS slope breaks—0–2 percent = A slope, 2–6 percent = B slope, 6–12 percent = C slope, 12–18 percent = D slope, 18–40 percent = E slope, and >40 percent = F slope (Soil Survey Staff 1981)—by visually drawing lines around areas of generally similar slope class. Using this slope map, we were able to break up the soil series map into a map that had discrete soil series and slope units.

A presettlement vegetation map was downloaded from the Michigan Geographic Data Library (http://www.mcgi.state.mi.us/mgdl/) in ArcGIS shapefile format. This map is based on tree data and original descriptions of the forest vegetation by General Land Office (GLO) surveyors, as interpreted by the Michigan Natural Features Inventory (MNFI). The digital map is in Michigan GeoRef projection and was originally drawn at a scale of 1:24,000. We also consulted copies of the original GLO surveyor notes at the State of Michigan Archives, Lansing, and obtained data on witness trees noted by those surveyors, within the study area, from personnel at the MNFI offices in Lansing. Witness tree data were used to generate comparable indices of stand characteristics (relative dominance, relative frequency, relative density, and importance value) for presettlement forests in the study area, as was done for the contemporary forests.

We created a contemporary vegetation (land cover) map by incorporating our field-based data on vegetation characteristics into a heads–up digitizing process on a 1998, leaf-off, false-color air photograph with one-meter resolution, obtained from the Michigan Geographic Data Library. Most of the study area is mature oak-hickory forest, although we were able to delineate small areas of red pine plantation, fields (both grass and corn), open wetlands, and cut-over areas. We also mapped the locations of individual trees, originally sampled by the point-quarter method, in order to ascertain if there are any spatial trends in certain species within the study area. Maps were made for each of the major tree species (white oak, black oak, red oak, red maple, sassafras, hickory, and black cherry). For instance, if both a white oak and a red maple tree were found at a vegetation sample site, the site's location would be plotted on both the white oak species distribution map as well as the red maple species distribution map. In order to ascertain possible temporal-spatial successional trends, we also plotted the distribution of oak and red maple saplings.

Finally, we delineated the major landform regions in a geomorphic map. Landform boundaries were established using data on topography, glacial sediments, and soils. After gaining a general understanding of the terrain, we were able to further delineate landform boundaries by correlating the relief with soil boundaries and the various forms of glacial drift observed.

The penultimate draft of the report was presented, in the field, to two physical geography professors, a NRCS soil mapper who has experience in this area, a representative from the Michigan Geological Survey, and students in an upper-level soils class at MSU, in order to obtain input and hone the results of the research. The written report and field "meeting" formats were patterned after field research conferences, for example, Friends of the Pleistocene.

Results and Discussion

Geomorphology

Thick (31–122 m), coarse-textured glacial drift of Late Wisconsin age is the main influence on topography, soils, and vegetation within the study area (Thoen 1990). Much of the drift is "ice-contact" and stratified, having been deposited within a complex interlobate system associated with the Saginaw and Lake Michigan lobes of the Laurentide glacier (Leverett and Taylor 1915; Folsom 1971; Kehew and Brewer 1992; Albert 1995). The date of final deglaciation of this landscape has not been precisely determined, but, based on correlations from nearby areas, it is likely to have become ice free about 15.5 ka (Kevin Kincare, MI Geol. Survey, conversational personal communication 2003). Beneath the drift are various types of sedimentary rocks associated with the Michigan Basin—mostly sandstone and shale.

The highest part of the interlobate moraine runs northeast–southwest through the study area (Albert 1995; Figure 1). Data from Dworkin, Larson, and Monaghan (1985) suggest that the majority of the sediment in this part of the moraine is from the Lake Michigan lobe, rather than the Saginaw lobe. The largest of all the landform units, this moraine comprises 60 percent of the study area and is highest in elevation and most rugged in its southwest section. The moraine is dominated by well-sorted and often well-stratified sands of varying size, and a small amount of gravel; till is present usually only as a thin (< 2 m) carapace on the sands. Slopes within the moraine are commonly > 15 percent, and on the inner slopes of kettles, they are often near the angle of repose, > 50 percent. The dominance of sand and ice-contact stratified drift within the interlobate moraine attests to the large influence of glaciofluvial, rather than direct glacigenic, processes during the final stages of deglaciation. Sandy loam till, with noticeably more gravel than in the sandy glaciofluvial sediment, occasionally drapes the top edges and inside slopes of the large kettles in the moraine. This till is much more common, and thicker, in the low-relief landscape in the southeast part of the study area, delineated as a ground moraine (Figure 1).

The outwash plain in the northwest part of the study area has low slopes with a few shallow kettles (Figure 1). This landform occupies 19 percent of the study area. Sediment composition is largely well–sorted, medium sand. We

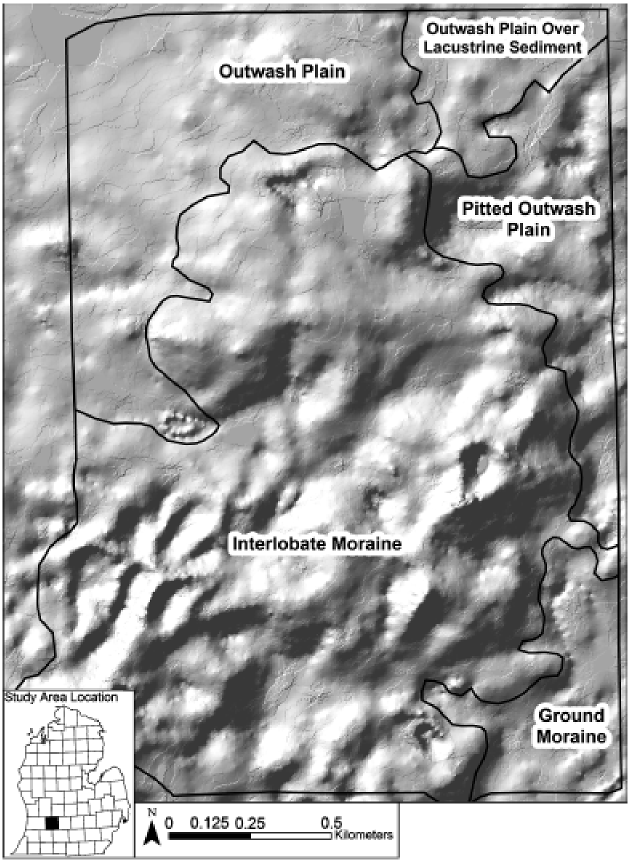

Figure 1 *Color, shaded-relief, digital elevation model (DEM) of the study area with the major landforms delineated. Details on the production of this DEM are provided in the text. Figures 1–3 are all in the Michigan GeoRef projection, NAD 83 datum. The total (local) relief in the 3.9 km^2 study area is 98.6 meters (lowest point: 237.14 m, highest point: 335.76 m).*

recognize that the areas designated as "outwash plain" may simply be low-relief variants of the interlobate moraine.

The entire landscape is variously kettled (Figure 1); most of the kettles are high enough on the landscape so that they do not retain water. The uplands of the interlobate moraine contain several impressive kettles with steep slopes, often exceeding 70 percent. Generally, the kettles slopes are steeper when the sediments immediately below them contain gravel and loamy materials, as opposed to the more gentle slopes of kettles containing only clean, sandy sediment.

In the northeast part of the study area, sand is variously interfingered with (usually overlying) stratified, silty clay sediment that we interpret as glaciolacustrine material (Figure 1). Here, slight depressions on the landscape often retain water, even into summer. Sandy outwash ridges, several meters high, rise above the plain and divide the periodically flooded low spots. These sandy ridges are often distinguished by red pine plantations, planted several decades ago to reduce soil erosion.

Soils

Soils in the study area are generally coarse textured and well drained (Figure 2, Table 1, Thoen 1990; Albert 1995). Only in kettle bottoms and where water is held up (perched) by subsurface clayey sediment is the water table even occasionally within two meters of the surface. Fine and medium sands dominate the soils, especially on outwash landforms and on the interlobate moraine proper.

Upland, sandy soil series were differentiated by the total thickness of, and depth to, lamellae. Plainfield soils lack lamellae, Coloma soils have thin, deep lamellae, and Spinks soils have thicker, shallower lamellae (Table 1). Colonie soils are a fine sand variant of Coloma. These sandy soils are all dominant on the interlobate moraine and on the adjoining outwash surfaces (Figure 2). Tekinink and Marlette soils have formed in sandy loam and loam till, respectively, and because their parent materials have at least 10 percent clay, they exhibit continuous Bt horizons, rather than lamellae. They are found primarily on the ground moraine in the southeast part of the study area, where some are cultivated as wildlife feed plots (Figure 2). Two series, Oshtemo and Boyer, are defined as having layers of sand and gravel within the profile. They are generally associated with kettles and ice stagnation topography. Ithaca and Rimer soils are formed completely or partially in lacustrine sediment, respectively. They are observed in a map unit complex on the lacustrine surface in the northeast part of the study area (Figure 2). Lastly, two Histosol soil series are mapped: Houghton in deep (>50 inches) organic materials and Adrian, where the organic materials are more shallow and overlay sandy sediment. In the study area, these two soils only occur in kettles.

Soil boundaries often followed, and changed at, landform boundaries (Figures 1 and 2). Vegetation—both overstory and ground cover—was also an important indicator of soils. For example, in outwash areas, the presence/absence and thickness of herbaceous ground cover below the oak overstory often indicated that lamellae (clay bands) were near the surface or were present only at great depth. In the outwash areas, soils without lamellae in the top two meters supported only sparsely spaced oaks, whereas soils with thicker and more shallowly placed lamellae had denser forest cover. The reliance of vegetation on sandy soils to landforms, which in turn reflect subtle variations in soils, illustrates how important soil water-holding capacity is on upland, sandy landscapes. Relationships among understory vegetation, overstory vegetation, and soils have been demonstrated elsewhere in sandy parts of Michigan (Host and Pregitzer 1992) and appear to hold here as well.

Our soil map (Figure 2) is, understandably, more complex than the one that is in the published county soil survey (Thoen 1990). Although the talent and experience of the class with regard to soils was varied and we did not have within the group anyone experienced in soil mapping, we were able to spend much more time in the field, in this small area, than the NRCS field mappers were able to. The main similarity between the two maps centered on the dominance of Coloma and Spinks soils on much of the landscape.

Vegetation

Presettlement vegetation in the study area consisted of mixed oak savanna, oak–hickory forest, and black oak barren (Figure 3; Albert 1995). Oak–hickory forest occupied most of the south-

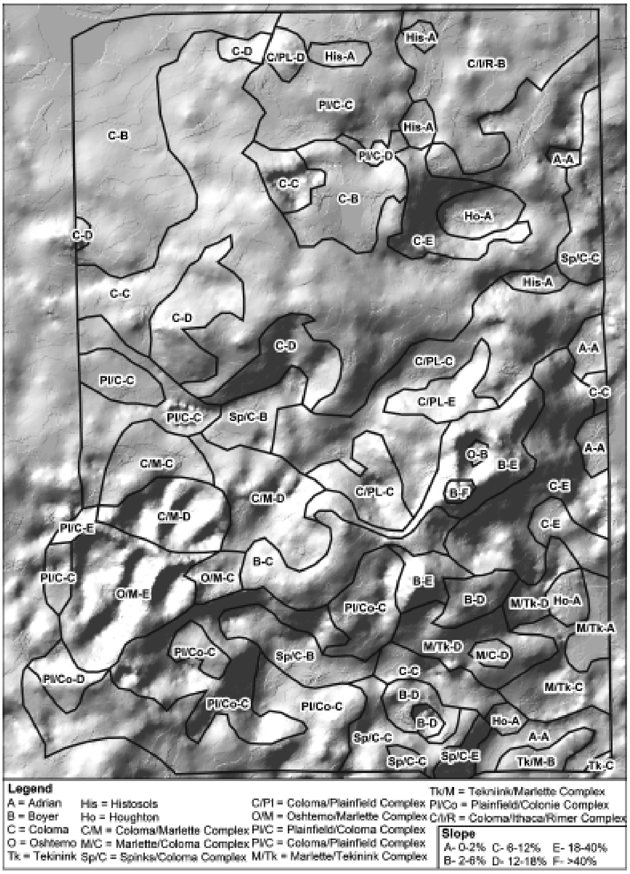

Figure 2 *Color, shaded-relief, digital elevation model (DEM) of the study area showing the soil map unit consociations and complexes.*

east parts of the study area, whereas the more open "barrens" and "savanna" communities dominated the remainder of the landscape. The low density of trees on the presettlement landscape is probably due to frequent fire-related disturbance; areas of open forest or barrens probably had been burned frequently, or at least immediately prior to the survey. The southeast section of the study area might have been less fire prone because of the rugged topography coupled with finer-textured and wetter soils. Fires sweeping into the area from the west would have encountered little topographic resistance in the northern half of the study area; this area was mostly barren of trees at the time of the survey. Witness tree data from GLO survey listed only oak species (white oak, chinquapin oak, and black oak), with white oak as the overwhelmingly dominant species (Table 2). Indeed, in the seven written descriptions of the vegetation along 1.6-km-long transects in or near the study area, oak was the only tree genus mentioned.

Upland forests on dry sites in south–central Lower Michigan generally tend to be dominated by species of oak and hickory (Livingston 1903; Dodge and Harman 1985), and our heavily forested site is no exception. The class sampled 525 trees of twenty-two different species, and oak stood out as dominant (Figure 3, Table 3). Although one might be tempted to classify the upland forests here as "oak-hickory," data from the forests (Table 3) clearly indicate that "white oak-black oak" or simply "oak" is a more accurate description. The three main tree species, listed by importance value (IV) are white oak (20.9), black oak (19.2), and red oak (11.2) (Table 3). Red maple, a recent invader, is fourth

Table 1 *Descriptive Data for the Soils Mapped in the Study Area*

Series	Taxonomic subgroup	Textures and organic materials	Typical horizonation	Parent materials	Natural soil drainage class
Adrian	Terric Haplosaprists	Organic material (16–50'') over sandy material	Oa1-Oa2-Oa3-C-Cg1-Cg2	Herbaceous organic material	Very poorly drained
Boyer	Typic Hapludalfs	Sand or loamy sand (22–40'') over sand and gravel	Ap-E1-E2-2Bt1-2Bt2-3C	Sandy and loamy glacial drift	Well drained
Coloma	Lamellic Udipsamments	Loamy sand	A-Bw1-Bw2-E&Bt	Sandy glacial drift	Somewhat excessively or excessively drained
Colonie	Lamellic Udipsamments	Loamy fine sand	Ap-E1-E2-E&Bt1-E&Bt2- C	Glaciofluvial or eolian sands	Well to excessively drained
Houghton	Typic Haplosaprists	Organic material (>50'') over sandy material	Oa1-Oa2-Oa3-Oa4-Oa5-Oa6	Herbaceous organic material	Very poorly drained
Ithaca	Aquic Glossudalfs	Loam and/or clay loam	Ap-BE-Bt-Bk	Glacial till	Somewhat poorly drained
Marlette	Oxyaquic Glossudalfs	Loam or clay loam (25–40'') over calcareous gravelly sand	Ap-BE-Bt-BC-C	Calcareous glacial till	Moderately well drained
Oshtemo	Typic Hapludalfs	Loamy sand (40–66'') over sand and gravel	Ap-E-Bt1-Bt2-BC1-BC2-C	Stratified loamy and sandy drift	Well drained
Plainfield	Typic Udipsamments	Pure medium or coarse grained sand	Ap-Bw1-Bw2-BC-C	Sandy drift	Excessively and moderately well drained
Rimer	Arenic Hapludalfs	Loamy sand (25–40'') over clay	A-E1-E2-Bt-2Btg-2Bt-2BC-2Cd	Sandy glaciolacustrine deposits	Somewhat poorly drained
Spinks	Lamellic Hapludalfs	Fine loamy sand or sandy loam	Ap-Bw-E&Bt-C	Sandy glacial till or outwash	Well drained
Tekenink	Typic Glossudalfs	Fine sandy loam (40–80'') over calcareous gravelly sand	A-E-E/B-Bt/E-Bt	Sandy loam glacial till	Well drained

(IV = 9.2). The hickory species with the highest importance value is bitternut hickory, at 3.0 percent (ninth in IV). Black cherry, fifth in IV, was most common on the more mesic sites in the southeast part of the study area and on soils with a gravel component, such as Boyer.

Red maple, dogwood, and sassafras are the three most important sapling species in the study area, with importance values of 32.0 percent, 20.4 percent, and 10.9 percent, respectively (Table 4). Dogwood and sassafras are generally small trees that remain in the understory even when mature, and thus their high IVs do not necessarily reflect a future change in overstory composition. The high IV of red maple, however, suggests that, barring major disturbance, the oak-dominated forests of the study area will gradually succeed to an oak-red maple forest, as has been happening over much of eastern North America (Lorimer 1984; Abrams 1998). The increasing dominance of red maple within oak forests on dry, nutrient-poor sites is ascribed to many factors: (1) its low resource requirements; (2) the low degree of competition on these sites from such species as sugar maple, beech, and basswood; (3) contemporary fire suppression; (4) its ability to establish opportunistically following small-scale disturbances such as logging, tree uprooting, and disease infestations; (5) consumption of acorns, and browse damage to oak seedlings and saplings, by white-tailed deer, which have reached high densities in this area over the past few decades; and (6) its habit of being a "super generalist" (Lorimer 1984; Reich et al. 1990; Abrams 1998). Preferential defoliation of oaks by the gypsy moth may also have played a role (Barbosa and Krischik 1987); this part of Barry County experienced a large gypsy moth infestation five to ten years ago. Red maple seedlings also grow quickly in high light, and are drought tolerant. Other studies of presettlement oak forests in the Great Lakes region also noted that red maple was relatively rare in these stands (Larsen 1953). It is clear that, in the absence of large-scale disturbance such as fire or clear-cutting, red maple will continue to increase in abundance, at the expense of oaks, on dry and dry-mesic sites like the one we mapped (Figure 4).

Pedagogy

This study involved extensive amounts of pretrip planning, a heavy dose of fieldwork, and

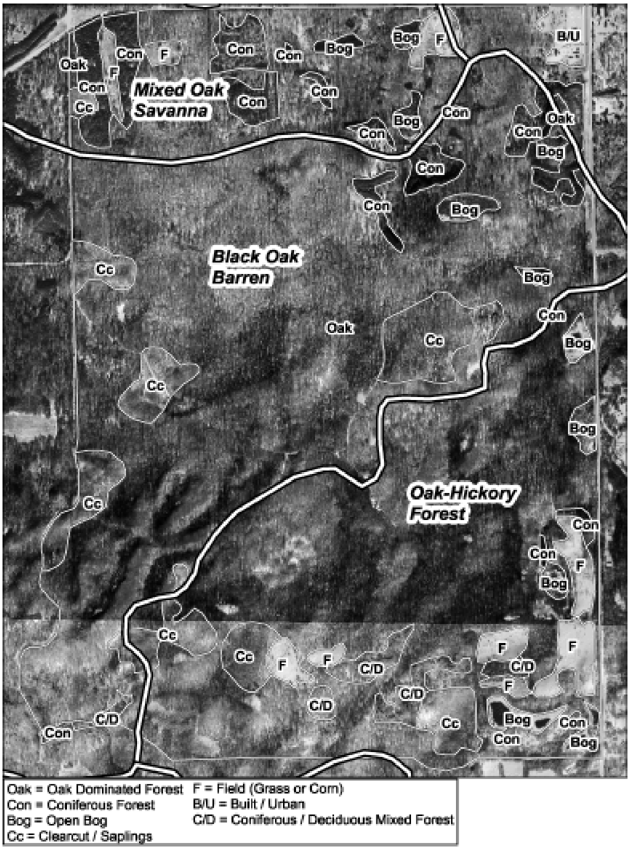

Figure 3 *Contemporary vegetation in the study area, based on field data and aerial photo interpretation. Overlaid onto these data are the much larger, more generalized polygons that depict presettlement vegetation, based on General Land Office notes. Source: Michigan Geographic Data Library (http://www.mcgi.state.mi.us/mgdl/).*

postfieldwork data analysis and map generation. In the end, all students were exposed to working with a GIS, large data sets (both their own and those of the GLO surveyors), survey methods, statistics, and field and lab mapping techniques, as well as being introduced to the literature on the physical geography of southern Michigan. The students had to function individually, in small teams of two or three, and as a part of the larger (class) group. For much of the semester, the professor remained more a facilitator than an active instructor. The value of group learning in geography courses is well documented (Healey et al. 1996), and this project clearly used that to an advantage. In the end, this course was an excellent learning experience, embodying much of what a team-focused, field-based learning experience should—for example, collecting data in an outdoor setting, practicing experiential learning, developing observational and analytical skills, providing opportunities for team building, taking responsibility for one's own learning, and furthering discovery, teamwork, leadership, and a sense of belonging

Table 2 *Descriptive Statistics on the Presettlement Vegetation (Trees) in the Study Area*[1]

Species	Number recorded in GLO notes	Relative dominance	Relative density	Relative frequency	Importance Value
White Oak	15	78.7	79.0	79.0	78.9
Yellow Oak	2	12.6	10.5	10.5	11.2
Black Oak	2	8.8	10.5	10.5	10.0

[1] *Based on witness and line tree data from the General Land Office Survey notes, on file at the State of Michigan Archives, Lansing.*

Table 3 *Descriptive Statistics on the Contemporary Vegetation (Trees) in the Study Area*[1]

Species	Number observed	Relative dominance	Relative density	Relative frequency	Importance Value
White Oak	110	24.3	21.0	17.4	20.9
Black Oak	99	24.1	18.9	14.6	19.2
Red Oak	62	12.1	11.8	9.7	11.2
Red Maple	53	7.6	10.1	10.0	9.2
Black Cherry	40	6.7	7.6	6.7	7.0
Sassafras	26	2.6	5.0	5.4	4.3
Populus spp.[2]	27	4.1	5.1	3.3	4.2
Bitternut Hickory	15	3.0	2.9	3.1	3.0
Almacea family[3]	18	2.9	3.4	2.3	2.9
Shagbark Hickory	15	2.3	2.9	2.8	2.7
Sugar Maple	14	1.4	2.7	2.8	2.3
Other species[4]	42	8.4	8.0	7.7	8.0

[1] *Based on data compiled while mapping.*

[2] *Includes quaking aspen and bigtooth aspen, which were not differentiated in the field, and which have very similar ecological niches.*

[3] *Includes American elm, slippery elm and hackberry, which were not differentiable in the field.*

[4] *The "Other species" category includes (in order of importance): pin oak, dogwood, black ash, white pine, red pine, quaking aspen, black walnut, white ash, pignut hickory, scotch pine, and eastern red cedar. Each of these species had Importance Values less than 2.0.*

(Haigh and Gold 1993; Pawson and Teather 2002).

Although everyone seems to agree that fieldwork in geography is important and students should do more of it, tangible evidence for its effectiveness is often lacking (Jenkins 1994). The project, a hybrid between staff-led and student-led participatory fieldwork (Darby and Burkle 1975), was a success from a pedagogical perspective, if for no other reason than because it led to tangible products, that is, maps and data, as well as student skills. The course and project (1) forced students of varying abilities to work together; (2) allowed for creativity and emphasized flexibility, as the focus of the project ebbed and flowed; (3) facilitated independent thinking and problem solving; and (4) resulted in a number of compelling findings about the physical environment of this complex area. An advantage of this type of project is that it goes beyond simple observational fieldwork, such as in a field trip, and engages the students in truly active learning (Haigh and Gold 1993). In fact, the more that the students can direct and control the experience themselves, with the faculty member serving as a guide or mentor, the better. Projects of this ilk also provide an excellent means of preparing students by giving them the self-confidence necessary for their own fieldwork and research. Be aware, however, that a certain dose of leadership, guidance, and mentoring is necessary, or else the project might disassemble rapidly.

In a field setting such as this, thinking on your feet is essential because the problems that arise usually occur when the professor is not present. Several groups encountered issues related to research protocol while in the field and were

Table 4 *Descriptive Statistics on the Contemporary Vegetation (Saplings) in the Study Area*[1]

Species	Number observed	Relative density	Relative frequency	Importance Value
Red Maple	165	31.6	32.6	32.0
Dogwood	114	21.8	19.0	20.4
Sassafras	57	10.9	10.8	10.9
White Oak	46	8.8	8.5	8.6
Sugar Maple	24	4.6	4.7	4.6
Bitternut Hickory	20	3.8	4.7	4.3
Black Cherry	19	3.6	4.4	4.0
Shagbark Hickory	17	3.2	3.8	3.5
Almacea family[2]	20	3.8	3.2	3.5
Other species[3]	40	7.7	8.8	8.2

[1] *Based on data compiled while mapping.*

[2] *Includes American elm, slippery elm and hackberry, which were not differentiated in the field.*

[3] *The "Other species" category includes (in order of importance): bigtooth aspen, red oak, beech, pignut hickory, common prickly ash, black oak, eastern red cedar, ironwood, white ash, witch hazel, quaking aspen, black ash, red cedar, red pine, and white spruce. Each of these species had Importance Values less than 2.0.*

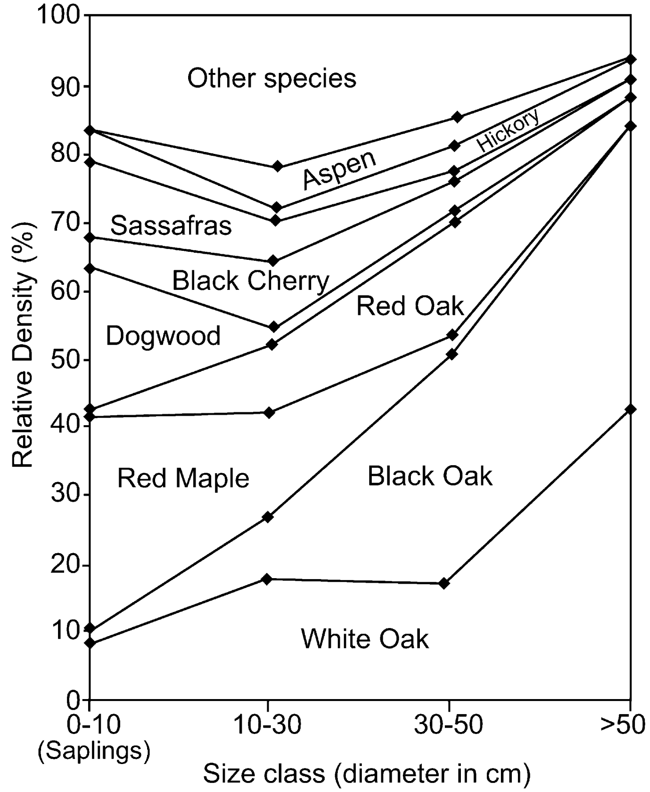

Figure 4 *Dynamics of tree and sapling species, as indicated by relative density values for cohorts of different tree and sapling species.*

forced to solve them independently by discussing their options within the group and, later, with the class as a whole. One such example centered on the soils in the bottoms of large, dry kettles. Early mapping excursions noted that the soils in these areas were unlike any on the uplands or any mapped by the NRCS (Thoen 1990). Knowing this, subsequent mapping groups deliberately went to these sites to acquire more data, and many enlightening discussions ensued. In the end, only one such area was large enough to exceed the minimum map unit size (0.5 ha), but the dialogue that these soils engendered was beneficial to all for it included issues that revolved around map scale, pedology, geomorphology, and land use.

Fieldwork is also an excellent way to lead students into the scientific literature. Topics of interest that cropped up in the field, most notably the dominance of red maple in the understory but its low IV in the overstory, initiated further reading and discussion on the ecology of red maple. The students were drawn to the literature on the ecology of red maple because they *wanted to*, not because they *had to*; they were trying to solve a field-generated problem (Simm and David 2002).

Recommendations for future projects of this type include: (1) keep the project area small in size but challenging in terms of complexity; (2) set and achieve several midsemester writing, reading, or fieldwork deadlines, rather than requiring one complete project report (deadline) at the end; (3) schedule more time for fieldwork than you think is necessary at the start of the project; (4) make a DEM of the area and assemble all available spatial products as soon as possible, to aid in pre-trip planning; (5) do not let the composition of the groups be wholly student determined; and (6) build flexibility into the research plan to account for unforeseen obstacles or findings. We also found that the more short cycles of "preparation-field activity-debriefing" there were, the more learning took place, the more efficient were subsequent field endeavors, and the better the end result was (Lonergan and Andresen 1988).

One possible shortcoming of a project of this type centers on assessment and quality control measures (Healey et al. 1996). As Pawson and Teather (2002) pointed out, assessment of fieldwork, both from the perspective of the staff and the student, is a critical but often difficult task. It would have been very difficult for the instructor to "field check" every aspect of the maps, and even if this could have been done, it would only have verified that errors existed, as they do in any soil or land cover map (Campbell and Edmonds 1984). This left the field reviewers feeling somewhat equivocal about the maps and slightly unsure as to the quality and accuracy of the students' work. In this context, however, that may have been unavoidable. We agree with Habeshaw, Gibbs, and Habeshaw (1992) that one of the more controversial aspects of using this approach in formal coursework involves assessment; determining the extent of each student's contribution, in terms of quality and quantity, is always difficult. Jenkins (1994) suggested some ideas for assessment of fieldwork as taught within a formal class. Lastly, short of direct polling of the students, the long-term benefits of this approach, from *their* perspective, is not immediately clear.

Conclusions

In this study of the soils, landforms, and vegetation of a part of the Barry State Game Area, a class of geography graduate students of varying ability and interest spent numerous days in the field, mapping and observing the physical environment. The end product of this effort was a series of large-scale maps that provide important information for a complex area in southwest Michigan, for which little research had previously been performed. In that regard, the work provides a valuable springboard for future research. Although the examples are from physical geography, we argue that the approach used in this study will be relevant to other field disciplines such as geology, biology, and soil science.

Just as importantly, this project demonstrated that collaborative field research can be a highly useful pedagogical tool and can be employed even among groups where the ability/skill levels are highly variable. In such a setting, talented individuals develop leadership skills and less-talented group members quickly develop skills required for field mapping—out of necessity if for no other reason. As was stated by Pearce (1987, 36), "In the best forms of fieldwork, the task does the teaching, not the teacher." ■

Literature Cited

Abrams, M. D. 1998. The red maple paradox. *Bioscience* 48:355–64.

Albert, D. A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A working map and classification. USDA Forest Service General Technical Report NC-178.

Barbosa, P., and V. A. Krischik. 1987. Influence of alkaloids on feeding preference for eastern deciduous trees by the gypsy moth *Lymantria dispar. American Naturalist* 130:53–69.

Bolton, T., and D. A. Newbury. 1967. *Geography through fieldwork*. London: Blanchard Press.

Campbell, J. B., and W. J. Edmonds. 1984. The missing geographic dimension to Soil taxonomy. *Annals of the Association of American Geographers* 74:83–97.

Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology* 37:451–60.

Darby, D. A., and L. H. Burkle. 1975. Student-initiated field studies. *Journal of Geological Education* 23:24–31.

Dodge, S. L., and J. R. Harman. 1985. Woodlot composition and successional trends in south–central lower Michigan. *Michigan Botanist* 24:43–54.

Dworkin, S. I., G. J. Larson, and G. W. Monaghan. 1985. Late Wisconsinan ice-flow reconstruction for the central Great Lakes region. *Canadian Journal of Earth Science* 22:935–40.

ESRI (Environmental Systems Research Institute). 2003. ArcGIS Desktop Help. Online Documentation. Redlands, CA: ESRI.

Falk, J., W. Martin, and J. Balling. 1978. The novel field trip phenomenon: adjustment to novel settings interferes with task learning. *Journal of Research in Science Teaching* 15:127–34.

Folsom, M. M. 1971. Glacial geomorphology of the Hastings quadrangle, Michigan. PhD diss., Department of Geography, Michigan State University.

Habeshaw, S., G. Gibbs, and T. Habeshaw. 1992. Students lack group work skills. In *53 Problems with large classes: Making the best of a bad job*, ed. S. Habeshaw, G. Gibbs, and T. Habeshaw, 101–103. Exeter, U.K.: BPCC, Wheatons.

Haigh, M. J., and J. R. Gold. 1993. The problems with fieldwork: A group-based approach towards integrating fieldwork into the undergraduate curriculum. *Journal of Geography in Higher Education* 17:21–32.

Healey, M., H. Matthews, I. Livingstone, and I. Foster. 1996. Learning in small groups in university geography courses: Designing a core module around group projects. *Journal of Geography in Higher Education* 20:167–80.

Host, G. E., and K. S. Pregitzer. 1992. Geomorphic influences on ground–flora and overstory composition in upland forests of northwestern lower Michigan. *Canadian Journal of Forest Research* 22:1547–55.

Jenkins, A. 1994. Thirteen ways of doing fieldwork with large classes/more students. *Journal of Geography in Higher Education* 18:143–54.

Kehew, A. E., and M. E. Brewer. 1992. Groundwater quality variations in glacial drift and bedrock aquifers, Barry County, Michigan, U.S.A. *Environmental Geology and Water Sciences* 20:105–15.

Kent, M., D. D. Gilbertson, and C. O. Hunt. 1997. Fieldwork in geography teaching: a critical review of the literature and approaches. *Journal of Geography in Higher Education* 21:313–32.

Larsen, J. A. 1953. A study of an invasion by red maple of an oak woods in southern Wisconsin. *American Midlands Naturalist* 49:908–14.

Leverett, F., and F. B. Taylor. 1915. The Pleistocene of Indiana and Michigan and the history of the Great Lakes. U.S. Geological Survey Monograph 53.

Lewis, R. S., R. F. Burmester, M. D. McFaddan, P. D. Derkey, and J. R. Oblad. 1999. Digital Geologic Map of the Wallace 1:100,000 Quadrangle, Idaho. Open File Report No. 99–290. U.S. Dept. of the Interior and U.S. Geological. Survey. Available online at: http://wrgis.wr.usgs.gov/open file/of99-390/OF99-390.PDF (last accessed December 2003).

Livingston, B. E. 1903. The distribution of the upland plant societies of Kent County, Michigan. *Botanical Gazette* 35:36–55.

Lonergan, N., and L. W. Andresen. 1988. Field-based education: Some theoretical considerations. *Higher Education Research and Development* 7:63–77.

Lorimer, C. G. 1984. The development of red maple understory in northeastern oak forests. *Forest Science* 30:3–22.

Maguire, S., and S. Edmondson. 2001. Student evaluation and assessment of group projects. *Journal of Geography in Higher Education* 25:209–17.

Pawson, E., and E. K. Teather. 2002. "Geographical Expeditions": Assessing the benefits of a student-driven fieldwork method. *Journal of Geography in Higher Education* 26:275–89.

Pearce, T. 1987. Teaching and learning through direct experience. In *A case for geography: A response to the Secretary of State for Education from members of the Geographical Association*, ed. P. Bailey and T. Binns, 34–37. Sheffield, U.K.: Geographical Association.

Reich, P. B., M. D. Abrams, D. S. Ellsworth, E. L. Kruger, and T. J. Tabone. 1990. Fire affects ecophysiology and community dynamics of central Wisconsin oak forest regeneration. *Ecology* 71:2179–90.

Sauer, C. O. 1956. The education of a geographer. *Annals of the Association of American Geographers* 46:287–99.

Simm, D. J., and C. A. David. 2002. Effective teaching of research design in physical geography: A case study. *Journal of Geography in Higher Education* 26:169–80.

Soil Survey Staff. 1981. Soil Survey Manual. Ch. 4 supplement. Washington, DC: Government Printing Office, USDA Soil Conservation Service.

Thoen, G. F. 1990. Soil survey of Barry County, Michigan. Washington, DC: Government Printing Office, USDA Soil Conservation Service.

Walcott, S. M. 1999. Fieldwork in an urban setting: Structuring a human geography learning exercise. *Journal of Geography* 98:221–28.

Warburton, J., and M. Higgitt. 1997. Improving the preparation for fieldwork with "IT" Two examples from physical geography. *Journal of Geography in Higher Education* 21:333–47.

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